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INTERACTIVE EFFECTS OF TYPE A PERSONALITY AND PSYCHOLOGICAL AND PHYSICAL STRESSORS ON HUMAN CARDIOVASCULAR FUNCTIONING

by

GLENN L. ALBRIGHT

A dissertation submitted to the Graduate Faculty in Psychology
in partial fulfillment of the requirements for the degree of
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1986

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Abstract

INTERACTIVE EFFECTS OF TYPE A PERSONALITY AND PSYCHOLOGICAL AND PHYSICAL STRESSORS ON HUMAN CARDIOVASCULAR FUNCTIONING

by

Glenn L. Albright

Adviser: Professor Solomon S. Steiner

Traditional cardiovascular measures of heart rate and blood pressure have not reliably correlated with Type A personality measures. The first study, defines Type A behavior as scores on the Jenkins Activity Survey and correlates these with previously unavailable measures of cardiovascular function. Using non-invasive impedance cardiography, measures of stroke volume, Heather's index of myocardial contractility, cardiac output and total systemic resistance were obtained (in addition to the traditional measures of heart rate and blood pressure). These physiological measures were taken during a baseline condition, period of self-relaxation, a psychological stressor and a cold pressor stressor. A step-wise multiple linear regression analysis was used to correlate Type A score from the composite of psychophysiological variables.

Gender and stroke volume changes during the psychological stress accounted for 45% ($p<.017$) of the variance in Type A score. 78% ($p<.01$) of the job involvement sub-scale variance was accounted for by changes in total systemic resistance, stroke volume and heart rate during the psychological stressor and systolic blood pressure during the cold pressor stressor. Thus, Type A behavior reliably correlates with cardiovascular changes produced by a psychological stress.

The second and third studies in this series extended the concept that a specific stressor would produce specific patterns of psychophysiological responses. A third stress condition, aerobic exercise, was studied in addition to the psychological and cold pressor stressors. The effects of these stressors on cardiodynamic variables was ascertained for each stressor alone and in combination.

All three stressors showed reliable patterns of cardiodynamic changes characteristic of each stressor tested. Furthermore, the combined effects of these stressors was interactive and not merely additive.

These studies demonstrate that: 1. Different stressors show specific patterns of psychophysiological response associated with them, 2. the combined effects of stressors is different than the sum of their individual effects, and 3. the concept of Type A personality is meaningful in correlating the cardiodynamic changes to specific stressors (psychological stress). This finding would not be evident with mere measures of heart rate and blood pressure, which simply show elevation to a variety of stressors.

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CHAPTER I

INTRODUCTION: PREVIOUS LITERATURE AND RESEARCH QUESTIONS

HISTORY

The notion that behavior and emotions affect the cardiovascular system has a long history. Early biblical writers associated pain in the heart with sorrow or great fear (Leibowitz, 1970). This belief was expressed more scientifically 350 years ago when a young English physician by the name of William Harvey stated that every affection of the mind that is attended with either pain or pleasure, hope or fear, is the cause of agitation whose influence extends to the heart (Eastwood & Trevelyan, 1971).

One-hundred-and-fifty years later the British surgeon John Hunter elucidated Harvey's observation after noticing the connection between his own angina pectoris and his emotions and behavior. He stated that his life was in the hands of any rascal who chooses to annoy him, and later, following a heated debate at a board meeting at St. Georges Hospital, he died (Leibowitz, 1970).

In 1897 Sir William Osler observed that the condition of atherosclerosis and its attendant episodes of angina pectoris did not appear to be randomly spread throughout the community, but rather tended to attack a specific type of person. He believed that the high pressure at which men live and the habit of working the human machine to its maximum capacity are responsible for arterial degeneration rather than excesses in eating and drinking (Osler, 1897).

Osler's descriptions of the coronary prone patient as an individual striving for success in a responsible but high pressured way were elaborated upon by the famous American psychiatrists Karl and William Menninger (1936). It was their contention that coronary prone patients have strong aggressive tendencies that are usually strictly repressed.

CORONARY HEART DISEASE

Coronary heart disease (CHD), or ischemic heart disease, is the major cause of death in this country, and is a disorder that is thought to result from damage to the coronary arteries. This damage to or thickening of the arterial walls is called atherosclerosis. The major clinical manifestations of the disease include myocardial infarction (death of heart tissue), angina pectoris (a syndrome of chest pain and discomfort resulting from insufficient oxygen supply to the myocardium), and sudden death.

