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Sex Differences in Autonomic Responses (Heart Rate, Respiration and Blood Pressure) to Electric Shock

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SEX DIFFERENCES IN AUTONOMIC RESPONSES (HEART RATE, RESPIRATION AND BLOOD PRESSURE) TO ELECTRIC SHOCK

by

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LIFE

Cathryn Walters Liberson was born in Manly, Iowa, on October 25, 1919. She graduated from Roosevelt High School in Cedar Rapids, Iowa in June, 1936. She received her B.A. from Oklahoma City University in 1959 with a major in psychology. She moved to Chicago, Illinois, in the fall of 1963 and received the degree of M.S. from the University of Oklahoma in June, 1968. Her major was psychology. In the fall of 1968 she began her studies at Loyola University of Chicago in clinical psychology. She completed her clerkship at Loyola University Hospital in the Mental Hygiene outpatient clinic in January, 1971, and completed her internship at the Veterans' Administration Hospital in Miami, Florida, in March, 1972. During her internship, she was rotated to the Childrens' Psychiatric Center of Jackson Memorial Hospital in Miami for three months.

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Chapter I

Introduction

There are indications in the literature that coronary disease occurs more frequently in males than in females, at least in Western civilization and in certain age groups (Pell & D'Alonzo, 1961; Schlesinger & Zoll, 1941). With the advent of antibiotics there has been a dramatic decrease in mortality due to acute infections and to such insidious killers as tuberculosis and syphilis. As a result, the statistics of public health organizations reflect a shift of the leading causes of death, with cardio-vascular disease and cancer leading the list. With this shift in emphasis, increasing research has focused on these two diseases. Among cardio-vascular disease, coronary thrombosis has a place of prominence in these investigations not only because it is, at times, responsible for sudden death at an age when men reach the peak of their activities, but also because emotional factors are thought to contribute to its genesis.

While psychologists have focused more on the question of how emotional factors may contribute to the disease, medical science has focused attention on physiological causes such as blood cholesterol, obesity, smoking, hormonal factors, etc. Whatever the focus of these studies, one observation which deserves special attention is concerned with the fact that before the menopausal age in woman, females have considerably lower incidence of cardiac disease. This raises the question of whether emotional factors affect cardiac function differently in men and women. More specifically, the way in which individuals of either sex respond to physical or psychological stress may be an important factor that contributes to the development of heart disease (rather than some other illness).

A survey of the literature, reviewed in the next section, disclosed no studies devoted to the specific investigation of sexual differences in autonomic responses of heart rate (HR), respiration (R) and blood pressure (BP) to painful stimulus. The purpose of this investigation was to see if any consistent differences exist between the sexes in these responses to stress of electrical stimulation. It was hoped that if such differences exist, they might shed new light on the genesis or incidence or cardio-vascular disease.

Review of Literature

The studies reviewed here will be reported under separate headings for each autonomic response, although the separate findings may be part of the same study.

Heart Rate

Darrow (1929) in summarizing the literature on differential effects of "sensory" and "ideational" stimuli, came to the conclusion that simple sensory stimuli calling for "no extensive association of ideas" results in a lowering of heart rate, while either noxious stimuli or activity requiring "associative processes" produces an increase in heart rate. Lacey, Kagen, Lacey and Moss (1963) investigated autonomic responses and came to the conclusion that when a task or stimulus requires internal manipulation of symbols and retrieval of stored information, heart rate is accelerated, but when the demand is only to receive environmental input, without strong cognitive demands, heart rate decreases. In fact, the rate may even go below base level. In addition, the greater the involvement in mental concentration, in contrast to environmental intake, the greater the increase in heart rate. Johnson and Compos (1967) confirmed these observations. They examined the effects of different cognitive tasks on heart rate in twenty male undergraduates and found that when Ss were exposed to conditions requiring attention to internal processes, heart rate increased, and when requested to view innocuous external stimulus, heart rate decreased. Further evidence confirming the hypotheses of Lacey and Darrow is furnished by Craig (1968), who found that imagining a painful stimulus was capable of producing as much acceleration of HR as the actual stimulation.

Some investigators have used only the threat of shock as noxious stimuli to measure changes in HR. One such study is by

Taylor and Epstein (1967). Using normal male subjects (Ss), these authors designed a study to examine the relationship between HR and skin conductance. Results showed that HR decreased to below resting levels after finding threshold shock levels, but increased when subjects were given instructions about either receiving shocks from or giving shocks to a mythical opponent in a reaction time contest, i.e., they were told they were competing with someone in the next room who was not there.

Another investigation of this type was by Hodges (1968) who exposed 108 male undergraduates to threat of shock. They were told the research was designed to measure the relationship between verbal tasks and physiological measures. The authors compared HR changes under three conditions: (1) threat of failure; (2) threat of shock; and (3) no-threat. Under conditions of threat of failure Ss were asked to give digits backward; then during testing, were told they were not doing well. For the "shock threat" condition, they were told they would receive shock during a digit testing session; however, no shock was actually administered. During the no-threat trial, they were told they would not be shocked, and in addition, were told that they were doing well. Before the test started, they were given a rest period of eight minutes, of which the last fifteen seconds of recording were used for measuring pre-test resting state. Results showed that under the no-threat condition, HR on the average increased from resting state only four beats per minute, while under threat of failure, average rate increased by eleven beats per minute and under threat of shock the increase was twenty beats per minute. They also divided Ss into high and low anxious groups on the basis of the Taylor Anxiety Scale and found greater increases in high anxious subjects than in low anxious Ss under both threat conditions, but in the no-threat condition, the low anxious Ss had a greater increase.

Jenks and Deane (1961), also using normal male Ss, found that when Ss were told to expect shock at a given time during either visual or auditory presented stimulus, HR increased early in the series and decreased at the point when the shock was expected.

Alfert (1966) studied 48 normal males under condition of shock and the showing of a motion picture described as distasteful and shocking and found increased HR in both instances, with the greater increase found under shock conditions. Frazier (1966) also reported increased HR in normal males under shock conditions. Tursky and Sternbach (1967), also using electric shock stress, studied HR responses in sixty normal females. They compared the pre-test resting period with a pre-established shock level, i.e., when Ss wanted the shock stopped. Both rest period and shock period were repeated a second time. The findings were not significant; on the first test, average HR increase was from 72.2 to 73.3 and on the second trial, increase was from 71.2 to 71.9 beats per minute.

Oken, Heath, Shipman, Goldstein, Grinker, and Fisch (1966), using both male and female psychiatric patients in an outpatient clinic, exposed Ss to mild shock and pretended that it was an accident in order to increase the Ss' anxiety. Later they were told it was not accidental and reassured about the purpose of the research. As expected, an increase in HR was recorded for all Ss but no sex differences were reported.

In a symposium on atherosclerosis in November, 1969, a large group of investigators from the Peoples Gas Company headed by Stamler (1969), reported on their 10 year findings of HR in 1,329 males in the age group 40-59. They found that increased resting heart rate contributed to, or was correlated with, heart disease and/or sudden death. They concluded that HR is an important risk factor for coronary mortality and sudden death.

A search of the literature failed to turn up any studies comparing normal male and female HR in response to electric shock. In fact, only one study was found comparing HR of male and female Ss in response to stress. This was a study by Davis and Buchwald (1957) who showed stimulus pictures to Ss and found a greater response in HR in males than in females.

In summary, a review of the literature reveals that males show significant increases in HR under conditions of shock or threat of shock and increases in HR in response to other stressful stimuli while females show lesser increases in response to visual stimulus and no significant increase in responses to electric shock.

Respiration

Studies of respiration under stress conditions other than electric shock have been most often carried out within the same studies that also measured heart rate. On the other hand, most of the studies using shock as a stressor have combined the measurements of HR with skin conductance. The findings therefore are extremely limited for respiration rate in response to electrical stimulation. Frazier (1966) reported that he found no significant changes in respiration in response to shock in normal males, although changes in HR did occur.

Paul (1969) studied respiration rate in 60 normal females under relaxation training, and reported that respiration was significantly decreased, while HR showed lesser effects of the training. He suggested that this finding was related to the fact that respiration is under voluntary control.

