FINGER TEMPERATURE RECOVERY FROM STRESS

BY

Bonnie Kathleen Jeffery ©

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Supervisor: Dr. J. Jamieson
Second Reader: Ken Allan

Department of Psychology
Lakehead University
Thunder Bay, Ontario, Canada
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ABSTRACT

The purpose of the study was to determine whether finger temperature is a useful and reliable measure of physiological recovery from stress. The design was an ABA format in which days one and three involved a stressor, while day two simply entailed sitting quietly. The three sessions were one week apart. Gender differences in finger temperature recovery were found, with the finger temperature of females failing to return to baseline levels ten minutes following the stressor. However, this gender difference was also apparent on the control day, and thus it appears to reflect gender differences in baseline drift. The implications of this gender difference in finger temperature drift are discussed.

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INTRODUCTION

Finger temperature has been of recent interest because of the potential application of finger temperature biofeedback as a treatment for migraine headache and Raynaud's disease (Gillespie & Peck, 1981; Kluger, Jamner, & Tursky, 1985; Rose & Carlson, 1987). Finger temperature has also been used as an index of the physiologicial response to stress (Boudewyns, 1976; Blanchard, Morrill, Wittrock, Scharff, & Jaccard, 1989). One aspect of the physiological stress response which has attracted attention is the recovery phase (Dienstbier, 1989). The present study is designed to explore whether finger temperature might prove to be a particularly useful measure of this recovery process.

SKIN TEMPERATURE

Skin temperature is a function of peripheral circulation. Since there is no muscle and little bone in the digits, the main function of the blood flow to the fingers is temperature regulation (Hassett, 1978). Plutchik (1956) contends that the skin temperature of both the fingers and toes "will be maximally sensitive to the effects of stimulation or changed conditions" of the body. Since the "exchange of heat between the body and environment occurs over the entire surface" the "skin temperature of the fingers and toes serve as the most sensitive indicators of the changes of the blood flow of the superficial vessels." This is a result of the organism striving for homogeneity of the internal body temperature; thus the rate of heat production should equal the rate of heat loss (Plutchik, 1956, p.253).

Blood flow to the hand is dependent on the relative pressure of the ulnar and radial arteries. However, the radial artery tends to be the dominant supplier of blood to the hands and consequently the digits (Kleinert, Fleming, Smith Abel, & Firrell, 1989). There is evidence that the small blood vessels in the fingers alternate between either vasoconstriction or vasodilation. The average time period between episodes of vasoconstriction is dependent on the environmental temperature, while their frequency is dependent on whether the individual is warm or cool to begin with (Burton, 1959).

The peripheral blood vessels are governed by mechanisms in the hypothalamus and brainstem which respond to changes in the temperature of the blood by initiating either constriction or dilation of the blood vessels to increase or decrease heat loss (Kluger et al., 1985). A decrease in finger temperature will occur if there is a constriction of the blood vessels, while a dilation of the blood vessels will result in an increase in finger temperature (Davis, 1988). Both sympathetic vasoconstricting nerves and "the interactions of circulating vasoactive compounds with various biochemical receptors" control bloodflow in the fingers (Freedman, Morris, Norton, Masselink, Sabharwal, & Mayes, 1988, p. 299).

Two kinds of chemicals which naturally occur in the body directly affect the arterioles and subsequently the temperature of the skin: metabolites and hormones. As the amount of oxygen or hydroxyl ions increases there is a drop in skin temperature due to vasoconstriction. On the other hand, as the level of carbon dioxide or hydrogen increases the temperature of the skin also increases as a result of vasodilation. Epinephrine, pituitrin, renin and sympathin are all hormones which are considered to have a role in vasoconstriction. Thus increases in the levels of these vasoconstricting activating hormones will result in lowered skin temperature. On the other hand, increased levels of the vasodilating activating hormones such as histamine, will be accompanied by an increase in the temperature of the skin (Plutchik, 1956).

One substance that can mediate an increase in the skin temperature of the hands is alcohol (Higgens et al., 1968; Newlin, 1985). The reason that alcohol serves to increase the skin temperature is because its ingestion creates a peripheral vasodilatory effect, whereby the peripheral blood vessels of the skin dilate since alcohol is a mild beta adrenoreceptor blocker.

Nicotine, on the other hand serves to decrease the temperature of the skin as it causes vasoconstriction (Moss, Hammer, & Sanders, 1984; Bowdewyns, 1985; Pomerleau & Pomerleau, 1987).

Some drugs such as tolazoline have been observed to result in vasodilation as they are alpha-adrengeric receptor blocking agents (Rose et al., 1987). Alternatively, phenylephrine and clonidine are alpha one and alpha two antagonists which result in vasoconstriction (Freedman, Sabharwal & Desai, 1987). Other drugs, reserpine for example, produce vasodilation as they deplete norepinephrine from the sympathetic nerves. Drugs such as guanethidine, serve to produce vasodilation with the release of norepinephrine at the sympathetic neuroeffector junction. Vasodilation can also be produced by beta-adrenergic receptor simulating drugs, two of which are nylidrin (Rose et al., 1987) and isoproterenol (Freedman et al., 1987). It has also been observed that patients taking antipsychotic medications have higher hand temperatures than patients who are not taking such medication. This effect is probably due to the medicine since the patients taking antipsychotic medicine had higher overall temperatures (Kappes & Morris, 1982).