RISK FACTORS

To understand the pathogenesis of these disorders, it is necessary to consider the interplay of hereditary factors, metabolic alterations and individual life-styles.

An array of standard risk factors have been identified by epidemiological research (Brand, Rosenman, Sholtz, & Freidman, 1976; Kannel, McGee, & Gordon, 1976). The most widely accepted of these include age, hypertension, elevated low-density and low levels of high-density lipoproteins in the blood, cigarette smoking, family history of heart disease and the presence of diabetes mellitus. In the last decade there has been a considerable amount of evidence compiled implicating psychological and social factors in the pathogensis of CHD (Glass 1977; Jenkins 1976). The two categories of psychological variables that have received the most support as coronary risk factors include psychological stress and certain personality patterns.

STRESS

Psychological stress is often defined as an internal state that occurs when an individual confronts a threat to his/her physical or psychological well-being (Lazarus 1966).

The physiological pattern constituting this internal state in response to stressful situations (psychological and/or physical) has a tendency to be idiosyncratic (Sternbach 1966). This tendency, which involves the autonomic nervous system, is called individual response stereotypy or specificity.

AUTONOMIC NERVOUS SYSTEM

In the traditional model of the autonomic nervous system (ANS), the sympathetic and parasympathetic subdivisions produce antagonistic visceral and glandular responses as a means of maintaining the body in a steady state. The anatomical features of the autonomic nervous system were elucidated by Gaskell who found that one of the subdivisions provided a relatively diffuse and undifferentiated pattern of visceral innervation (1886, 1916). Langley examined the physiology of this involuntary nervous system and proposed that it be called the autonomic or self-governing nervous system. Langley applied the term sympathetic to the less differentiated division, and named the other division parasympathetic (1905, 1921). Loewi demonstrated the inhibitory effect of acetylcholine (ACh) on cardiac activity, which established it as the parasympathetic post ganglionic transmitter. In 1933 Dale termed the parasympathetic as cholinergic (i.e., releasing ACh) and he called the sympathetic nerves adrenergic (i.e., releasing adrenalin). In 1946 von Euler demonstrated that it is norepinephrine which is the transmitter primarily responsible for the activating effect of sympathetic stimulation of the cardiovascular system.

Eppinger and Hess (1910/1917) were the first to propose the concept of autonomic imbalance to explain the role of the ANS in physiological disorders such as hypertension, cardiac arythmias, and cardiac arrest. They reasoned that if normal functioning of the body were dependent upon a balance between the two autonomic divisions, then a shift in the direction of either influence could result in physiological disorders. On the basis of pharmacological studies, they concluded that some individuals demonstrate altered sympathetic or parasympathetic activity.

The notion of autonomic imbalance was further developed by Walter B. Cannon who proposed the concept of homeostasis to describe the role of the ANS in stabilizing the body's internal milieu within tolerable limits (1929, 1932).

RESPONSE SPECIFICITY

The concept of individual response (IR) specificity has had an interesting historical development. Andreassi (1980) reviews the literature starting with the work reported by Malmo and Shagass (1949) whose psychiatric patients with a history of cardiovascular problems and those with head and neck complaints responded differentially to pain stimuli. For example, those with cardiovascular symptoms showed elevated heart rates (HR) while those with headaches and neck pains had higher EMG's in response to pain.

Malmo and associates proposed the principle of symptom specificity to describe situations in which psychiatric patients responded to stressful stimuli according to the physiological mechanism underlying the symptom. This principle was applied to normals by Lacey and associates