Wilson and Wilson (1970) examined respiration rate along with a number of other physiological parameters in male hospitalized medical patients undergoing muscle relaxation training. Ss were divided into hi and low anxious groups on the basis of the IPAT anxiety inventory. The authors found no difference in respiration rate due to anxiety levels. Investigators such as Lacey (1956) and Lazarus (1967) have reported increases in respiration rates in response to a number of anxiety provoking situations. However, Lacey points out that respiration rate does not show the differences between "environmental rejection" and "environmental detection" that have been observed in heart rate and blood pressure. He has also shown that changes in respiration are not related to changes in heart rate. The paucity of research regarding respiration changes in response to stress does not allow any definite conclusions to be drawn about whether sex differences exist in this area of measurement.

Blood Pressure

Only one study was found reporting blood pressure changes in response to electric shock for both sexes. Oken, _et al_. (1966) exposed 16 male and 17 female psychiatric outpatients to mild shock and one minute of noise. They found that under stress, all indices went up except diastolic pressure, which went up in 10, remained the same in 4, and went down in 19 patients. Of these 19, two also had a drop in systolic, three had heart rate decreases, one dropped in both systolic pressure and heart rate and three showed no increase in any of the three variables. The authors commented that there was nothing characteristic about these nine (9) subjects with lowered diastolic pressure except they were all women. Since they also found some preponderance of women whose scores dropped on at least one of the three variables, they decided to compare the males and females for both stress situations, but reported that they found no significant differences except for systolic pressure in which the men were consistently higher. However, in their report, no tables or data were presented showing male-female differences.

Oken, Grinker, Heath, Herz, Korchin, Sabshin and Schwartz (1962) exposed 18 normal male subjects to two types of psychological stress (deception and stressful movie) and one type of physical stress (95' temperature with 50% humidity). They found that under all conditions, systolic pressure went up but diastolic pressure went down.

Raab (1966) recorded systolic and diastolic blood pressure in addition to heart rate in their study of 100 males, ages 17 to 50 exposed to cognitive tasks as well as visual and auditory stimuli. They found that both systolic and diastolic pressure increased more in response to cognitive stress than to sensory stress. The average increase for systolic pressure was 3.1.

Schnore (1959) recorded only systolic pressure in 43 males between the ages of 16 and 23 during tracking with stylus and arithmetic tasks. He compared levels during the motor task and the arithmetic task and found that in the motor task, systolic pressure increased an average of 16.6, while in the arithmetic task it increased only 7.3.

Bridges, Jones and Leak (1968) compared the systolic readings of male medical students just before a final examination, to readings taken two months later. He found the mean average before the examination to be 144.27 while the mean average taken two months later was only 122.29.

Goldstein (1964) showed increased diastolic pressure in anxious women patients but a decrease in normals in response to noise. Both groups showed increases in systolic pressure, but the increases were greater in the anxious patients. In a second study (1965) she examined 33 males and 27 female psychiatric patients aged 18 to 42. These patients were exposed to noise and showed an increase in systolic pressure but not in diastolic. There were equal numbers of males and females in the different diagnostic groups, but no data on sex differences were available.

Walters (1960) in some unpublished data found differences in differential pulse pressure between males and females exposed to underwater sensory deprivation, with males showing greater changes than females.

The findings in blood pressure responses to stress are scattered and inconsistent. Most of the research on blood pressure changes has been conducted on patients with heart disease and inasmuch as their state of health precludes exposing them to unnecessary stress, studies have not been focused on this area of investigation. Lacey (1967) reported, however, that blood pressure changes, as well as heart rate changes, show clear cut differences between what he terms "environmental detection" and "environmental rejection". He describes "environmental detection" as when the subject is oriented to take in environmental input and "environmental rejection" as the orientation to reject the environment.

In summary, systolic increase in men under stress has been reported, but no comparable findings are available on women. Because of the disparity among conditions under which these studies were conducted, it was difficult to make any comparisons about the results.

Conclusions

The findings in autonomic responses reported here are indeed meagre, but they do suggest that consistent sex differences may exist in autonomic responses to stress of painful stimuli. Personality has been considered an important variable in considering how individuals handle stress (Opton & Lazarus, 1967), but little is known about sex-linked differences. Lazarus (1966) has written quite extensively on the coping process of organisms when confronted with stressful situations and suggests that the type of coping process an individual uses may influence his physiological pattern of reaction. He states that in order to understand and predict the physiological pattern of stress reaction, one must know the nature of coping, and that conversely, the coping process can be inferred from the pattern of reaction. Bowers (1968) has suggested that anxiety about a pain stressor is related to how the stressor is perceived; and Blitz and Dinnerstein (1968) have shown how different instructions to Ss can affect pain parameters. If sex is found to be a major or significant contributing factor to physiological patterns of stress reactions, new insights may be developed about the nature of the coping process.

A hypothesis was made from the above review that males would show greater changes in systolic blood pressure and heart rate than would females in response to stress of electric shock. Since the findings in respiration rate are scattered and inconsistent, no hypothesis was made concerning this response.

Chapter II

Statement of the Problem

During the past several decades, as more and more men in proportion to women, at least in western cultures and in certain age groups, succumbed to coronary disease, investigators became concerned with looking for causes. Medical investigators quite understandably were concerned with looking for biological reasons. The finding that females possess two X chromosomes whereas males have only one, generated much research in that direction. Another idea advanced was concerned with the protective role of the female hormone, estrogen, and endocrinologists followed this path of inquiry. In addition, much attention was focused on other physical causes such as smoking, obesity, cholesterol levels, exercise, etc.

On the other hand, psychologists were interested in investigating the role of psychological factors in the etiology of heart disease. However, many of these investigators were primarily concerned with looking for relationships between personality differences and stress, heart disease and personality, autonomic activity and mental disease or personality, and a variety of combinations of these factors.

Anthropologists, such as Margaret Mead (1939), have often pointed out that psychological factors in the environment play an important role in the different behavioral demands made on males and females in different cultures. It is well known that behavioral demands are related to emotional factors and that emotional factors effect physiological reactions. Therefore, if one has a society where a man is forced to live up to an image of strength which precludes giving way to his emotions, one may well wonder what implications this may have for his physiological reactions. In Western cultures, from the time boys are born, they are told they must behave like a man. If a little boy cries, he is told he is a baby; if he reacts to pain, he is told he is a sissy. On the other hand, girls are allowed much more freedom of expression without the resultant negative feedback. In fact, giving in to emotions is considered to be a natural or even desirable characteristic on the part of females. While there have been advocates of free expression of emotion by men and boys, the majority of males continue to behave in a way consistent with the historic role of the male in our society. Since it is commonly accepted that suppressing emotions can lead to psychosomatic illnesses of many kinds including heart disease, it is extraordinary that so little interest has been shown in examining how males and females differ in their physiological reactions to stressful situations. In a review of the literature regarding personality and stress in relation to coronary disease, Mordkoff and Parsons (1967) criticized the investigators in the field for giving inadequate attention to the sex variable as well as to socio-economic factors.

Another psychological factor considered by some investigators to play a critical role in contributing to heart disease is the personality factor, but the evidence is inconclusive. Friedman, Rosenman and Brown (1963) and Rosenman, Hahn, Werthessen, Jenkins, Messinger, Kositchek, Wurm, Friedman and Straus (1966) showed that driving and ambitious persons with urgent needs to always meet deadlines, had a higher incidence of myocardial infarction, higher cholesterol, reduced clotting time and sympathetic overactivity than persons without these personality characteristics. However, a criticism of Friedman, et al. was made by Mai (1968) on the grounds that these authors' method of identifying individuals belonging to a certain behavior pattern are questionable since the assessment was made by lay people and no orthodox psychological tests were used.

In his review of the literature on personality and stress in coronary disease, Mai (1968) concluded that in general, personality studies which were methodologically sound tended to be inconclusive or to present conflicting results. A particular criticism was that most studies ignored the socio-economic factor. He added, however, that recent evidence has suggested that personality and stress do seem to be more relevant to the pathogenesis of angina pectoris than they are to myocardial infarction.

Whatever the reasons for the lack of information regarding sex differences in this area of investigation, it is apparent that almost no light has been shed on the question of whether consistent sex differences in autonomic responses to shock do exist.