SYMPATHETIC CONTROL OF SKIN TEMPERATURE

Vasoconstriction also occurs as a result of the activation of the sympathetic nervous system (Smith, Houston, and Zurawski, 1984). Emotions such as depression, embarrassment (Hassett, 1978), pain, fear, and anger (Schachter, 1957; Davis, 1988) have been documented as being responsible for mediating decreases in finger temperature. Boudewyns (1976) demonstrated that hand temperature increases with relaxation while it decreases under stressful conditions. The effect of experimentally induced stress resulting in lowered finger temperatures has been reported by others (Hugdahl, Fagerstrom & Broback, 1984; Clarke, Moris, & Cooney, 1987; Pomerleau et al., 1987; Blanchard, et al., 1989).

While finger temperature has not been one of the most widely used measures of the stress response, it has received some attention. For example, Hugdahl, Fagerstrom, and Broback (1984) compared the differential effects of cold temperatures versus mental stress combined with cold temperatures in females with vasospastic disorders and those without. In the cold temperature only condition, both groups exhibited similar decreases in finger temperature from baseline. However, the individuals without vasospastic disorders demonstrated a larger finger temperature decrease from baseline in the cold plus mental stressor condition; presumably as a result of a floor effect for the vasospastic subjects since their baseline finger temperatures were significantly lower than the subjects without vasospastic disorders.

Other research has focused on finger temperature as demonstrating differential responses in Type A and Type B cardiac patients when participating in guided imagery tasks. The Type A subjects were found to have colder finger temperatures than the Type B subjects, when exposed to Type A relevant guided imagery scenes (Baker, Hastings, & Hart, 1983).

Finger temperature response to positive versus negative valence music has also been assessed. McFarland and Kennison (1989) found that the relationship between the finger temperature response and the emotional valence reported by males during music is dependent upon the cerebral hemisphere which is most involved in processing the music.

The stability of finger temperature has also been studied. McFarland and Kadish (1990) conducted an experiment to evaluate the stability of finger temperature with respect to adaptation time. Five groups of subjects were administered a negative emotion inducing stimulus (music) after four, eight, twelve, sixteen, or twenty minutes of adaptation. The stability of finger temperature was concluded to increase as the length of adaptation time increased.

The reliablity of finger temperature response to stress has also been examined. Arena, Blanchard, Andrasik, Cotch, and Myers (1983) evaluated the finger temperature responses of fifteen subjects over four sessions. They concluded that finger temperature response to both cognitive (mental arithmetic) and physical stress (cold pressor task) was virtually unreliable.

Attempts to help control migraine headache have led to numerous speculations regarding not only the origins of the headache but as well the reactivity of the neurovascular pathways. More specifically, there are speculations that individuals who suffer from migraine headache tend to respond to stress via the neurovascular pathway as opposed to the interneuronal, neuromuscular and the neurohumoral pathways (Clarke et al., 1987). Such theorists have speculated that the finger temperature response to stress will vary depending on the neurophysiological pathway that is characteristic of the individual. Unfortunately, support for these suggestions is mixed. Clarke et al. (1987) found no significant differences among three groups of subjects: migraine headache, tension headache and normal participants in their finger temperature response to a number of cognitive stressors. Blanchard, et al. (1989) on the other hand, found that migraine and mixed (migraine and tension) headache groups had significantly lower finger temperatures during rest and during both physical and cognitive stressors as compared to normals, hypertensives, tension headaches, and irritable bowel syndrome groups.

ENVIRONMENTAL TEMPERATURE

Gibbon and Landis (1932) and Rinzler, Travell and Cevin (1944) have reported that normal room temperatures, those from 20 to 26 degrees Celsius will not alter skin temperature. Furthermore, Plutchik (1956) claimed that the clothing worn by the subjects will have little influence on the results of the experiment. However these earlier views now appear to be incorrect. Kappes et al. (1982) observed that a subject's finger temperature may move toward room temperature over time, a phenomenon referred to as the "drift effect". This phenomenon has been noted to occur both with (Hugdahl et al., 1984) and without a prior stressor (Higgons et al., 1968; Moss et al., 1984; Hugdahl et al., 1984; Gwosdow, & Berglund, 1989). The temperature of the room has also been established to affect the temperature of the hand (Hanna & Smith, 1975; Gillispie et al., 1981; Kappes et al., 1982; Duckro & Schultz, 1986; and Rose & et al., 1987).

Even seasonal changes may affect hand temperature. Boudewyns (1985) reports that people tend to have colder hands during the winter months. Rose et al. (1987) also note that hand temperatures depend on the season.

