



Feedback-aided finger temperature control as a function of locus of control and number of training sessions
by Janice Gray Ryles

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
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Abstract:

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An analysis of variance indicated that locus of control was not a significant factor in performance after six sessions of training. Increase subjects performed significantly better than decrease subjects. This was in contrast to the findings of the majority of previous skin temperature studies.

Further research was recommended to assess the relationship of locus of control and biofeedback performance with sufficient training sessions and employing adequate baseline measures.

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ABSTRACT

Sixteen male undergraduate students were selected from a class of 91 to participate in a biofeedback study. Selection was based on their extreme external or extreme internal locus of control scores on Rotter's Social Reaction Inventory. Subjects were divided into four groups based on internalness or externalness and instructions to decrease or increase skin temperature. All subjects participated in six sessions which consisted of a 21 minute adaptation-baseline period, a 21 minute training period and a 15 minute post-baseline period.

An analysis of variance indicated that locus of control was not a significant factor in performance after six sessions of training. Increase subjects performed significantly better than decrease subjects. This was in contrast to the findings of the majority of previous skin temperature studies.

Further research was recommended to assess the relationship of locus of control and biofeedback performance with sufficient training sessions and employing adequate baseline measures.

INTRODUCTION

The ability to learn control of skin temperature through biofeedback has been confirmed by several authors (Roberts et al, 1973; Keefe, 1975; Roberts et al, 1975; Taub and Emurian, 1976; Surwit, Shapiro and Feld, 1976; and Ohno et al, 1977). However, according to Surwit, Shapiro and Feld (1976), "there are surprisingly few studies which have the full rigor of controlled laboratory investigation," (p. 242). Brown (1977) agreed that "background control research that explores the influence of environmental and physiological contributing influences is sparse" (p. 164).

Maslach et al (1972) investigated the difference in ability to change temperature between subjects trained in hypnosis and normal subjects. The subjects trained in hypnosis successfully changed the skin temperature of their two hands in opposite directions while the normal subjects did not. No biofeedback of performance was given.

Roberts et al (1973) found large individual differences in ability to learn, rate of learning and magnitude of change in temperature in hypnotic subjects. The

authors noted that the variables of auditory feedback and hypnosis were confounded.

Keefe (1975) criticized previous skin temperature research because of the use of multiple treatment procedures which made it "impossible to evaluate whether feedback or the specific instructional sets are responsible for the observed changes in skin temperature" (p. 289). In his study, subjects were given only feedback and simple straight-forward instructions. Subjects received audio and visual feedback for 12 training sessions. After four sessions subjects had achieved relatively poor control over differential skin temperature, but after eight sessions subjects had significantly changed skin temperature. It must be noted that the baseline period was only three minutes long.

Roberts et al (1975) tested the hypothesis that hypnotic susceptibility and the capacity for absorbed, imaginative attention would enhance autonomic learning. Each subject participated in 16 training sessions which made use of audio feedback. The baseline period was ten minutes in length. They concluded that "there are significant individual differences in learning ability, but that the trait of hypnotic susceptibility and, by inference,

the hypnotic state itself, as well as the capacity for absorbed, imaginative involvement, are not necessary conditions for learning" (p. 287).

Taub and Emurian (1976) trained 21 subjects for a minimum of four days using visual feedback. Nine subjects were instructed to increase temperature and twelve were instructed to decrease skin temperature. The training session consisted of a stabilization period, a self-regulation period and a rest period. "The results demonstrated that it is possible to train most humans, in a relatively short span of time, to either decrease or increase skin temperature on the hand dorsum through the use of augmented feedback" (p. 221). They concluded, however, that

. . . subjects vary widely in their ability to achieve self-regulatory control of skin temperature, and some appear capable of only slight or moderate control. However, at least one-third of the population tested demonstrated self-regulated temperature changes of sufficient magnitude to have potential use in clinical and other practical situations. (p. 222)

Taub and Emurian admitted that their experimentation was exploratory and "consequently, no attempt was made to adhere to a specific experimental design" (p. 211). The baseline period was 45 minutes in length, but did not

immediately precede the training session. Music was played during the stabilization period and the use of thermal imagery was encouraged. All subjects were instructed to relax.