(1953) and became formulated as autonomic response specificity or what is now called individual response specificity. The notion that individuals would respond maximally with a certain physiological response was confirmed in the 1953 study (Lacey et al.). They measured skin conductance level (SCL), heart rate (HR), and HR variability under four stressful conditions: cold pressor, mental arithmetic, letter association and hyperventilation. Evidence was found for maximal response in the same physiological variables under different stress conditions. Further, they concluded that some people responded to different stimuli with a fixed pattern, for example, the greatest response change might be HR, followed by SCL and then HR variability. An example of this response patterning to various stimulating conditions was provided by Lacey (1959). He obtained results that indicated similar response patterns to the CP test, mental arithmetic, and word fluency within a given subject. For example, diastolic blood pressure decreased for one subject, while it consistently increased for another under the conditions just mentioned. Moos and Engel (1962) reported that hypertensive subjects showed more blood pressure changes in reacting to stressors than did arthritic patients. However, those with arthritis showed more electromyographic (EMG) increases in muscles overlying the arthritic joints than did hypertensives. Hodapp et al. (1975) reported that 20 hypertensives responded to landscape slides with a greater rise in systolic blood pressure than did a group of 31 matched normal control subjects. Engel and Bickford (1961) stated that diseases which are neurally mediated would show a hyper-reactivity to stress in systems related to the disorder. This claim was substantiated in a study conducted with a group of hypertensives who demonstrably reacted to stressors with changes in blood pressure, while emitting more consistent responses than normotensive subjects in other physical systems. In light of this study, Garwood et al., (1982) obtained findings that individual response consistency increased as age increased.

More recently, Wilson et al. (1985) reported implementing impedance cardiography to measure stroke volume, heart rate, cardiac output, myocardial contractility and total systemic resistance during a taped oral quiz and a cold pressor test. Results showed that subjects who responded to the stressors with increases in blood pressure did so manifesting different hemodynamic responses. For example, those responding to stressful cognitive tasks showed blood pressure increases that were significantly correlated with increases in heart rate, cardiac output, cardiac contractility, and peripheral resistance accompanied by a decrease in peripheral skin temperature. The hemodynamic response patterns to the cold pressor stress also produced increases in blood pressure, heart rate and peripheral resistance, however, stroke volume, cardiac output, cardiac contractility and skin temperature decreased.

Thus Wilson's research demonstrated that the two stress conditions produced an equivalent activation of all the more traditional measures. However, the measures obtained by impedance cardiography showed entirely different patterns during the two conditions. Such differentiation allows, for the first time, a more in-depth assessment of those mechanisms that underlie the traditional measures thus greatly facilitating our understanding of response stereotypy.

IMPEDANCE CARDIOGRAPHY

The use of impedance cardiography as a research tool in psychophysiology is relatively new. This noninvasive, impedance-based measure of cardiac performance allows researchers to examine such variables as stroke volume, cardiac output, and cardiac contractility, which were only previously available via invasive technology. The instrumentation evolved in late 1960 when a noninvasive monitor of cardiac performance was developed for the National Aeronautics and Space Administration to study cardiac function during space flight (Kubicek, 1969). This technique employs a pair of surface electrodes that induce a radio-frequency (r-f) electromagnetic field across the chest cavity. A second pair of electrodes monitor changes in the impedance to the passage of this r-f current through the chest. The result is a pulsatile signal which is synchronous with the heartbeat. By calculating the first derivative or rate of change (dZ/dt) of the impedance signal, one can represent the change in velocity of the ejection of blood during systole.

Measurements can be made from well-defined landmarks on the dZ/dt waveform and electrocardiogram (ECG). These landmarks have been shown to correspond to such cardiac events as valvular closing and the point of maximal ejection of blood from the left ventricle. The resulting measurements can then be entered into empirically validated formulae to produce estimates of: stroke volume, cardiac output, and contractility (Kubicek, Patterson, & Witsoe, 1970; Miller & Horvath, 1978).

The measures derived from impedance cardiography have been compared to those obtained from invasive procedures such as: thermal dilution, dye dilution, and the Fick principle. These studies have shown very high correlations, often above .90, between the invasive and noninvasive estimates (Mohapatra, 1981). The correlations are generally highest in healthy populations. A major limitation of impedance cardiography to some clinical applications is its tendency to overestimate the stroke volume and cardiac output. A second limitation is its reduced accuracy in patients with significant cardiac pathology. The use of impedance cardiography in cardiology has been limited as a result of these problems. Its potential value in psychophysiology has been presented by Miller and Horvath (1978). They made clear the value of the technique for noninvasive measurement of intra-subject change as it is frequently the object of much psychophysiological research. For this reason the procedure seems to hold considerable promise for the investigation of cardiovascular behavior.