Body Mass Index

There appears to be a relationship between body temperature and body mass. Adam (1989) found that oral body temperatures are inversely related to body mass index irrespective of gender. Her subjects were tested during resting conditions and ranged in age from 41 to 70 years. On the other hand, there is contradictory evidence that body temperature and body mass are positively related. Eriksson et al. (1985) reported that body mass index has a strong positive relationship with oral body temperature in men aged 57 and 67. His results are based on recording the oral temperatures of 816 men during resting conditions.

Although there is evidence that core body temperature has some relationship to body mass index, the relationship between skin temperature and body mass index has not been widely explored. However, Tochinhera, Ohnaka, Yamazaki, Tanaka and Yoshinda (1984) observed that the skin temperature of the hand and body mass index of males were signficantly correlated during whole body exposure to cold.

GENDER DIFFERENCES

The reports of gender differences in finger temperature in the literature are mixed even though women have been reported to suffer from vascular diseases more frequently than men (Freedman et al., 1987). Raynaud's disease for example, is far more prominant in women than men. Raynaud's disease results in lowered skin temperatures of the hands and feet as a result of periods of vasoconstriction (Rose et al., 1987).

Boudewyns (1976) found no gender differences in baseline finger temperatures during the colder months of the year. However, during the warmer months females were signficantly cooler than males. Freedman, et al. (1987) report that after a baseline period of twenty minutes there were no significant differences in finger blood flow between men and women. Likewise, Lucus and McIlvaine (1985) did not find gender differences in finger temperature for baseline measures. However, they did report small but significant gender differences, whereby women had cooler hands than men during the experimental phase in which the subjects were asked to try to increase their finger temperature using various types of feedback.

On the other hand, Kappes et al. (1982) found that males tend to have significantly higher finger temperatures both at baseline and over time. McFarland et al. (1990) found that the finger temperature of males decreased less than that of females when presented with a negative emotion producing stimulus. Although a gender difference was not evident when the negative stimulus was presented after only four minutes of adaptation, a gender difference was evident when the stimulus was presented after eight, twelve, sixteen, and twenty minute adaptation periods. Wyon, Fanger, Olesen, and Pedersen (1975) also found that males maintained a higher skin temperature than females in a thermal neutral environment. Surwit, Shapiro, and Feld (1976) found that the appearance of gender differences may depend on room temperature. No gender differences were present during baseline days or finger temperature increase training session days when the room temperature was 22.5 degrees Celsius. However when the room temperature was 19.5 degrees Celsius, females displayed significantly lower finger temperatures during baseline days but had similar temperatures during finger temperature increase training days.

RECOVERY FROM STRESS

One aspect of the physiological response to stress which is of interest in the literature at present is the recovery period. The recovery phase is the time during which the previously elevated physiological indices return to baseline measures. There is a theory that slow recovery from stress is maladaptive (Cameron & Meichenbaum, 1982; Shapiro & Goldstein, 1982). Heart rate recovery from stress has received attention in the literature since prolonged recovery may be related to factors which are considered to increase the risk of heart disease (Jamieson & Lavoie, 1987). However, heart rate recovery is generally complete within one minute following the stressor, which is a brief time frame in which to study individual differences in recovery rate. Finger temperature response to stress on the other hand, "is relatively slow to 'track' changes in stimulus conditions" (Boudewyns, 1976, p. 54), thus making it a potentially useful physiological indicator of pathological stress responses. Unfortunately there has been surprisingly little attention given to the return to basal temperatures following a period of reduced finger temperature. This is also important as delayed recovery from reduced finger temperatures may not only result in physical discomfort, but may indicate vasospastic disorders such as Raynaud's disease.

In an attempt to identify pathological finger temperature recovery, Dupuis (1987) examined finger temperature recovery following hand immersion in water at 15 degrees Celsius for one minute in 317 subjects. He concluded that the subjects could be divided into three finger temperature recovery groups: 1) normal recovery (finger temperature was greater than or equal to 28 degrees Celsius within fifteen minutes); 2) moderate delay (finger temperature was greater than or equal to 28 degrees Celsius within 16 to 30 minutes); and 3) strong delay (finger temperature was less than 28 degrees Celsius at the end of thirty minutes). Unfortunately there was no mention of the gender of the subjects that these results are based on.

Boudewyns (1976) conducted an experiment in which a group of subjects listened to a relaxation tape for ten minutes, followed by a seven minute stress period in which there was a threat of electric shock. The session concluded with a second relaxation phase which lasted 15 minutes or until finger temperatures reached those of the first relaxation phase. The finger temperature recovery from stress to the second relaxation phase was similar for both males and females. However, when the stress phase was increased to fifteen minutes the finger temperature recovery from stress to the second relaxation phase was significnatly slower for females.