Surwit, Shapiro and Feld (1976) stated that in their review of existing published reports of successful skin temperature control ". . . the data needed to substantiate these claims does not exist" (p. 242). Surwit et al conducted two experiments, the first of which included 16 subjects assigned to two groups in which either increases or decreases in temperature were rewarded. Half of the subjects were run for seven sessions (five training sessions) and half were run for 11 (nine training sessions) sessions. Decrease subjects achieved a greater mean change in temperature in the correct direction than did subjects in the increase group. Their second experiment was designed to control for this by lowering the ambient temperature of the room. The first experiment was replicated using fewer subjects and a lower room temperature. Mean temperatures for baseline days were lower than those taken in the first experiment. During training the increase subjects decreased temperature in the cold room. Surwit et al concluded that ". . . the significant increase in

absolute temperature over days (in the first experiment) was not due to learning, but possibly to some habituation process influencing baseline temperature" (p. 246).

Again, 45 minute baselines were taken, but not on the same days as the training sessions.

Ohno et al (1977) divided 40 subjects into four groups: (1) temperature increase, (2) temperature decrease, (3) no feedback group, and (4) false feedback group. Their results showed that most subjects showed an increase in skin temperature in the temperature increase group, a decrease in the temperature decrease group and a decrease in temperature in the no feedback control group. Subjects were not informed of the aim of the experiment. The baseline measure used was the last measure in a five minute pre-training period. Monetary contingent reinforcement was given to subjects meeting previously determined criteria. Only three training sessions were given.

Ohno et al commented that the "big standard errors of each group suggest large individual differences between subjects " (p. 34).

A measure of individual differences which has been investigated in regard to biofeedback performance is locus of control. "Locus of control refers to the degree to

which one sees reinforcements as contingent on his own behavior (internals) or determined by fate, chance, or powerful others (externals)" (Wagner et al, 1974, p. 1142).

Research has shown that internals are better able to control physiological processes through feedback than externals (Goesling et al, 1974; Johnson and Meyer, 1974; Wagner et al, 1974; and Carlson, 1977) as measured by a locus of control scale.

Goesling et al (1974) and Johnson and Meyer (1974) identified internal and external locus of control subjects and evaluated their ability to increase alpha wave production with biofeedback. Both authors found that internals were better able to increase alpha wave production with feedback than externals.

Carlson (1977) trained internals and externals to lower EMG levels. One-half of the subjects received contingent auditory feedback, whereas, the other half received constant non-contingent feedback. With feedback internal subjects acquired lower frontal EMG levels than external subjects. External locus of control subjects given feedback showed a significant shift to the internal direction when pre- and post- questionnaires were compared. Finger temperatures were also monitored (although no training in

this area was given), however, no consistent differences were found. It should be noted that the average temperatures for subjects were rather high (94.0°F for males and 92.6°F for females).

Investigations of the relationship between locus of control and heart rate control resulted in different conclusions (Fotopolus, 1970; Ray, 1974; Gatchel, 1975).

Fotopoulos (1970) stated that her "data clearly indicate internals are significantly more capable of increasing their HR without either external feedback or reinforcement. External controllers were incapable of increasing HR without reinforcement but could significantly do so under a reinforcement paradigm" (p. 3704-B).

Ray (1974) instructed internal and external locus of control subjects to control heart rate and used awareness training procedures (feedback practice). He found that the internals were better able to increase their heart rates and externals were better able to decrease heart rates. There was no significant differences between awareness and non-awareness groups.

Gatchel (1975) found results that indicated "that during the initial training sessions, internals were better able to increase their HR than externals and

externals were better able to decrease HR than internals. However, this association diminished to nonsignificance when additional training sessions were provided.