RESPONSE SPECIFICITY

As Andreassi (1980) has pointed out, individual response specificity is different from the concept of stimulus response specificity, which refers to a patterning of physiological responses according to the particular stimulus situation. He (Andreassi, 1980) goes on to say that it has been discussed in the writings of Ax (1953), Lacey et al. (1953, 1963), and Engel (1972), among others. The concept states that an individual's patterns of physiological activity (e.g., HR, EMG, SCL, respiration, and blood pressure) will be similar in a given situation and that the pattern may vary when the situation is different. One basic question here is whether the pattern of physiological response will indicate the kind of emotion being experienced. Or, to put it another way, will it indicate the pattern of response in happiness versus sadness, or in anger versus fear, or in disgust versus surprise? One of the first investigators to study this experimentally was Ax (1953), who induced fear in his 43 subjects by pretending to accidentally shock them. Anger was produced in the same persons through insults and criticism. Ax found greater increases in respiration rate and SCL in fear than in anger. However, greater increases in EMG and diastolic blood pressure, but greater decreases in HR were observed in anger as compared to fear.

Variations in the stimulus situation produced different patterns in physiological responses as reported by Lacey (1959). He gave examples of situations in which HR showed a decrease while SCL increased, and instances in which they changed in the same direction. The divergent response of these two measures was referred to by Lacey as directional fractionation of response. This term describes stimulus situations in which direction of change in physiological activity is contrary to the view that ANS responses must co-vary, that is, either up or down, in a given stimulus situation.

Obrist (1976, 1981) expresses his growing doubts that the cardiovascular system will provide us with very much information when used as an index of behavioral processes such as emotion, motivation, learning, or attention, which all appear to be more directly under the realm of the central nervous system. He points out a fundamental inadequacy in our research strategy; namely, the failure to view the cardiovascular system within a more global context for which it serves and, as a result, an indifference to evaluating neurogenic mechanisms of cardiovascular control. The cardiovascular system is primarily involved as a major life support system which is regulated by intricate neural and nonneural control mechanisms. Thus changes in cardiovascular functioning, which are unique to experimental manipulations, must be superimposed on this background of metabolically relevant activity (i.e. supplying tissues with oxygen, removing waste, maintaining electrolyte balance, etc.).

The Laceys (1959, 1970) were among the first investigators to point out the difficulties in using cardiovascular events as affect or arousal meters. They called attention to two types of observations. One has been labeled autonomic response specificity or interstressor specificity. It refers to the demonstration that different aspects of cardiovascular activity, as well as galvanic activity, show little consistency when used to rank subjects with respect to the arousal value of stimuli. A subject considered highly aroused by a stimulus according to one measure of autonomic activity may not be considered particularly aroused by another measure. The second observation has been referred to as directional fractionation. Reports have illustrated that some autonomic-like activity (SCL) evidence sympathetic-like changes to motivationally or emotionally significant events, while other measures, like heart rate, evidence parasympathetic-like changes, such as decreases in heart rate. Lacey also pointed out that fractionation can occur even with a single measure like heart rate. Tasks which focus attention on external events (i.e. listening to a dramatic passage recited by a professional actor) commonly resulted in heart rate deceleration, while tasks which focus attention on internal events (i.e. solving mental arithmetic problems) resulted in heart rate acceleration.

Obrist's (1970) work on cardiac-somatic interaction has led to several interesting hypotheses about the relationship between the cardiovascular system and behavioral processes. In his cardiac-somatic coupling hypothesis, cardiac response changes are seen as facilitating the preparation for, and performance of, a behavioral response. A coupling between heart rate and somatic activity was demonstrated by several researchers (Roberts and Young 1971; Black and DeToledo 1972, etc).

More recently Obrist (1982) points out several problems with an indexing approach that researchers should be aware of in supporting the cardiac-somatic coupling hypothesis. He points out that if we accept the assumption (Malmo, 1959) that heart rate increases reflect increased arousal, then those tasks and conditions resulting in a decrease in heart rate reflected a decrease in arousal, which doesn't appear to be the case in anticipatory heart rate changes during adversive conditioning in humans. The situation becomes more diffuse when considering species differences, for, in dogs (Dykman, Gantt, & Whitehorn, 1956) anticipatory response resulted in heart rate increases. This would suggest that humans and dog have different arousal or affective states as they ready themselves for a shock. This is conceivable, but Obrist points out that cats and rabbits show heart rate deceleration, while monkeys accelerate theirs. And interestingly, rats and several species of desert rodents evidence both anticipatory increases and decreases in heart rate. In reviewing the literature concerning tonic heart rate studies, Elliott (1974) concluded that there is no obvious mandate in evidence for using heart rate to measure complex variables in social psychology and personality.