PRESENT STUDY

The purpose of this study was to determine whether finger temperature is a useful and reliable measure of physiological recovery from stress. An ABA design for the present study was chosen to determine whether finger temperature recovery is a reliable indicator of delayed stress response or is simply due to a drift effect. Both A days involved a cognitive stressor while day B was a rest day. An advantage of this design was that both A days can be compared to day B. Such comparisons enabled an evaluation of whether the recovery period on the two stressor days is a different phenomena to what happened to finger temperature on the rest day. This design was also appropriate to study the reliability of finger temperature recovery and to observe any gender differences in finger temperature recovery.

METHOD

SUBJECTS

Twenty-one males and twenty-one females participated in this study. The average age of the subjects was 21.8 years. Subjects were volunteers from first year psychology classes and received credit towards their final grade for participating. Prior to testing subjects were asked to refrain from smoking, ingesting caffeine, eating or being outside for one hour prior to reporting to the laboratory.

APPARATUS

A Beckman polygraph with Yellow Springs Thermistor (series 400) attached to the temperature input coupler (9859) was used in this investigation. Calibration of the input coupler centered the pen at 29 degrees Celsius and caused the pen to deflect 1 cm. for every 1 degree Celsius change in finger temperature. Calibration of the polygraph machine was checked prior to testing each day.

PROCEDURE

Upon entering the laboratory subjects were asked to sign a consent form. Following this, each subject was weighed and their height was measured and recorded. Each subject reported to the laboratory three times, once each week at approximately the same time to control for any circadian rhythms in temperature regulation which may influence finger temperature. During each of the recording days the subjects were seated in a reclining chair while the thermistor was attached to the volar surface of the distal phalanx of the middle finger of the left hand. Sessions one and three were identical except that the stressor was slightly modified on the third session. This modification was done to counteract the decreased stressfulness which might otherwise result from the familiarity with the task.

In both of these sessions each subject was asked to sit quietly and relax so a baseline temperature could be obtained. After ten minutes of temperature recording subjects were told that in two minutes they would be asked to count backwards by 13's for session one, and 17's for session three, from a preselected number. Each subject was given a practice trial to ensure that the procedure was understood. Once two minutes had passed the subject was asked to count backwards from 674 by 13's for session one, and from 714 by 17's for session three, as quickly and as accurately as possible. If a mistake in counting was made, subjects were corrected and asked to continue counting from the corrected number. Furthermore, to make sure that the third session was as stressful as the first, each subject was told to "Try to go a little faster" at 90 and again at 120 seconds during counting. The counting stressor lasted for three minutes. Following the stressor finger temperature was recorded for a final ten minutes while subjects were asked to relax. During session two each subject was asked to simply sit and relax while their finger temperatures were recorded for twenty-five minutes.

Temperature was measured in degrees Celsius at the end of selected time periods. For days one and three finger temperature was measured at the tenth minute of rest (baseline), at minute three of stress, at minutes one, two, three, four, five and minute ten of recovery. For day two, finger temperature was measured at minute ten, minute 15 (which corresponded to minute three of stress), minute twenty (which corresponded to minute five of recovery) and minute twenty-five (which corresponded to minute ten of recovery).

All analyses which involved a finger temperature change from baseline levels were calculated with baseline levels as covariates to control for any initial differences in finger temperature. This compensation for the Law of Initial Values was necessary since finger temperatures which are higher to begin with will result in greater decreases than lower baseline temperatures in response to stimuli presentation (Jamieson, 1987). However in some cases repeated measures analyses of variance are presented in order to illustrate the significance of the change from baseline. In all cases where analyses of variance are presented, the corresponding analyses of covariance yielded identical conclusions.

RESULTS

PRELIMINARY ANALYSES

1. BASELINE FINGER TEMPERATURE

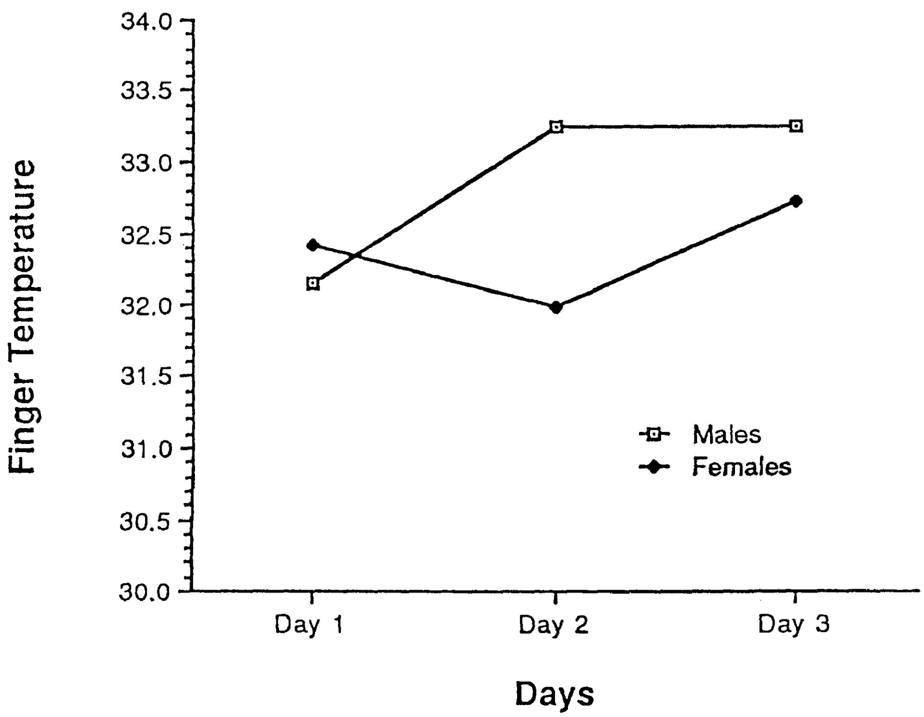
The baseline finger temperature was examined to determine a) whether there were any differences in baseline finger temperature among days one, two and three of the experiment and b) if there were any differences between males and females. A two-way (Gender X Day) repeated measures ANOVA revealed that the effect of day was not significant $F(2,76) = 2.27$. Furthermore, the analysis revealed no significant gender differences in baseline finger temperature $F(1,38) = 1.66$, nor was the gender by day interaction significant, $F(2,76) = 2.81$. Thus, baseline finger temperature was stable across all three days and there were no significant differences between males and females (refer to Figure 1).