Problems in Methodology

In trying to evaluate the research in this area of autonomic responses to stress, some of the problems are immediately apparent while others are more difficult to identify. For instance, there is much controversy about how stress should be defined. Arnold (1967) states that stress may be considered as any condition of disturbed normal functioning. She goes on to say that physiological stress is accompanied merely by feelings of discomfort or pain while psychological stress is seen as accompanied by what she terms "contending emotions," primarily fear and anger and their combinations. To date, there are no conclusive studies that have been able to specify precisely the total pattern of activation in response to pain as distinguished from other stimuli such as fear or anger. It is virtually impossible to isolate these factors when one attempts to measure reactions to pain. However, if the stimuli are perceived as painful by the S, they are also perceived as stressors threats if only on the basis of discomfort without any accompanying signs of emotion or conscious awareness (although these may be present however covert).

A similar problem appears when one tries to assess pain thresholds. Beecher (1962) has shown that there is considerable individual variability in pain thresholds. On the other hand, Tursky and Sternbach (1967) have shown that there is considerable constancy in Ss responses to electric shock of varying magnitudes, as expressed verbally. Since it is not possible to equate the amount of shock given with the amount of pain felt, it seems reasonable to accept the Ss subjective report as to the amount of pain he can tolerate as the most reliable way of ascertaining what is stressful to him. The data become more meaningful obviously if an objective measure of the amount of shock administered is available, and in this study it was. However, the subjective pain was considered as a stressful stimulus and the attempt was made to assess this particular kind of stress, recognizing that any results may not be generalizable to other kinds of stress.

Another problem concerns levels of autonomic functioning. It is known that anticipation of an anxiety-provoking situation raises the level of autonomic functioning, yet all of the studies reviewed above have used the base level just prior to the testing situation for the pre-test measurement. Lacey (1962) found that any stimulus produces activation of the autonomic nervous system in general, so there is a limited range of response left available to the subject for the testing conditions since he may already be functioning at a high level of excitation. Dykman, Reese, Galbrecht and Thomasson (1959) have also shown that the magnitude of the response level is in part, a function of the pre-stress level; that is, the higher the initial level, the smaller the response. Therefore, base levels of resting rates should be recorded, as well as the level taken just before the testing situation.

A third problem in methodology concerns the finding that different kinds of stimuli result in different kinds of autonomic response, e.g. one stimulus produces heart acceleration, while another decreases it. For this reason, a standardized method of inducing stress was devised.

A more subtle problem may lie in the individual specificity response. Grossman and Greenberg (1957) have shown that considerable individual differences in autonomic response exist from birth. Furthermore, if one subject reacts with changes in heart rate or blood pressure, while another reacts with changes in respiration, it is difficult to know whether these changes are due to physiological or psychological factors. For instance, if a person has a highly reactive autonomic system, he may show a high level of heart rate, not necessarily because of psychological stress, but because his system reacts with high activation. On the other hand, the change may be due to the disposition of the subject to interpret the stimulus in a certain way.

Lazarus and Alfert (1964) have shown that Ss who use denial defenses report less anxiety, but show greater autonomic disturbances than do Ss who use little denial. In our culture, males are expected to deny their reaction to pain and appear brave and stoic, while women are not criticized for expressing their distress when they feel pain or threat. If, indeed, men are forced to use denial to cope with threatening situations, it seems reasonable to assume that they would exhibit greater changes in physiological measurements under stress than do females.

Therefore, the hypothesis was that men would show greater changes in their autonomic responses to electric shock than would women. However, since there is so little information available on sex differences in autonomic responses to electric shock, the hypothesis must be viewed with caution.

The following methodological problems found in the above reported studies were resolved for this study: (1) base line measurements of autonomic responses taken on a day other than the experimental day; (2) a repeatable method of measuring electric shock was used; and (3) male and female subjects were equated for age, education and socio-economic level (see Appendix A).

Chapter III

Method

The method used for inducing electric shock in this study was one devised from the current studies (Liberson, 1963 Wiederholt, 1970) of recording median nerve evoked potentials at the wrist following stimulation of the index finger. The stimulus is reported to be painful and therefore comparable to the more commonly used application of electric shock, but can be considered more advantageous for the following reasons: (1) the physiological response to the stimulus is measurable whereas the usual electric shock is not, (2) the technique, although painful because of the repetitive stimulation, has been proven to be acceptable to patients in a clinical examination, (3) the method has been standardized and is currently used and described in a number of textbooks, for example Smarto and Basmajian (1972), and therefore can be duplicated exactly by other investigators.

Subjects

Subjects were 18 male and 18 female volunteers. Most were employees of the Veterans Administration Hospital, Hines, Illinois. They were examined by a physician for freedom from cardiac or any systemic disease, and were given the MMPI to rule out any gross psychological pathology. They were equated for age; Hollingshead's (1956) Two Factor Index of Social

Position was used to equate for education and occupation (see Appendix B).

Experimental Condition and Apparatus

Subjects were run in an electrically shielded, partially sound-proof Electroencephalogram room. A recording cardiac tachometer was used to obtain tracings related to pulse changes during different phases of the experiment. These tracings along with a strain gauge pneumograph were recorded on a Brush two-channel recorder. A Grass stimulator was used to deliver square wave electric shocks of 1/2 msec. duration at a frequency of one per second. Total duration of stimulus was one minute. Maximum voltage was 100 volts. Systolic and diastolic blood pressure were taken with an ordinary sphygmomanometer. Median nerve potentials were obtained by using a standard electromyograph and amplitude of recorded potentials was measured on a cathode ray screen.

Procedure

On the first day of the experiment, Ss reported to the laboratory between the hours of 7:30 a.m. and 10:00 a.m. They were put on a bed in a supine position in a brightly lit room. A male technician placed two electrodes on the right wrist over the median nerve and two stimulating electrodes were placed around the index finger of the right hand. A ground electrode was applied on the right forearm. Two electroencephalogram electrodes (Beckman) were placed on the head for the purpose of recording cerebral evoked potentials. One electrode was placed in the left central region on the scalp (7 centimeters from the vertex and the other on the ipsilateral ear). Data recorded from these placements will be reported elsewhere. A pneumograph was strapped around the chest and a sphygnomanometer cuff was placed on the upper right arm. Cotton pads were placed over the eyes.

S̲s were instructed to lay quietly for 15 minutes, but not to go to sleep. They were also informed that at the end of the 15 minute period there would be a 1 minute experiment and that they would again lay quietly for a second 15 minute period. At the end of the first 15 minutes, the investigator entered the room and recorded blood pressure. The subject was told that the experiment was to begin and the switch establishing the current to the electrode on the right index finger was turned on. After establishing the fact that they could feel the current, they were told that the sensation of a pulse beat would be gradually increased and that when it reached a point they felt was the limit of their tolerance, they were to inform the investigator and the intensity would be stopped at that point and recorded for one minute. The S̲ was also told that pictures were being taken of the recordings and they should accept as much intensity as they could tolerate, so as to get a good picture of the recording. Voltage ranged from 0 to 100 volts. Eighteen percent tolerated the maximum of 100 volts, while fifty-three percent tolerated 90 volts. The remaining twenty-nine percent tolerated 70 and 80 volts. All the subjects, including those who went to maximum, asked to have the current stopped and none knew they were at the maximum. The effects of the shock were measured by using evoked potentials recorded over the median nerve. At the end of one minute of recording, current was turned off and blood pressure was immediately recorded. The subject was then told to lie quietly for another 15 minutes and the examiner again left the room. At the end of the second 15 minute period, the examiner entered the room and again recorded blood pressure. The technician then entered the room and removed the apparatus and the S was told by the investigator to make an appointment to return to the laboratory sometime within the following week in order to have his heart rate, respiration, and blood pressure recorded without the experiment. It was explained that a record of their normal resting rates was necessary to see if they differed from the day of the experiment. This explanation was deliberate in order to reassure the subject that there was no hidden motives on the part of the examiner for the second day of recording. The subject was then dismissed from the laboratory.

Chapter IV

Results

Results were analyzed using the Clyde* multiple analysis of variance (Anova) computer program at the University of Miami. The analysis performed was a 2 x 4 trend analysis of repeated measurements. Data are presented for each measurement in the following order: heart rate, respiration, systolic and diastolic blood pressure.

Heart Rate

Table 1 presents the means and standard deviations for heart rate for all subjects and a breakdown of the data by sex. Measurements are for the one minute immediately before stimulation (BS), one minute during stimulation (DS), one minute immediately after stimulation (AS) and the last minute of a 15 minute rest period following the shock, termination (T).