Obrist and the Laceys appear to have valid objection to the use of traditional heart activity measures in behavioral situations. Thus, this makes it more imperative that other indices of cardiovascular activity, such as those measured by impedance cardiography, be assessed for use in psychophysiological studies.

PSYCHOPHYSIOLOGICAL PROFILES

Historically, psychophysiological profiles were developed to determine characteristic response patterns to psychological and physical stressors. Cannon (1937) suggested that the fight or flight response was an emergency pattern of physiological changes to perceived psychological or physical threats. Actual profiles reflecting cardiovascular changes date back to Palmer (1937), who performed studies dealing with stress and hypertension. In using the cold pressor test, he concluded that hypertension is the result of a chronic emergency response. Cranston et al., (1945) combined the cold pressor test with a stressful interview and demonstrated that there was an interactive potentiation in blood pressure between two adjacent stressors. In 1962, Harburg found that increased diastolic levels in response to the cold pressor test were associated with higher hostility in college males. Blood pressure reactivity to possible stressors other than the cold pressor, (e.g., dreams, music, interviews, testing situations and loud sounds, Lovell, 1941) has also been investigated. This study will investigate physiolgical reactivity in response to multicondition psychophysiologcal stress tests that employ both a psycholigical and two physical stressors.

CARDIOVASCULAR STRESSORS

A psychological stressor that is being increasingly used in evaluations is the IQ Quiz developed by Schiffer et al. (1976) for testing cardiovascular responses to stress. It is a tape recorded quiz that is designed to increase the subject's anxiety by increasing the difficulty of questions under a time pressure. In the initial study, it was found to be an effective pscyhological stressor in hypertensive and angina populations. Those subjects with existing cardiovascular disorders responded to the quiz more strongly compared to normals, as is evidenced by elevated heart rate, blood pressure and depression of S-T segments.

The S wave is caused by currents generated in the ventricles as they depolarize prior to contraction. The T wave is caused by currents generated upon ventricular recovery from a state of depolarization (Guyton, 1981). Ellestad (1980) defines the S-T depression as resulting from increased myocardial oxygen demands exceeding oxygen perfusion abilities of the coronary arteries. Thus, the mechanism responsible for cardiac contraction is altered causing a failure to pump calcium out of the cell and, as a result, decreases relaxation time remaining during diastole. The incompletely relaxed muscle is stiffer and less compliant. This reduction in compliance, along with increases in the rate of inflow into the ventricles during exercise, applies a greater pressure to the layers of tissue of the myocardium. This not only further inhibits coronary blood flow between myocardial layers but accelerates the reduction in total myocardial perfusion and produces a characteristic S-T segment depression.

The cold pressor test is one of the most common physical stressors used consistently throughout many psychophysiological studies. The test consists of the immersion of one hand into a bucket of ice water for a set period of time. This elicits physiological responses that are predictable even in a test/retest paradigm (Hilgard 1975). Validation of the cold pressor test's adequacy as a reliable cardiovascular stressor was demonstrated by Keyes (1971). In a 23 year longitudinal study, he determined that the blood pressure response to the cold pressor test had major predictive power regarding eventual myocardial infarction.

DYNAMIC EXERCISE

Using physical exercise as a standard stressor can be credited to Feil and Siegal (1928) who exercised patients with known angina to bring about pain and concurrent S-T and T wave changes in the ECG. A review of the mechanisms leading to changes in cardiac output and other circulatory adaptations associated with exercise will be helpful for making differential comparisons with non-physical stress. Various factors including venous tone, body position, blood volume and depth of respiration control the input to the heart. The heart responds by pumping into the arterial circulation any volume delivered from the venous side. The amount per beat in milliliters is called the stroke volume. Total cardiac output (measured in liters per minute) is stroke volume multiplied by heart rate.