2. FINGER TEMPERATURE DURING STRESS

The finger temperature response to stress was examined by comparing the change from baseline to the third minute of stress. This analysis was done to determine whether males and females differed in their finger temperature responses to stress and whether finger temperature responses were of comparable magnitude

FIGURE 1

Baseline Finger temperatures for males and females on days one, two, and three



on days one and three.

The mental arithmetic stressor presented on days one and three resulted in a finger temperature decrease (Figures 2 & 3). To compare the consistency of the stress response across both days one and three, a three-way ANOVA was performed, with the factors being day (one and three), gender, and period (baseline and minute three of stress). The main effect of period, $F(1, 38) = 93.79$, $p < .001$ was highly significant, confirming the stressfulness of the arithmetic task. The day by period interaction was not significant $F(1, 38)$ 2.39, indicating relative consistency of the stress response on both days one and three. There were no gender differences in response to stress $F(1, 38)$ .20. As well the three way interaction $F(1, 38) = 2.63$, was not significant, indicating that males and females did not differ in their stress responses across days one and three.

In summary, there was a decline in finger temperatures from baseline as a result of the cognitive stressor and this stress response was of comparable magnitude on both days one and three. There were no gender differences in finger temperature response to stress.

FIGURE 2

Finger temperatures during baseline, stress minutes one to three, recovery minutes 1 to 5 and minute 10 for males on days one and three

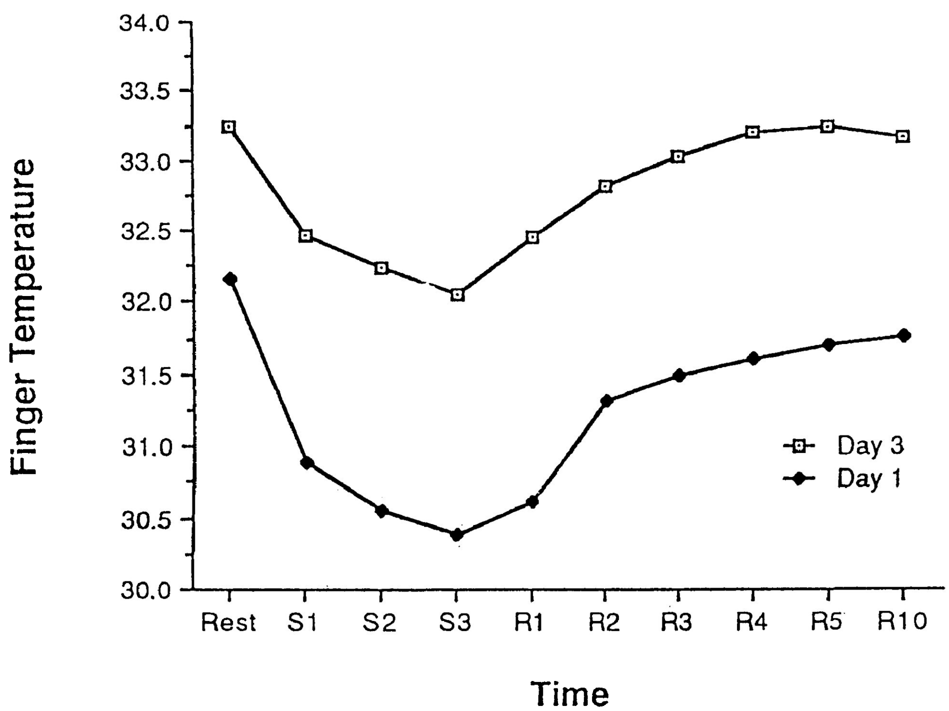
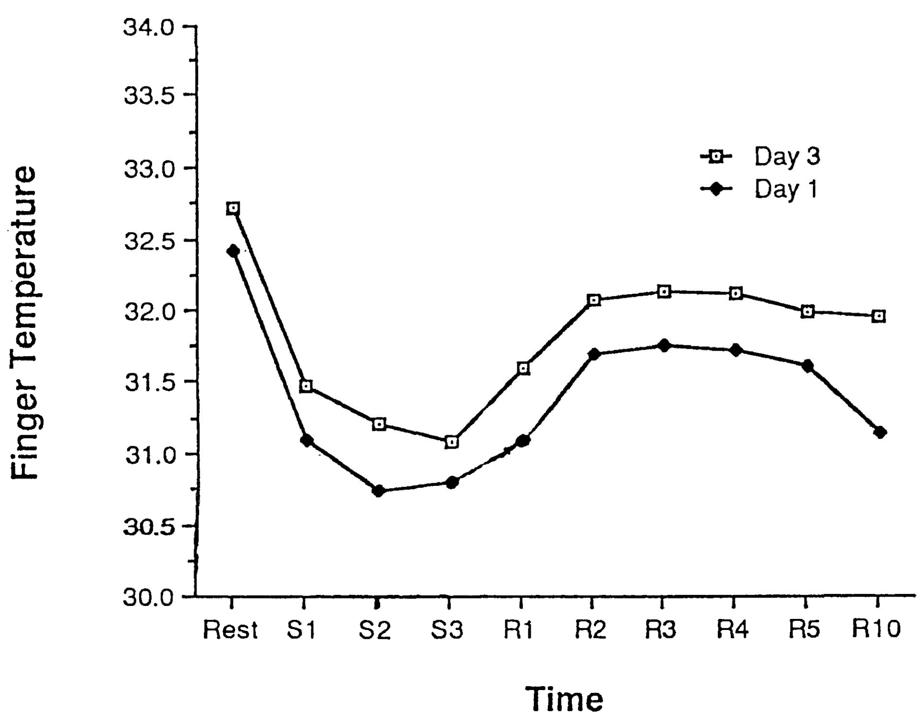