There was no significant difference in levels of HR for combined sexes ($df = 3, 32$; $F = 2.16$; $p < .11$). However, a repeated measurements Anova (Table 2) showed that the combined heart rate for all subjects changed at various stages of the experiment yielding a significant quadratic component ($df = 1, 34$; $F = 6.22$, $p < .02$). There was an average increase of 1.8 beats per minute during the stimulation which gradually decreased following the shock.

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* Clyde, D. Manova, 1969, Clyde Computer Service, Coconut Grove, Florida.

Table 1

Combined Heart Rate for All Subjects
Before, During, After, and Termination
of Shock
(N = 36)

	BS	DS	AS	T
M.	70.08	71.94	71.05	69.86
S.D.	9.88	10.07	9.94	10.26

Males
(N = 18)

	BS	DS	AS	T
M.	69.22	72.00	70.22	68.84
S.D.	10.48	11.06	10.64	10.18

Females
(N = 18)

	BS	DS	AS	T
M.	70.94	71.89	71.88	70.89
S.D.	9.45	9.29	9.41	10.53

Table 2

Heart Rate

Anova for Combined Sexes

Source of Variation	df	Mean Squares	F	P
Linear	1,34	4.35	.56	.46
Quadratic	1,34	84.03	6.22	.02
Cubic	1,34	10.76	.97	.33

The repeated measurements Anova found no significant differences between males and females over trials. However, when one looks at the pattern of change, the males show a more rapid return to the original value than do the females. Average increase during shock was 2.8 beats per minute for men and 1.0 beats per minute for women. Average range for men during all stages of the experiment was 40 beats per minute and for women, 31 beats per minute.

Respiration

Table 3 presents the means and standard deviation for respiration rates for all subjects and a breakdown of the data by sex.

Averaging over both males and females, there was a significant change over trials for respiration rate (df = 3,32; F = 3.02; $p < .04$). Table 4 shows that there was a significant cubic component for respiration rate over treatments (df = 1,34; F = 7.18, $p < .01$).

The repeated measurement Anova indicated that the two sexes reliably differed on respiration rate over treatments (df = 3,32; F = 3.02, $p < .04$). The direction of change is consistently down in males, while in females the change is polyphasic. Furthermore, as seen in Table 4, the trend analysis revealed that the sexes differed significantly along the cubic component (df = 1,34; F = 3.95, $p < .05$). Figure 1 illustrates

Table 3

Combined Respiration Rate for All Subjects Before, During, After, and Termination (N = 36)

	BS	DS	AS	T
M.	14.94	15.67	14.39	14.56
S.D.	3.18	3.71	3.04	3.07

Males (N = 18)

	BS	DS	AS	T
M.	15.33	14.94	14.28	14.22
S.D.	4.02	3.89	3.59	3.81

Females (N = 18)

	BS	DS	AS	T
M.	14.56	16.39	14.50	14.89
S.D.	2.09	3.48	2.46	2.14

Table 4

Respiration

Anova for Combined Sexes

Source of Variation	df	Mean Squares	F	P
Linear	1,34	10.75	3.22	.08
Quadratic	1,34	2.78	0.52	.47
Cubic	1,34	21.36	7.18	.01

Anova for Male/Female

Source of Variation	df	Mean Squares	F	P
Linear	1,34	4.36	1.30	.26
Quadratic	1,34	7.11	1.34	.25
Cubic	1,34	11.76	3.95	.05

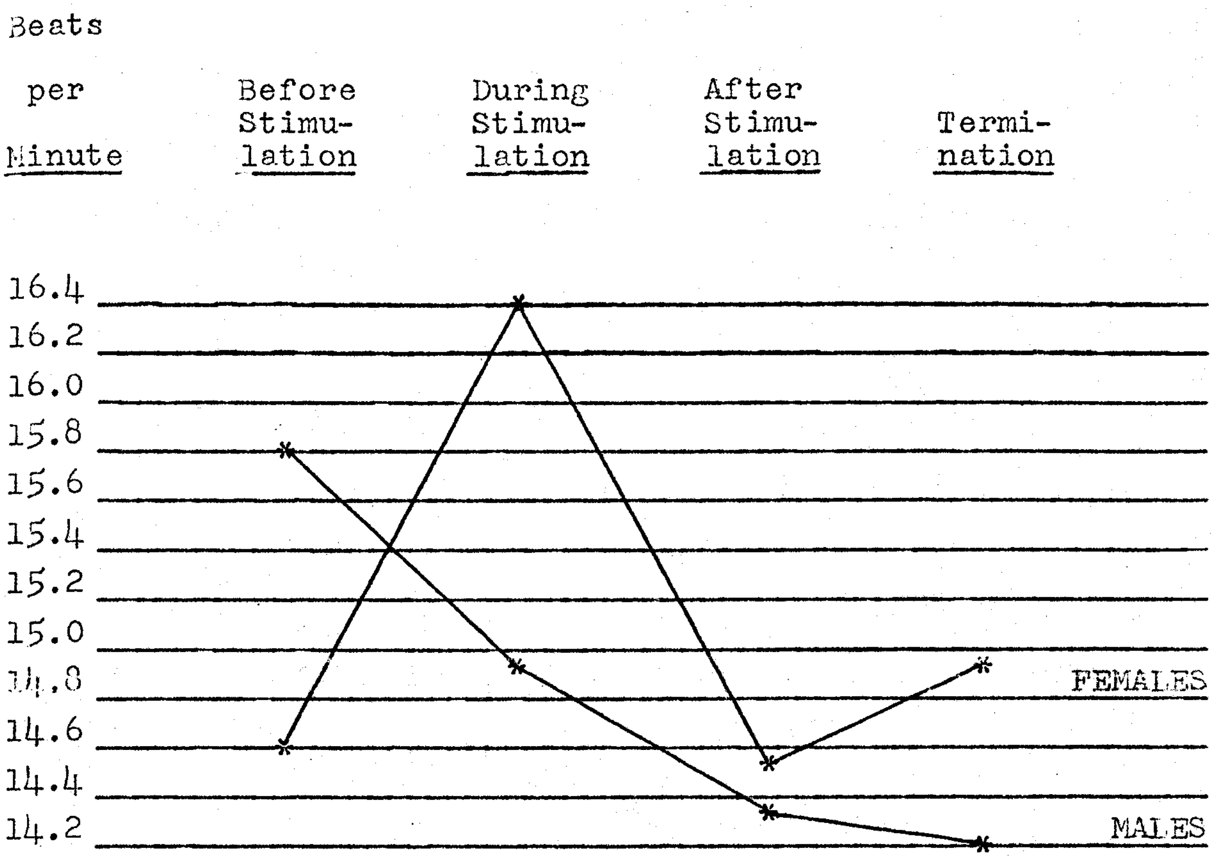

Figure 1
(N = 36)

This figure shows change in respiration rate as a function of the stimulus and at the end of 15 minute rest period (Termination).

that the females show an S-shaped function, while the males show a downward trend.

Systolic Blood Pressure

Table 5 presents the means and standard deviation for systolic blood pressure for all subjects and a breakdown of the data by sex. Measurements are those taken immediately preceding the shock, immediately after shock and at the termination (T) of the second 15 minute rest period.

Averaging over sex, there was a significant change in systolic pressure over the repeated measures (df = 2,33; F = 3.99, $p < .03$). In addition, a significant quadratic trend was found for systolic pressure over trials (df = 1,34; F = 8.22, $p < .01$), **(Table 6).**

The repeated measurements Anova revealed that males significantly differed from females on systolic pressure over trials (df = 2,33; F = 4.34, $p < .03$). It was also found that the two groups differed significantly along the quadratic component (df = 1,34; F = 5.45, $p < .03$). When this difference is graphed, the male responses show an inverted U shape, while the female responses are in the downward direction (see Figure 2). In addition, an Anova was done by averaging the three trials and comparing the systolic scores. It was found that males differed significantly from females for overall systolic pressure levels (df = 1,34; F = 5.24, $p < .03$). Of all the

Table 5

Combined Systolic Pressure for All Subjects BS, AS, and T (N = 36)

	BS	AS	T
M.	117.33	118.83	117.33
S.D.	9.69	10.48	10.24

Males (N = 18)

	BS	AS	T
M.	120.00	123.22	121.00
S.D.	7.26	9.31	8.79

Females (N = 18)

	BS	AS	T
M.	114.67	114.44	113.67
S.D.	11.21	9.93	10.50

Table 6

Blood Pressure (Systolic)