Reports of the relationship between locus of control and ability to change skin temperature have not yet appeared in publication.

The purpose of this study is to investigate the relationship between locus of control (as a measure of individual differences) and ability to increase and decrease finger temperature with the aid of visual biofeedback.

The secondary purpose of the study was to investigate the variability of performance by groups over sessions.

METHOD

Subjects.

An introductory psychology class of 177 students was administered Rotter's locus of control scale, entitled the Social Reaction Inventory (Lefcourt, 1976, pp.177-180). The inventories of the 86 females in the class were not scored because they were not intended for use in this study. Of the 91 males in the class, the inventories of five were disregarded because of failure to follow directions.

The inventories of the remaining 86 males in the class were scored on the basis of externalness. The class was asked to indicate on the back of the inventory whether or not they would be interested in participating in a biofeedback experiment. They were told that some persons in the class would be randomly selected to participate in the biofeedback experiment.

Eight males were selected for their internalness as measured by Rotter's scale (with a score of approximately one standard deviation from the mean) and eight males were selected for their externalness (with scores of approximately one standard deviation above the mean). The groups

were designated as A and B by a second experimenter, so that the primary experimenter would not be aware of the identity of the groups.

Each group of eight was divided into two cells of four each representing an increase group and a decrease group. Subjects were randomly selected for these subgroups.

Apparatus.

Skin temperature was recorded by the Autogen 2000 Feedback Thermometer using a temperature thermistor placed on the middle finger of the subject's dominant hand. Visual feedback was provided by the meter and lights of the Autogen 2000. The full scale meter deflection was four degrees (Fahrenheit).

Data were computed and displayed by the Autogen 5600 Data Acquisition Center.

Procedure.

Each of the 16 subjects participated in six sessions held over a five week period. Not more than four days was to lapse between sessions. Each session consisted of an adaptation-baseline period; a training period and a post-baseline period. Absolute temperature was recorded at one minute intervals. Percent time of increasing was recorded

at three minute intervals. Room temperature was maintained at $75.5^{\circ}\text{F} \pm .5^{\circ}\text{F}$.

Adaptation-baseline period: All subjects were given an adaptation-baseline period of 21 minutes at the beginning of each session. Subjects were read (given) the following instructions:

The purpose of this experiment is to study the effects of biofeedback on the ability to change hand temperature. Biofeedback is the feedback of biological information to a person through equipment used to monitor processes such as heart rate, blood pressure and temperature which were previously thought to be involuntary. This machine will measure your hand temperature, specifically your finger temperature, from a thermistor taped to your finger. A thermistor measures temperature by monitoring changes in resistance. You cannot be shocked by the equipment, so do not worry. Please sit quietly and move your hand as little as possible. Do not fall asleep. The purpose of this part of the experiment is to allow your temperature to adjust to the room and to take a baseline reading. I will come in and tell you when the next part will begin.

The first six minutes of each adaptation-baseline period was considered to be the adaptation phase (initial adaptation to sitting down having the thermistor attached). The additional 15 minutes consisted of the adaptation to room temperature phase. The mean of the final three minute interval was taken as the baseline measure. All

subjects were to complete the 21 minute adaptation-baseline period prior to each training session.

Training period: The training period was initiated at the end of the 21 minute adaptation-baseline period. During this period subjects received visual feedback from the meter and lights. The subject was given the following instructions:

The purpose of this part of the experiment is to study finger temperature change. Using this meter and these lights as feedback, I would like you to increase (decrease) your finger temperature. Move your hand as little as possible. Please keep increasing (decreasing) your finger temperature until I come in and tell you to stop.

If the needle on the meter deflects to either side and does not move, you may recenter it by using this dial.

Post-baseline: The post-baseline period consisted of a 15 minute no feedback period. Subjects were told to sit quietly in order to let their temperature readjust.

When the subject had completed all six sessions, he was given a brief medical and methods questionnaire to fill out (see Appendix, page 32). At this time, the locus of control inventory was readministered. The subject was told that the reason for this was similar to the reason for a post-baseline (a regular practice in experiments).