FIGURE 3

Finger temperatures during baseline, stress minutes one to three, recovery minutes 1 to 5 and minute 10 for females on days one and three



DRIFT EFFECT

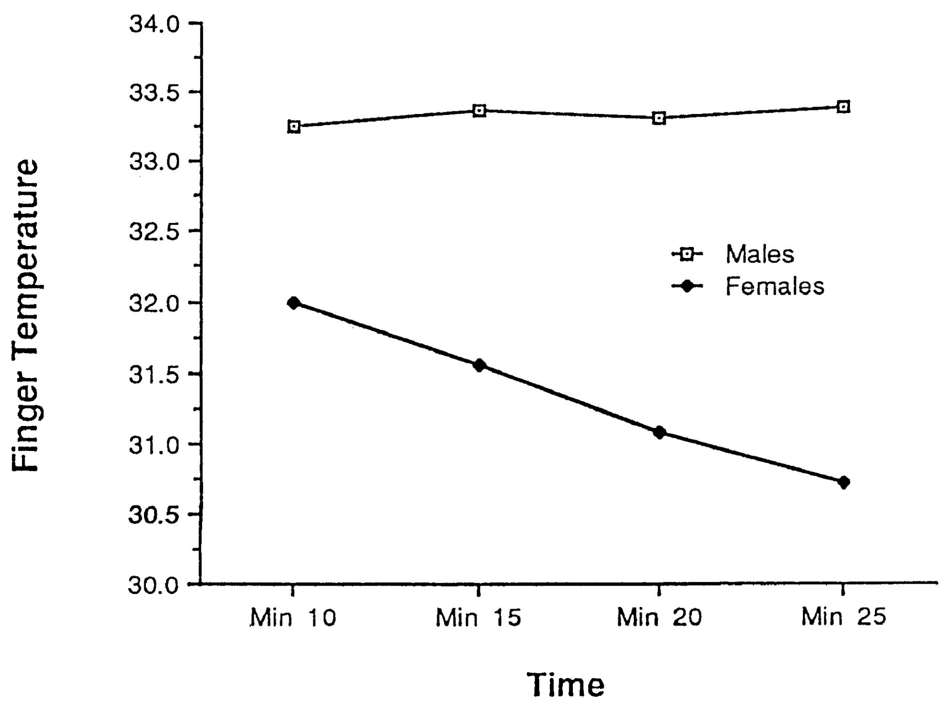
Finger temperature on the control day (day two) was examined during four periods, minutes: ten, fifteen, twenty, and twenty-five to evaluate the effect of finger temperature drift. These periods were chosen as they correspond to baseline, minute three of stress, minute five and minute ten of recovery on the experimental days. A two-way (Gender X Time) ANOVA was calculated to determine whether finger temperature drifted towards room temperature (decreased over time) on the control day. The main effect of gender was significant, $(1,39) = 11.72$, $p < .001$. Thus, males and females had different temperature responses on the control day. The effect of time was also significant $(3,117) = 5.66$, $p < .001$, revealing that finger temperature changed from baseline to the final minute of recording. The gender by time interaction was significant $(3,117) = 7.99$, $p <.001$ demonstrating that females showed a finger temperature drift towards room temperature while males did not (see Figure 4).