Anova for Combined Sexes

Source of Variation	df	Mean Squares	F	P
Linear	1,34	0.00	0.00	1.00
Quadratic	1,34	54.00	8.21	.01

Anova for Males/Females

Source of Variation	df	Mean Squares	F	P
Linear	1,34	18.00	3.03	.09
Quadratic	1,34	35.85	5.45	.03

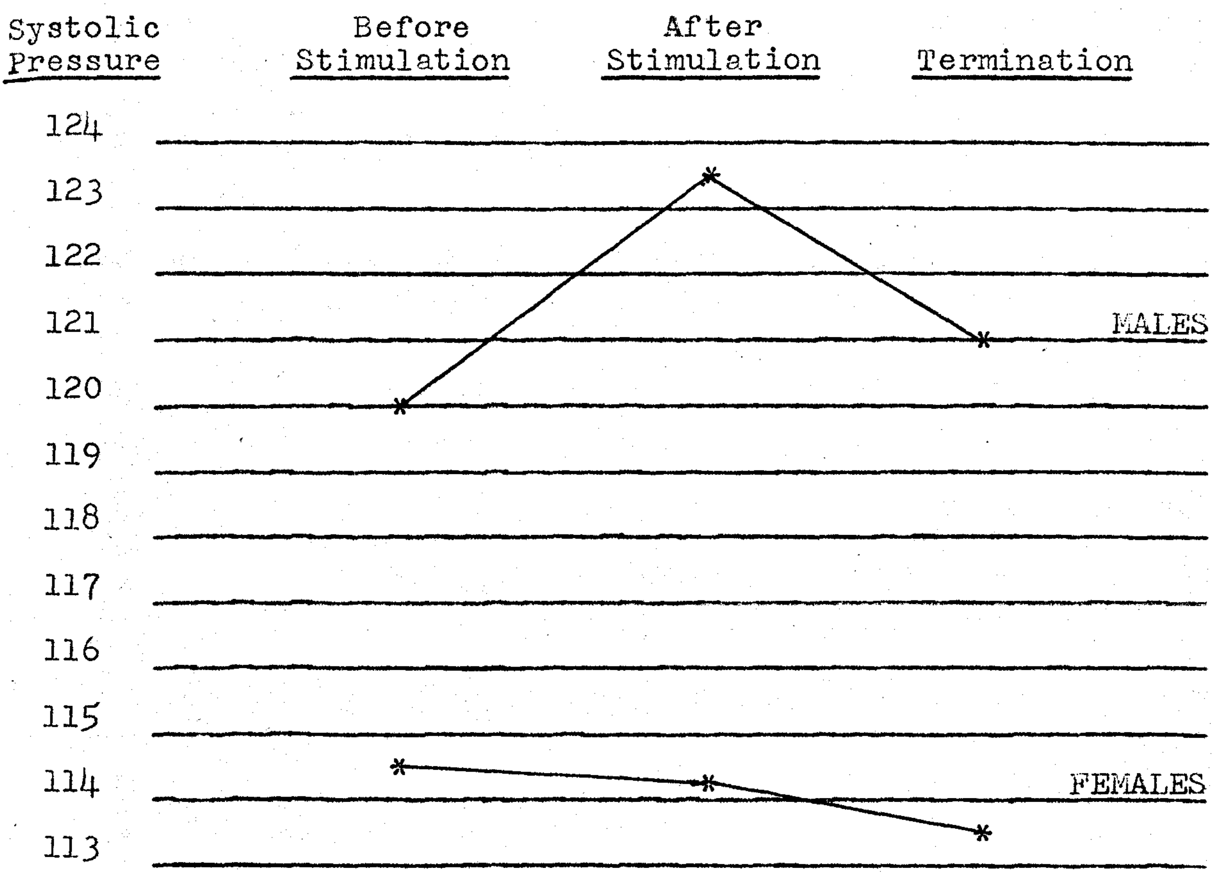

Figure 2

(N = 36)

This figure shows systolic blood pressure change following stimulation and at the end of 15 minute rest period (Termination).

measures recorded in this study, the systolic pressure changes due to shock appear to be the most sensitive to differences between the two sexes. The greatest difference in pre-shock resting rate between the sexes is also noted in this measurement.

Diastolic Blood Pressure

Table 7 presents the data for all subjects on diastolic pressure and the breakdown of the data by sex. Measurements are the same as those for systolic pressure.

Inspection of Table 8 shows that a significant quadratic trend was found in diastolic pressure for all subjects over the repeated measurements (*df* = 1,34; *F* = 4.20, $p < .05$).

The repeated measurements Anova revealed that there were no significant differences between the sexes, either as a result of the shock or over trials.

A further Anova was done comparing resting rates of autonomic responses of male and female subjects on the experimental day and a day of control. Measurements used for comparison were the last minute at the end of the first 15 minutes rest period just before the shock, and the last minute of the 15 minute rest period on the control day.

Table 9 presents the means and standard deviation for these comparisons. No differences were found on any measurements between the experimental and control days. Heart rate

Table 7

Diastolic Pressure for All Subjects
BS, AS, and T
(N = 36)

	BS	AS	T
M.	79.11	80.03	79.44
S.D.	9.23	8.04	8.36

Males
(N = 18)

	BS	AS	T
M.	80.22	81.17	80.89
S.D.	9.65	7.84	8.18

Females
(N = 18)

	BS	AS	T
M.	78.00	78.89	78.00
S.D.	8.92	8.30	8.51

Table 8

Blood Pressure (Diastolic)

Anova for Combined Sexes

Source of Variation	df	Mean Squares	F	P
Linear	1,34	2.00	0.22	.64
Quadratic	1,34	13.50	4.20	.05

Table 9

Comparison of Experimental (EXP) and Control (CON) Days

Males

(N = 17)

	Resp		HR		BPs		B Pd	
	EXP	CON	EXP	CON	EXP	CON	EXP	CON
M.	15.77	15.82	69.77	68.47	120.24	120.12	80.59	79.88
S.D.	3.68	2.68	10.54	8.61	7.41	11.15	9.82	9.58

Females

(N = 18)

	Resp		HR		BPs		B Pd	
	EXP	CON	EXP	CON	EXP	CON	EXP	CON
M.	14.56	15.11	70.94	68.83	114.67	114.67	78.00	77.94
S.D.	2.09	2.47	9.46	10.03	11.21	12.00	8.92	9.37

and systolic and diastolic pressure were essentially the same on both days for both men and women. The only difference of any kind noted was that the women had a slightly higher respiration rate on the control day than they had on the experimental day.

In addition to the trend analysis, Pearson Product correlation co-efficients (r) were determined to test the relationship between voltage and evoked potentials for both men and women (see Appendices C&D). In neither sex was any significant correlation found; for men $r = .34$ and for women $r = .19$. A t test for difference between means of maximum voltage tolerated (see Appendix E) also failed to achieve significance. ($t = 1.3$; $df = 17$, $p < .13$).

Since respiration in women and systolic pressure in men were the only significant differences in absolute levels as a result of the shock, additional co-efficients of correlations (r) were determined for age, voltage, or evoked potentials and how they are related to these changes (see Appendix F1, F2, F3, F4, F5, & F6). No significant correlations were found between any of these three variables and the observed changes. Table 10 presents the values for these correlations.

Table 10

Pearson Product r Values for Systolic and Respiratory Changes and Other Variables

Males

Voltage & Systolic Change	.04	N.S.
Age & Systolic Change	.18	N.S.
Evoked Potential & Systolic Change	.03	N.S.

Females

Voltage & Respiration	.19	N.S.
Age & Respiration	.21	N.S.
Evoked Potential & Respiration	.26	N.S.

Chapter V

Discussion

It has been suggested that emotional stress may be a contributing factor to heart disease (Russek, 1959), and it has also been suggested that certain personality characteristics are associated with a high incidence of cardiac disease (Dunbar, 1948). Although there is some consensus of opinion concerning the role of emotional stress in heart disease, there is little experimental evidence to support the concept of a "coronary personality" (Mordkoff & Parsons, 1967). The results of this study seem to suggest that sex differences in specific organ functions in response to stress of pain may be a contributing factor to the higher incidence of coronary disease in men. Before discussing the implications of the findings, it may be appropriate to consider an important methodological problem, i.e., how does one go about equating the subjective amount of stress felt by each individual.