Each subject was given eight bonus points in their introductory psychology course for participating in and completing the experiment.

Data was analyzed using a "two-between and one-within" analysis of variance. Statistics were computed on both absolute temperature and percent time in order to analyze the differences in performance between the four subgroups (internal increase, internal decrease, external increase, external decrease) and differences in performance by groups across training sessions 2, 4 and 6. Session one was not used in the analysis because of the tendency for subjects to experience anxiety in the initial session.

RESULTS

As shown in Table 1, the analysis of variance indicated that the difference in performance between internals and externals was not significant. However, the difference in performance by increase subjects and decrease subjects was significant [$F(1,12) = 4.078, p < .05$]. The combined effect of the increase and decrease groups across sessions 2, 4 and 6 was also significant [$F(2,24) = 5.444, p < .05$].

Table 2 shows the absolute temperature changes (training \bar{x} - baseline \bar{x}) for each group for sessions 2, 4 and 6. As is shown, 12 out of 16 subjects exhibited changes in the correct direction by session 6. All four groups showed improvement in temperature change in the correct direction across sessions 2 and 6 as shown in Table 3.

During 93 out of the total 96 sessions (16 subjects x 6 sessions each) subjects showed an increase in temperature during the adaptation-baseline period. These temperature increases ranged from $.18^{\circ}\text{F}$ to 28.86°F over the 21 minute adaptation-baseline period.

The mean baseline temperature for increase subjects was 94.53°F and 94.64°F for decrease subjects. This

difference was not significant.

There was no significant difference between initial locus of control scores and post-training locus of control scores for internals, externals, or combined groups as indicated by t tests.

Analysis of variance performed on "percent time increasing" data yielded no significant results.

Table 1

"F" Ratios Computed Across Sessions 2, 4 and 6

Source of Variation	Sum of Squares	df	Mean Square	F
internal/external	0.322	1	0.322	0.452
increase/decrease	2.906	1	2.906	4.078*
sessions (2, 4 & 6)	0.090	2	0.045	0.100
locus of control/inc.dec.	0.043	1	0.043	0.060
locus of control/sessions	0.113	2	0.056	0.124
inc.dec./sessions	4.927	2	2.464	5.444*
locus of control/inc.dec./ sessions	0.378	2	0.189	0.418

*significant at $p < .05$

Table 2

Absolute Temperature Changes
(training \bar{x} - baseline temperature)

Group	Subject #	Session		
		2	4	6
Internal increase	1	.05	.29	2.38
	2	.15	.22	.53
	3	.76	.40	-.21
	4	.63	.16	1.12
Internal decrease	5	.45	-.46	-1.48
	6	-.24	-.04	.42
	7	.36	-.50	-.38
	8	.99	.42	-1.20
External increase	9	1.22	-.04	.49
	10	-.07	.15	1.43
	11	1.06	1.87	1.36
	12	1.52	.09	.35
External decrease	13	.24	.29	-.97
	14	.20	.56	.56
	15	.71	-.80	-.41
	16	.02	.24	.38

Table 3

Mean Absolute Temperature Changes for the Four Groups

Group	Session	
	2	6
Internal increase	.017	.955
Internal decrease	-.39	-.66
External increase	.172	.907
External decrease	.292	-.11

DISCUSSION

Locus of Control.

After six training sessions, locus of control did not prove to be an adequate measure of individual differences in performance. Internals did not perform significantly better than externals. This is consistent with the findings of Gatchel (1975) that the association between locus of control and performance diminishes to nonsignificance with additional training sessions.

The fact that the major locus of control/biofeedback studies involved only one training sessions may account for their findings of enhanced performance by internals (Fotopoulos, 1970; Ray, 1974; Wagner et al, 1974; Goesling et al, 1974).

Gatchel (1975) stated that "the failure of previous research to provide more than one session of training prevented the illumination of this significant I-E Group X Session Effect" (p. 426).