FINGER TEMPERATURE RECOVERY FROM STRESS

Finger temperature was analyzed for each of minutes one to five and minute ten of recovery from stress, using separate two-way (Gender X Day) repeated measures analyses of covariance

FIGURE 4

Finger temperatures during minutes 10, 15, 20, and 25 on day two for males and females



with baseline finger temperatures entered as covariates. This was done to determine whether, a) males and females differed in the time it takes to return to baseline temperatures and, b) if temperature recovery was comparable from day one to day three while controlling for any initial differences in finger temperatures. For minutes one through four of recovery, males and females did not differ in their finger temperature recovery from stress. The main effect of day was significant for minutes one, three and four and approached significance during minute two of recovery showing that finger temperature recovery was more rapid on day three. None of the interactions for minutes one through four of recovery were significant.

Males showed signficantly greater finger temperature recovery than females at both minutes five $F(1,39) = 4.43$, $p < .05$ and ten $F(1,39) = 4.49$, $p < .05$ of recovery. This gender difference is apparent in figures two and three. Males, on average, returned to baseline finger temperatures while females did not. Females had significantly cooler finger temperatures during the final minute of recovery when compared to baseline temperatures, on both days one, $t(20) = 4.47$, $p < .001$ and three $t(20)$ 2.67, $p < .015$. On the other hand, the finger temperatures of males during the final minute of recovery were not significantly different from their temperatures during baseline, on either days one $t(20) = 1.34$, or three, $t(20) = .21$.

In sum, females did not show less finger temperature recovery than males until minute five of recovery. Females continued to exhibit lowered finger temperature up to the tenth minute of recovery. an additional finding was that subjects demonstrated significantly faster recovery on the third day even though the amount of stress was comparable for both days one and three.

FINGER TEMPERATURE RECOVERY COMPARED TO THE DRIFT EFFECT

Finger temperatures on the stress days (one and three) were averaged for each of four periods: baseline, minute three of stress, and minutes five and ten of recovery. These averaged values were then compared to the corresponding minutes on the control day (two) to determine whether finger temperature recovery from stress is a different phenomenon than finger temperature drift towards room temperature. Three separate two-way (Gender X Day) repeated measures analyses of covariance with resting finger temperatures as covariates were analyzed.

The results reveal that the decrease in finger temperature during stress on minute three was a result of the cognitive stressor as the finger temperatures were significantly cooler than the corresponding minute on the control day $F(1, 39) = 50.51$, $p < .001$. The main effect of gender and the interaction of gender by day were not significant indicating that the males and females had similar finger temperature responses to stress (days one and three) and to rest at minute fifteen (day two) on experimental and control days.

The main effects of gender were significant for both minutes five $F(1,39) = 9.75$, $p < .01$ and ten $F(1,39) = 12.67$, $p < .001$ of recovery and the corresponding minutes on day two, indicating that the females were cooler than the males on both the stress and control days. The main effect of day was not significant for either minutes five or ten of recovery and the corresponding minutes on the control day, revealing that there is no difference between drift towards room temperature and finger temperature recovery from stress. Furthermore none of the interactions were significant demonstrating that males and females finger temperature during minutes five and ten of recovery were not different from those exhibited during the control day. Thus, the gender difference in finger temperature recovery which was reported in the previous section appears to be the same phenomenon as the gender difference observed in the drift effect.

CORRELATES OF THE DRIFT EFFECT

For males on the control day the difference between minute fifteen and rest was not significantly correlated with body mass index ($r = .1295$) or weight ($r = -.0123$). For females, the difference between resting finger temperature and minute fifteen was significantly correlated with body mass index, ($r = -.5000$, $p < .05$) and weight ($r = -.5633$, $p < .01$). The results of a t-test revealed that the body mass indexes of the males (mean = 26.25, Sd = 5.17) were not signficantly different than that of females (mean = 23.97, Sd = 3.93), $t(40) = 1.61$. Thus, females who weighed less and had lower body mass indexes showed a greater tendancy to exhibit the drift effect, i.e., they finished with lower finger temperatures at the end of the session than they had at baseline.

RELIABILITY OF FINGER TEMPERATURE RESPONSE AND RECOVERY

Using difference scores from baseline to minute three of stress, and minutes one through five and minute ten of recovery, correlations were calculated between finger temperature response to and recovery from stress for day one and three to determine the reliability of finger temperature over time. These analyses were done separately for males and females. For both males and females the difference from baseline to minute three of stress was reliable from day one to day three (see Table 1). For males, the only correlations of significance were the correlations for first minute of recovery ($r = .5298$, $p < .05$) and the final finger temperature for days one and three ($r = .4917$, $p < .05$).