A stimulus which is painful for one person may not be considered as painful to another since pain is a highly individualized phenomenon. However, even if the intensity of the pain could be equated with the intensity of the stimulus, individual pain thresholds and tolerance for pain may vary greatly from one individual to another. In this study, each individual determined the intensity of the stimulus he or she received, and although all Ss' tolerance fell within a narrow range, one may question whether the responses reflect an emotional reaction to equal stress. For example, if the stress is perceived differently, one may wonder if the greater increases in systolic pressure found in men might be due to higher intensity of current or greater pain tolerance.

Since there was no significant difference in the amount of voltage tolerated by men and women respectively, and there was no correlation between voltage and systolic changes in men, it seems clear that the observed blood pressure change was not due to amount of maximum voltage tolerated. Regarding the pain tolerance, the lack of correlation between voltage and evoked potentials demonstrates that for the different levels of recorded sensory discharges in all <u>S</u>s, there is the same scatter of voltages at the point of tolerance. Conversely, for the <u>S</u> tolerating only 70V, the message to the brain registers the same amount of pain as for the <u>S</u> who tolerated 100V. Thus the shock was perceived as equally stressful by all <u>S</u>s. The observation that women more often showed greater increases in respiration rate in response to the same stimulus further supports the argument that the shock was perceived as equally stressful by both sexes.

A further observation related to the methodology used in this study concerns the fact that all of the autonomic responses recorded showed statistically significant changes as a result of the shock, indicating that the stimulus was effective.

In trying to assess the findings of this study, some readily apparent observations were that the resting heart rate was slightly higher in women, while resting systolic pressure was considerably higher in men. Resting respiratory rates seemed to be about equal. These observations were consistent with the reports of other investigators cited at the beginning of this paper.

Another consistent finding was that other investigators have reported significant increases in male heart rate in response to electric shock or threat of electric shock, although no comparable findings for females have been reported. While HR did not increase significantly in this study, the response pattern of the male circulatory system which emerges as significantly different from that of the female subjects was a new finding. Male subjects, as a group, showed a definite phasic increase of their heart rate during the painful stimulus while the pattern of the female subjects was less definite and lacked the phasic component. Even more impressive evidence of the sexual difference in patterning was found in the significant increases in systolic pressure which was phasic in men but consistently downward in women.

In contrast to the men, who showed the phasic component in the circulatory system, women showed a phasic component in their respiratory system. There was a phasic increase in their respiration rate during the painful stimulus, while the men showed a slight decrease which continued during the post stimulation period. These two significant findings of increased systolic pressure in men and increased respiration in women were not related to such variables as voltage, evoked potential or age, thus, indicating that these are significant sex differences.

A further interesting sexual difference was found in the variability of the male and female subjects. In men, there was lower variability in systolic pressure during various phases of the experiment while their pattern was more definite. Range of heart rate was also greater in men. On the other hand, women had lower variability in their respiration rate during the experiment, but also a more definite pattern. Thus, men are more variable in respiration and heart rate and less variable in systolic pressure which showed the most definite pattern while the converse was observed in women. This finding emphasizes the sexual difference in specificity of organ responses.

While it is true that respiration is different in the sexes, i.e., more thoracic in women and more diaphragmatic in men, this observation does not suggest any reason for the differences found in this study. Concerning heart rate, one might speculate that because men usually do more hard physical work than women do, their circulatory system may be more responsive to stress. However, athletes are known to have slower heart rates than the average individual with minimal activity, so this observation does not help account for the differences found.

Why men should respond to painful stimulation by more definite circulatory, yet less definite respiratory changes is not clear at the present time, but a higher incidence of heart disorders in men may be related to the fact that the male circulatory system is more responsive to stress than the females. Perhaps women, having more responsiveness to stress in the respiratory system, release emotional tension in this fashion and avoid strain on the circulatory system. If women have the ability to maintain circulatory system equilibrium under stress, it might be the result of sex adaption to pain congenitally transmitted for reasons of childbirth; this of course is conjecture. Whatever the reasons for the differences found, we are led to question the implications of these findings and thus come to our original notion, that western culture may be a contributing factor to higher incidence of coronary disease in men.

Although the findings in this study do not show any direct relationship between culture and heart disease, it is possible to reason how, indirectly, one may effect the other. Suppression of emotions is but one of a number of stressful conditions which can lead to physiological changes in the human organism. Although it is not known how much emotion was suppressed in this experiment, it is known that the Ss tolerated as much pain as they could since they all asked for the current to be stopped. Furthermore, the objective measurement of the shock revealed that the pain was perceived as equally stressful for all Ss. Under such conditions the men and women responded to the stress differently, i.e., men responded with circulatory changes (which affect the heart) and women responded with respiratory changes (which do not affect the heart). Therefore, if stress with its concommitant physiological manifestations effects men in our culture in a more harmful way than it does women, one may reason that submitting men to unnecessary stress (such as suppression of outward emotional behavior) could be a contributing factor to the high incidence of heart disease in men.

Suppressing of emotions has long been regarded as unhealthy by psychologists and psychiatrists while medicine has found a long list of somatic complaints attributed to this mechanism. Research in this area has revealed that any factor that contributes to emotional stress (including denial of emotion) can be injurious to the mental and physical health of both men and women. It seems only logical then, to go a step further and reason that if emotional physiological stress affects the male in a more harmful way than the female, a culture that places unnecessary emotional demands on the male could be a contributing factor to heart disease in men.

While this reasoning is clearly speculative at the present time, it is interesting to note that other investigators are beginning to question cultural factors in regard to pain. Blitz and Dinnerstein (1971) examined the influence of instructions on pain thresholds and reported that they accidently found sex differences; males showing greater elevation in pain thresholds than females in response to the instructions. They stated that the sex differences were unexpected and might imply that males tend to have a greater ability than females to modulate attentional mechanisms when confronted with noxious stimulation. They added that this reasoning is conosant with the cultural stereotype of greater pain tolerance in males. Another way of viewing this reasoning, is that males tend to have greater ability to suppress emotion.

An interesting concept related to this reasoning is one by Miller (1969) who showed that autonomic nervous system changes can be learned not only in classical conditioning but also in instrumental conditioning. He states that visceral learning may account for certain cultural differences. For example, he reasons that if social conditions are such that suppression of emotion is rewarded, the symptoms of the most susceptible organ will be the ones that are the most likely to be learned. It is possible, in the future, that improved instrumental training techniques could lead to positive changes in learned autonomic responses that are harmful to the individual.

The two major findings of this work were the sex differences in patterning of response whether or not one considers the direction of change, and the variability in relation to these patterns. Specifically, men responded to electric shock by significant changes in the circulatory system, while women responded with significant changes in the respiratory system. These findings indicate that examining autonomic responses only in terms of absolute values may obscure the differential responses which may exist. Since the mathematical difference of change has most often been used in investigations of autonomic responses, this factor may account for the often contradictory results reported in the literature.

We are left with the fundamental observation that men have a more definite circulatory response to pain than women do, the reverse being true of respiration rate, without being able to explain the psycho-physiological reason for this difference. Whether or not these findings may have any practical significance can only be determined by further research.

Chapter VI

Summary

In reviewing the literature on autonomic responses to stress of electric shock, one is struck by the fact that studies focused on sex differences are almost non-existent. In addition to the paucity of research in this area, related findings reveal a wide disparity among conditions under which studies have been conducted, which makes the results difficult to assess.

This study was designed to investigate differences in males and females in autonomic responses (heart rate, respiration and systolic and diastolic blood pressure) to stress of electric shock. The purpose of the study was to see whether sexual differences, if found, might shed some light on the higher incidence of coronary disease in men. A method of recording physiological changes in response to electric shock was used which permitted an objective measurement of the amount of shock received.

Eighteen male and eighteen female subjects were given a rest period of 15 minutes, submitted to one minute of shock, then given a second 15 minute rest period. Comparisons were made of autonomic responses just prior to the stimulus, during the shock, immediately following the shock and at the end of the second 15 minute resting period.

Results were analyzed by computerized multiple analysis of variance using trend analysis of repeated measures.

Significant differences for the combined groups were found on all autonomic measurements as a result of the stimulus. Significant sexual differences were found on measures of systolic pressure and respiration. Men were found to respond to the shock with significant changes in the circulatory system while women responded with significant respiratory changes.