Carlson (1977) utilized 8 training sessions in his study of EMG and locus of control and concluded that internals were better able to reduce EMG level than externals. He added that

the divergent patterns of responding across sessions when the feedback and control conditions are contrasted demonstrates the advisability of conducting a number of training sessions when investigating relationships between locus of control and bodily self-regulation. (p. 269)

In the present study, subjects did not significantly shift their locus of control after the completion of the biofeedback training as indicated by Rotter's inventory. This is contrary to the findings of Carlson (1977) whose results indicated that "locus of control orientation of external subjects given feedback shifted significantly in the internal direction . . ." (p. 268)

It is possible that some confusion about one's ability to control skin temperature existed among subjects. In the post-training questionnaire three out of the 16 subjects responded that they thought it was possible to change finger temperature through biofeedback only to some extent. Brown (1977) stated that

One problem the patient may encounter is his attitude about controlling internal processes of his body. Most people welcome the idea; the problem lies in implementing a change in attitude about control from the learned dogma that it has never been possible and that only medical authority could responsibly intervene in body processes. While the idea of self control is appealing, the weight of culture and beliefs can often act to confuse the patient. (p. 17)

Because the mean changes in temperature achieved by subjects was not greater than 2.38°F, it is likely that subjects did not perceive this change as directly related to their ability to control bodily processes. Particularly, in the regulation of skin temperature, subjects may associate changes in bodily processes with environmental factors as opposed to "inner control."

Although studies have shown a relationship between locus of control and ability to control bodily processes with the aid of biofeedback, the present study did not support this relationship. The usefulness of locus of control as an indicator of performance should not be over-rated as "the variables relating to this construct clearly are not simple ones" (Carlson, 1977, p. 269).

Temperature Control.

The present study demonstrated a significant difference in performance by subjects instructed to increase finger temperature and subjects instructed to decrease finger temperature. Differences in performance cannot be attributed to locus of control as measured by Rotter's Social Reaction Inventory. Consistent with the findings of Surwit et al (1976), there was no significant change

in performance for groups across sessions. However, all four groups did show increased temperature change in the correct direction across sessions two and six.

The mean temperature changes obtained in this study indicated that increase subjects performed better than decrease subjects. In a study by Keefe (1975) increase subjects achieved a greater temperature change than decrease subjects in line with the findings of the present study. Keefe also attempted to avoid the use of "multiple treatment procedures" and used only biofeedback and response-specific instructions.

The mean temperature changes obtained in this study varied somewhat from those obtained in several other studies. This variation was primarily due to the fact that in this study increase subjects performed better than decrease subjects. This is not in line with the generally accepted conclusion that vasoconstriction is easier to achieve than vasodilation (Surwit et al, 1976). There are several factors which may account for this difference.

One factor which may have contributed to the difference in performance by decrease subjects in this study and other studies is the absence in this study of multiple treatment procedures. The other studies noted included

the use of contingent reinforcement and autogenic suggestions. The subjects in these studies could have produced greater decreases in temperature due to the addition of these treatment variables. Taub (1976) found that his subjects who were contingently reinforced performed $.7^{\circ}\text{F}$ better than those who were not.

A single treatment procedure was utilized in order to avoid confounding of variables. Only visual biofeedback and minimal directions were given. Visual feedback was used as opposed to audio because

Focusing on the lights or meter encourages greater receptivity to the feedback information because a continued awareness must be maintained. Training with the eyes closed may encourage drowsiness or daydreaming, thus reducing the trainee's alertness and receptivity to the feedback information (it should be emphasized, however, that a state of alertness is distinct from a state of tension; one of the goals of skin temperature training is to facilitate sympathetic relaxation while maintaining alertness.) (Autogenic Systems, Inc., 1975, p. 38)

In the studies which reported better performance by decrease subjects than increase subjects, anxiety may have been affecting performance. "According to psychophysiological theory, stress causes vasoconstriction in the peripheral blood vessels which results in a decrease of

blood flow to the periphery of the body" (Bloom, 1977, p. 541). Skin temperature drops as blood flow decreases.