TABLE 1

Correlations For Finger Temperature Changes From Baseline Between Days One and Three During Minutes Three of Stress, One to Five and Minute Ten of Recovery For Males and Females

	S3	R1	R2	R3	R4	R5	R10
Males	.5501**	.5298*	.2110	.1575	.1376	.2258	.4917*
Females	.4522*	.4138	.2104	.0762	.0484	.1187	.0171

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

DISCUSSION

The purpose of this study was to examine the potential utility of finger temperature recovery as an index of physiological recovery from stress. The results revealed that males and females differed in their finger temperature recovery from a cognitive stressor. Males recovered to near baseline finger temperature at ten minutes of recovery while females did not recover to baseline levels. The lack of finger temperature recovery in females was not part of the physiological response to stress, but rather due to the drift effect, whereby finger temperature drifts towards room temperature over time. The drift effect was greatest in females with lower body weights and lower body mass indexes.

Finger temperature response to stress was reliable from session one to session three. On both days, finger temperature decreased significantly as a result of the cognitive stressor. Furthermore, there were no differences between males and females in their finger temperature response to stress. These results conflict with the findings of Arena et al. (1983) who reported that finger responses to cognitive stress was unreliable. Their subjects participated in four sessions using the same cognitive stressor (mental arithmetic) each time. It is possible that familiarity with the task decreased the stressfulness of the mental arithmetic.

Another possible explanation for the conflicting results of the reliability of finger temperature response to stress is that temperature response to a stressor may become less reliable as adaptation time increases. The subjects in the experiment conducted by Arena et al. (1983) were not administered the cognitive stressor until thirty-two minutes into the experiment. Thus, it is possible that the stress response was contaminated by the "drift effect" during which finger temperature was approaching room temperature even before the cognitive stressor was administered. This hypothesis warrants future research to determine the effect of adaptation time on the reliability of finger temperature response to stress.

The finger temperature recovery of males on average, was complete by five minutes following the termination of the stressor. The finger temperature of the females, however did not return to baseline levels even at ten minutes following the termination of the stressor. Yet there was no evidence that females exhibit slower recovery from stress than males, although this conclusion might have been erroneously made had the control day not been included in the experimental design. A comparison of the experimental days with the control day revealed that females were colder during the final ten minutes of temperature recording on all days. Thus, females were not demonstrating a slower finger temperature recovery than males on the experimental days but rather, their finger temperatures were drifting towards room temperature and this drift occured on both experimental and control days.

It is not known why the finger temperature of females drifts towards room temperature over time, although it appears that in females body mass index is related to the amount of drift. While body mass index was not correleted with the finger temperature difference between rest and the end of stress for males, it was correlated for females, even though the body mass indexes for males and females were similar.

Cooke, Creager, Osmundson, and Shepard (1990) studied gender differences in cutaneous hand blood flow and found that women have a lower basal hand blood flow than men. Furthermore, after inducing a 'thermal sympatholyses' by total body warming, the hand blood flow of women was greater than the hand blood flow of men. They concluded that the basal hand blood flow gender difference is a result of "enhanced sympathetic activity" in women as opposed to either functional or structural differences in the hand (Cooke et al., 1990, p. 1611).

However, Freedman et al. (1987) offer an alternative explanation for the occurance of gender differences in hand blood flow. They found that the finger pulse volumes of women were less reactive than those of men when they were given alpha and beta adrenergic antagonists. Such gender differences were not apparent when vasoconstriction was elicited by a reflex of the sympathetic nervous pathway or when a drug was given to cause vasoconstriction by inducing the release of norepinephrine from the sympathetic nerve endings. They concluded that females may simply have less sensitive or fewer alpha and beta adrenergic receptors.

The results of the present investigation demonstrate that studying finger temperature response to stress in both males and females is useful since finger temperature decreases are of a significant magnitude, which is consistent for males and females, as well as across days. Furthermore, finger temperature response to cognitive stress is reliable.

However, since the finger temperature recovery of females is seriously confounded by the drift effect, any future studies of finger temperature recovery must consider this gender difference. Moreover, the use of finger temperature recovery from stress to identify individuals who recover slowly, and are hypothesized to be showing a maladaptive physiological pattern (Dupuis, 1987) does not appear to be a promising approach, because of the unreliability of the recovery measures.

In the present study, gender differences were not apparent at baseline (after ten minutes of rest), but for all three days gender differences were apparent later in the session. This finding may help to resolve inconsistencies in the literature about whether or not there are gender differences in finger temperature response. Present data suggests that such differences should be most apparent with larger baseline periods. This is consistent with the findings of McFarland et al. (1990) who found gender differences to be more prominant as the length of the baseline period increases.

In conclusion the finger temperature of females exhibits a drift effect which can seriously confound studies of finger temperature recovery from stress. This effect is especially strong in females who are lighter, with lower body mass indexes. This effect, combined with the finding that finger temperature recovery from stress was generally unreliable, argues against the use of finger temperature to study the physiological recovery from stress.

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