Although present evidence is not sufficient to explain the psycho-physiological reasons for the differences found in this study, it was suggested that cultural demands may be a contributing factor to the high incidence of heart disease in men in our society.

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APPENDIX A

Matching Data for Each Subject

(N = 36)

Pair No.	Sex	Age	Education	Occupation	Class
1	M	55	2 = 8	1 = 7	II
1	F	53	2 = 8	1 = 7	II
2	M	49	2 = 8	1 = 7	II
2	F	50	3 = 12	1 = 7	II
3	M	47	2 = 8	1 = 7	II
3	F	46	2 = 8	1 = 7	II
4	M	55	4 = 16	1 = 7	II
4	F	55	3 = 12	4 = 28	III
5	M	51	6 = 24	3 = 21	IV
5	F	53	4 = 16	4 = 28	IV
6	M	40	3 = 12	1 = 7	II
6	F	41	3 = 12	1 = 7	II
7	M	48	4 = 16	1 = 7	II
7	F	48	1 = 4	1 = 7	I
8	M	32	3 = 12	1 = 7	II
8	F	31	3 = 12	1 = 7	II
9	M	43	2 = 8	1 = 7	II
9	F	44	1 = 4	1 = 7	I
10	M	46	5 = 20	8 = 56	V
10	F	47	6 = 24	8 = 56	V
11	M	29	3 = 21	1 = 7	II
11	F	28	4 = 16	1 = 7	II
12	M	25	4 = 16	1 = 7	II
12	F	26	4 = 16	1 = 7	II
13	M	23	1 = 4	1 = 7	I
13	F	24	1 = 4	1 = 7	I
14	M	31	1 = 4	1 = 7	I
14	F	32	1 = 4	1 = 7	I
15	M	35	1 = 4	1 = 7	I
15	F	34	1 = 4	1 = 7	I
16	M	32	1 = 4	1 = 7	I
16	F	33	2 = 8	1 = 7	II
17	M	40	1 = 4	1 = 7	I
17	F	40	1 = 4	1 = 7	I
18	M	40	3 = 12	4 = 28	III
18	F	43	3 = 12	4 = 28	III

APPENDIX B

Hollingshead Index of Social Position

Years of School Completed	Scale Value
Professional (MA, MS, MD, Ph.D, LLB)	1
Four-year college graduate (AB, BS, BM)	2
One-three year college (also business school)	3
High school graduate	4
Ten-eleven years of school (part high school)	5
Seven-nine years of school	6
Under seven years of school	7

Occupation	
Professional, technical, and kindred workers	1
Farmers and farm managers	2
Managers, officials, and proprietors except farm	3
Clerical and kindred workers	4
Sales workers	5
Craftsmen and kindred workers	6
Operatives and kindred workers	7
Private household workers and service workers	8
Farm laborers and foremen	9
Laborers except farm and mine	10

Occupation position has a factor weight of seven and educational position has a factor weight of four. These weights are multiplied by the scale value for education and occupation of each individual or head of a household to give a calculated weighted score. Example:

Factor	Scale Score	Factor Weight	Weight x Score
Occupation	3	7	21
Education	3	4	12
		Total Index of Social Position Score	33

Class	New Values
I	11-14
II	15-27
III	28-43
IV	44-60
V	61-77

APPENDIX C

Pearson Product Correlation Between Voltage and Evoked Potential in Men

Voltage	Evoked Potential	X	Y	X^2	Y^2	XY
9	21	0	+4	0	16	0
10	20	+1.0	+3	1.0	9	+3.0
10	13	+1.0	-4	1.0	16	-4.0
10	13	+1.0	-4	1.0	16	-4.0
9	17	0	0	0	0	0
9	11	0	-6	0	36	0
8	8	-1.0	-9	1.0	81	+9.0
9	15	0	-2	0	4	0
8	18	-1.0	+1	1.0	1	-1.0
9	14	0	-3	0	9	0
9	10	0	-7	0	49	0
9	19	0	+2	0	4	0
7	8	-2.0	-9	4.0	81	+18.0
10	24	+1.0	+7	1.0	49	+ 7.0
8	14	-1.0	-3	1.0	9	+3.0
10	9	+1.0	-8	1.0	64	-8.0
8	12	-1.0	-5	1.0	25	+5.0
10	16	+1.0	-1	1.0	1	-1.0
162	262			14.0	470	+27
M = 9	17					

$$r = \frac{\frac{27}{17}}{\sqrt{\left(\left\{\frac{14}{17}\right\}\left\{\frac{470}{17}\right\}\right)}} = \frac{1.6}{4.7} = .34 \text{ N.S.}$$

APPENDIX D

Pearson Product Correlation Between Voltage and Evoked Potential in Women

Voltage	Evoked Potential	X	Y	X^2	Y^2	XY
7	12	-1.6	- 2.6	2.56	6.76	+ 4.16
8	14	- .6	- .6	.36	.36	+ .36
9	7	+ .4	- 7.6	.24	56.76	- 3.04
7	25	-1.6	+10.4	2.56	108.16	-16.64
9	17	+ .4	+ 2.4	.16	5.76	+ .96
9	12	+ .4	- 2.6	.16	6.76	- 1.04
9	15	+ .4	+ .4	.16	.16	+ .16
9	12	+ .4	- 2.6	.16	6.76	- 1.04
9	12	+ .4	- 2.6	.16	6.76	- 1.04
9	7	+ .4	- 7.6	.16	56.76	- 3.04
9	16	+ .4	+ 1.4	.16	1.96	+ .56
9	22	+ .4	+ 7.4	.16	54.76	+ 2.96
9	9	+ .4	- 5.6	.16	31.36	- 2.24
7	10	-1.6	- 4.6	2.56	21.16	+ 7.36
10	20	+1.4	+ 5.4	1.96	29.16	+ 7.56
9	14	+ .4	- .6	.16	.36	- .24
7	23	-1.6	+ 8.4	2.56	70.56	-13.44
9	15	+ .4	+ .4	.16	.16	+ .16
154	262			14.56	464.46	-15.52
M=8.6	14.6					

$$r = \frac{\frac{-15.52}{17}}{\sqrt{\left(\frac{14.56}{17}\right)\left(\frac{464.48}{17}\right)}} = \frac{-.91}{4.82} = -.09 \text{ N.S.}$$

APPENDIX E

t Test for Differences in Means of Voltage

Males	Females	D	D^2
9	7	-2	4
10	8	-2	4
10	9	-1	1
10	7	-3	9
9	9	0	0
9	9	0	0
8	9	+1	1
9	9	0	0
8	9	+1	1
9	9	0	0
9	9	0	0
9	9	0	0
7	9	+2	4
10	7	-3	9
8	10	+2	4
10	9	-1	1
8	7	-1	1
10	9	-1	1
162	154	18 -8	40

M = 9.0 8.6 D -.44

$$t = \frac{-.44}{.33} = 1.3 \qquad p < .12 \text{ N.S.}$$

APPENDIX F

Pearson Product Correlation Between Voltage and Systolic Change in Men

Voltage	Systolic Change	X	Y	X^2	Y^2	XY
9	+ 2	.0	- .9	0	.81	0
10	+ 2	+1.0	- .9	1.0	.81	- .9
10	- 2	+1.0	-4.9	1.0	24.01	- 4.9
10	- 2	+1.0	-4.9	1.0	24.01	- 4.9
9	0	0	-2.9	0	8.41	0
9	+ 2	0	- .9	0	.81	0
8	+ 2	-1.0	- .9	1.0	.81	+ .9
9	+10	0	+7.1	0	50.41	0
8	- 2	-1.0	-4.9	1.0	24.01	+ 4.9
9	+ 8	0	+5.1	0	26.01	0
9	+ 2	0	- .9	0	.81	0
9	+ 6	0	+3.1	0	9.61	0
7	+10	-2.0	+7.1	4.0	50.41	-14.2
10	+ 8	+1.0	+5.1	1.0	26.01	+ 5.1
8	- 2	-1.0	-4.9	1.0	24.01	+ 4.9
10	0	+1.0	-2.9	1.0	8.41	- 2.9
8	+ 8	-1.0	+5.1	1.0	26.01	+ 5.1
10	0	+1.0	-2.9	1.0	8.41	- 2.9
162	52			14.0	313.78	- 9.8
M = 9.0	2.9					

$$r = \frac{\frac{-9.8}{17}}{\sqrt{\left(\frac{14}{17}\right)\left(\frac{313.78}{17}\right)}} = \frac{-.58}{15.13} = -.04 \text{ N.S.}$$