Skin temperature feedback training, like any new experience, may initially generate a certain amount of performance anxiety and self-consciousness on the part of the trainee. (It is interesting to note that this performance anxiety almost invariably brings about a decrease in hand temperature during the first training session).

If the trainee tries too hard to relax, he/she may fall prey to a "striving mode," which can bring about a decrease in hand temperature rather than the desired increase. This pressure to "produce" results in training can generate anxiety and significantly interfere with training. (Autogenic Systems, Inc., 1975, pp. 34 and 37)

It is possible that in studies that showed better temperature decrease (Ohno, 1977; Surwit et al, 1976; Taub, 1976) subjects were experiencing either performance anxiety or the "striving mode," both of which could account for greater temperature decrease. In this study this may be less likely to occur because of the 21 minute adaptation-baseline period preceding each training session. The fixed length of the stabilization period is based on the information provided by Taub and Emurian (1976) that stabilization for their subjects occurred between 10 and 30 minutes. Subjects were instructed to sit quietly during

this period and all subjects showed a temperature increase during this period in session six indicating vasodilation and presumably relaxation. If subjects were already tending to vasodilate, it is theoretically probable that it would be easier for them to continue to vasodilate than to actively vasoconstrict. " . . . it may be that the temperature change systems tend to operate more in a manner of "mass movement," with an apparent inertia to change and an inertia which continues a change once started" (Gaarder and Montgomery, 1977, p. 137).

It is important that sufficient time for temperature adaptation be allotted because "training which is done prematurely (i.e., before sufficient acclimatization occurs) can be misleading, as shifts in skin temperature would not necessarily be those associated with psychophysiological changes" (Autogenic Systems Inc., 1975, p. 30).

Brown (1977) acknowledged the importance of this factor and added

. . . without adequate adaptation periods and controls for room temperature or controls for individual differences in hand temperature, hand temperature would rise naturally and quickly; thus when temperature biofeedback is used results could be dramatic. It is unfortunate that no study has controlled for all of these factors; in fact, none has conducted

adequate controls for the adaptation phase.
(p. 167)

Another factor which may have contributed to the results obtained in this study is ambient temperature. The average room temperature during this study was 75.5°F. This is slightly higher than the temperature used by Taub (1976). Subjects were tending to vasodilate during the adaptation-baseline period and this possibly made it easier for increase subjects to continue to increase (to ceiling temperature), but also possibly made it more difficult for the decrease subjects who theoretically must inhibit a trend to vasodilate and now actively vasoconstrict.

Concluding Remarks.

The results of this study indicated that locus of control was not a significant predictor of ability to control finger temperature and did not significantly shift after biofeedback training. The effect of number of training sessions utilized on the relationship of locus of control and performance was cited as a possible variable.

It was shown that male subjects can produce increases and decreases in finger temperature with the aid of visual

feedback and minimal instructions. Although some improvement occurred in the ability to change temperature in the correct direction by session 6, the change across sessions was not significant.

Explanations were offered to account for the difference in performance by decrease subjects in this study and other temperature studies.

Further research is needed to confirm locus of control as a useful predictor of biofeedback performance. In the area of skin temperature control, additional studies are recommended which employ sufficient experimental controls and sufficient adaptation-baseline periods.

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APPENDIX

Questionnaire

Name

Group

Age

1. Are you currently receiving treatment for any medical problems?
2. Are you currently taking any medication?
3. Do you have high blood pressure?
4. Do you have migraine headaches?
5. Have you ever participated in a biofeedback experiment before this one?
6. Have you had training in meditation, yoga, or relaxation? (list)
7. Do you believe that it is possible to change your temperature through biofeedback?

Post:

1. Did you use any particular method to attempt to control your finger temperature?
2. Do you feel that you were able to change your finger temperature?

169-825