Pearson Product Correlation Between Age and Systolic Change in Men

Age	Systolic Change	X	Y	X^2	Y^2	XY
55	+ 2	+14	- .9	196	.81	- 13.1
55	+ 2	+14	- .9	196	.81	- 13.1
51	- 2	+10	-4.9	100	24.01	- 49.0
49	- 2	+ 8	-4.9	64	24.01	- 39.2
48	0	+ 7	-2.9	49	8.41	- 20.3
47	+ 2	+ 6	- .9	36	.81	- 5.3
46	+ 2	+ 5	+7.1	4	50.41	+ 14.2
40	- 2	- 1	-4.9	1	24.01	+ 4.9
40	+ 8	- 1	+5.1	1	26.01	- 5.1
40	+ 2	- 1	- .9	1	.81	+ .9
35	+ 6	- 6	+3.1	36	9.61	- 18.6
32	+10	- 9	+7.1	81	50.41	- 63.9
32	+ 8	- 9	+5.1	81	26.01	- 45.9
31	- 2	-10	-4.9	100	24.01	+ 49.0
29	0	-12	-2.9	144	8.41	+ 34.8
25	+ 8	-16	+5.1	256	26.01	- 8.2
23	0	-18	-2.9	324	8.41	+ 52.2
721	52			1695	313.78	-130.2
M = 41	2.9					

$$r = \frac{\frac{-130.2}{17}}{\sqrt{\left(\frac{1695}{17}\right)\left(\frac{313.78}{17}\right)}} = \frac{-7.70}{4.28} = \mp .18 \text{ NS}$$

Pearson Product Correlation Between Evoked Potential and Systolic Change in Men

E.P.	Systolic Change	X	Y	X^2	Y^2	XY
21	+ 2	+4	- .9	16	.81	- 3.6
20	+ 2	+3	- .9	9	.81	- 2.7
13	- 2	-4	-4.9	16	24.01	+19.6
13	- 2	-4	-4.9	16	24.01	+19.6
17	0	0	-2.9	0	8.41	0
11	+ 2	-6	- .9	36	.81	+ 5.4
8	+ 2	-9	- .9	81	.81	+ 8.1
15	+10	-2	+7.1	4	50.41	-14.2
18	- 2	+1	-4.9	1	24.01	- 4.9
14	+ 8	-3	+5.1	9	26.01	-15.3
10	+ 2	-7	- .9	49	.81	+ 6.3
19	+ 6	+2	+3.1	4	9.61	+ 6.2
8	+10	-9	+7.1	81	50.41	-63.9
24	+ 8	+7	+5.1	49	26.01	+35.7
14	- 2	-3	-4.9	9	24.01	+14.7
9	0	-8	-2.9	64	8.41	+23.2
12	+ 8	-5	+5.1	25	26.01	-25.5
16	0	-1	-2.9	1	8.41	+ 2.9
262	52			470	313.78	+11.6
M = 17	2.9					

$$r = \frac{\frac{11.6}{17}}{\sqrt{\left(\frac{470}{17}\right)\left(\frac{313.78}{17}\right)}} = \frac{.68}{22.51} = .03 \text{ N.S.}$$

Pearson Product Correlation Between Voltage and Respiration During Shock in Women

Voltage	Change in Respiration	X	Y	X^2	Y^2	XY
7	+ 1	-1.6	- .28	2.56	.078	+ .448
8	+ 4	- .6	+2.72	.36	7.398	-1.632
9	+ 3	+ .4	+1.72	.24	2.958	+ .688
7	0	-1.6	-1.28	2.56	1.636	+2.04
9	+ 2	+ .4	+ .72	.16	.518	+ .288
9	0	+ .4	-1.28	.16	1.636	- .512
9	+ 1	+ .4	- .28	.16	.078	- .112
9	0	+ .4	-1.28	.16	1.636	- .512
9	+ 4	+ .4	+2.72	.16	7.398	+1.088
9	+ 1	+ .4	- .28	.16	.078	- .112
9	- 1	+ .4	-2.28	.16	5.198	- .912
9	+ 2	+ .4	+ .72	.16	.518	+ .288
9	- 1	+ .4	-2.28	.16	5.198	- .912
7	+ 3	-1.6	+1.72	2.56	2.958	-2.752
10	+ 1	+1.4	- .28	1.96	.078	- .392
9	0	+ .4	-1.28	.16	1.636	- .512
7	+ 2	-1.6	+ .72	2.56	.518	-1.152
9	+ 1	+ .4	- .28	.16	.078	- .112
154	23			14.56	39.594	-5.920

$$r = \frac{\frac{-5.92}{17}}{\sqrt{\left(\frac{14.56}{17}\right)\left(\frac{39.59}{17}\right)}} = \frac{-.35}{1.41} = -.25$$

Pearson Product Correlation Between Age and Respiration During Shock in Women

Age	Change in Respiration	X	Y	X^2	Y^2	XY
55	+ 1	+15	- .28	225	.078	- 4.20
53	+ 4	+13	+2.72	169	7.398	+35.36
53	+ 3	+13	+1.72	169	2.958	+22.36
50	0	+10	-1.28	100	1.636	-10.28
48	+ 2	+ 8	+ .72	64	.518	+ 5.76
47	0	+ 7	-1.28	49	1.636	- 8.96
46	+ 1	+ 6	- .28	36	.078	- 1.68
44	0	+ 4	-1.28	16	1.636	- 5.12
43	+ 4	+ 3	+2.72	9	7.398	+ 8.16
41	+ 1	+ 1	- .28	1	.078	- .28
40	- 1	0	-2.28	0	5.198	0
34	+ 2	- 6	+ .72	36	.518	- 4.32
33	- 1	- 7	-2.28	49	5.198	+15.96
32	+ 3	- 8	+1.72	64	2.958	-13.76
31	+ 1	- 9	- .28	81	.078	+ 2.52
28	0	-12	-1.28	144	1.636	+15.36
26	+ 2	-14	+ .72	196	.518	-10.08
24	+ 1	-16	- .28	256	.078	+ 4.48
728	+23			1664	39.594	+51.28
M=40	M=1.28					

$$r = \frac{\frac{51.28}{17}}{\sqrt{\left(\frac{1664}{17}\right)\left(\frac{39.59}{17}\right)}} = \frac{3.02}{14.56} = .21$$

Pearson Product Correlation Between Evoked Potential and Respiration During Shock in Women

E.P.	Change in Respiration	X	Y	X^2	Y^2	XY
12	+ 1	- 2.6	- .28	6.76	.078	+ .728
14	+ 4	- .6	+2.72	.36	7.398	- 1.632
7	+ 3	- 7.6	+1.72	56.76	2.958	-13.072
25	0	+10.4	-1.28	108.16	1.636	-13.312
17	+ 2	+ 2.4	+ .72	5.76	.518	+ 1.720
12	0	- 2.6	-1.28	6.76	1.636	+ 3.328
15	+ 1	+ .4	- .28	.16	.078	- .112
12	0	- 2.6	-1.28	6.76	1.636	+ 3.328
12	+ 4	- 2.6	+2.72	6.76	7.398	- 7.082
7	+ 1	- 7.6	- .28	56.76	.078	+ 2.128
16	- 1	+ 1.4	-2.28	1.96	5.198	- 3.192
22	+ 2	+ 7.4	+ .72	54.76	.518	+ 5.328
9	- 1	- 5.6	-2.28	31.36	5.198	+12.768
10	+ 3	- 4.6	+1.72	21.16	2.958	- 7.912
20	+ 1	+ 5.4	- .28	29.16	.078	- 1.512
14	0	- .6	-1.28	.36	1.636	+ .768
23	+ 2	+ 8.4	+ .72	70.56	.518	+ 6.048
15	+ 1	+ .4	- .28	.16	.078	- .112
262	+23			464.48	39.594	+36.14
M =14.6	1.23					

$$r = \frac{\frac{36.14}{17}}{\sqrt{\left(\frac{464.48}{17}\right)\left(\frac{39.594}{17}\right)}} = \frac{2.12}{7.97} = .26 \text{ N.S.}$$

APPROVAL SHEET

The dissertation submitted by Cathryn Walters Liberson has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Oct 27 1972
Date

Ronald E Walker
Signature of Adviser