When exercise begins, a rather complex set of events can be measured that sets the stage for events that follow. Probably the first is the increase in venous tone, which is mediated by autonomic reflexes. This squeezes the blood from the large veins into the right side of the heart, thus raising cardiac output. This increase in venous flow increases stroke volume which levels off somewhat short of the maximal pumping capacity (Sheffield 1965). As more blood enters the heart during each diastolic interval, the muscle is subjected to more stretch which, based on Starling's law, will increase the force of contraction. During this process not only is more energy expended, but increased fiber length results in a larger stroke volume, all other factors being stable.

Circulating catacholamines exert the most important influence for they stimulate the production of adenyl cyclase which, in turn, increases the release of adensosine triphosphate, the force of contractility and the heart rate. Another factor is the resistance in the vascular bed through which the heart must pump. The resistance in the lungs is so low that in a healthy individual it plays a very minor role as a limiting factor in exercise. The resistance in the systemic circuit, as measured by blood pressure is extremely important. In the normal subject, the heart decreases its resistance to blood flow as exercise progresses. This may not be intuitively obvious to someone measuring blood pressure during exercise because it usually rises. Resistance is the product of blood flow muliplied by blood pressure. When the heart pumps more blood, cardiac output usually increases more than the resistance drops, therefore, there is a modest increase in systolic blood pressure during exercise in most subjects.

Heart rate is the result of a number of physical and emotional influences that are mediated through the autonomic nervous system. These include excitement, fear, anticipation, temperature alterations, respiratory maneuvers and physical work. At the onset of exercise, the heart rate has been shown to increase within 0.5 seconds (Petro 1970), which is probably secondary to an abrupt inhibition of a significant portion of vagal toning. An interesting sawtooth effect in heart rate has been described in the first few seconds of exercise (Fagaeus 1976) suggesting that the ANS is trying to establish a proper balance.

The peripheral effects of exercise are also quite extensive and need to be addressed. During exercise, the skin's blood flow increases and the sweating mechanism, which leads to increased vaporization, becomes the most important mechanism in heat loss. Muscle temperatures have been recorded as high as 109 degrees. A cold environment producing local vasoconstriction and, therefore, an increase of peripheral resistance, will increase cardiac work, however, as the work load increases, this effect is minimized (Ellestad 1984).

From the above discussion of temperature, it becomes obvious that the facility to selectively constrict certain vascular beds and preferentially shunt the blood to the areas of increased utilization is essential in adjusting to exercise. With strenuous exertion, the splanchnic flow (hepatic, visceral, and renal) drops to about 20% of control within 3-4 minutes after exercise is iniatiated as more blood is diverted to the skin and working muscles (Bergman 1973). This delay explains why warm-up is essential for optimum performance.

CORONARY PRONE BEHAVIOR

Friedman and Rosenman (1969) defined Type A or coronary prone behavior as a characteristic action-emotion complex which is exhibited by those individuals who are engaged in a relatively chronic struggle to obtain an unlimited number of poorly defined things from their environment in the shortest period of time, and, if necessary, against the opposing efforts of other things or persons in their dame environment. More recently, Rosenmen (1978) has asserted that the most critical aspects of Type A behavior is the excesses of aggression, hurry, and competitiveness experienced in trying to overcome environmental barriers. Type B behavior would then be a lack of Type A characteristics.

Jenkins (1975) stated that the Type A behavior pattern is considered to be an overt behavioral syndrome or style of living characterized by extremes of competitiveness, striving for achievement, aggressiveness, haste, impatience, restlessness, hyperalertness, explosiveness of speech, tenseness of facial muscles, and feelings of being under time pressure and under the challenge of responsibility. Persons having this pattern are often so deeply committed to their vocation or profession that other aspects of their lives are relatively neglected.

MEASURES OF TYPE A BEHAVIOR

Three measures of Pattern A have been related prospectively to coronary heart disease: the Structured Interview (Rosenman et al. 1975), the Jenkins Activity Survey (Jenkins, Rosenman & Ayanski, 1974; Jenkins, Zyanski, & Rosenman, 1971); and the Framingham Type A scale (Haynes, Feinleib, & Kannel, 1980).

The Structured Interview (SI) contains approximately 25 questions in which individuals are asked about their characteristic way of responding to a variety of situations that could elicit impatience, hostility, and competitiveness (Freidman, 1978). Some questions are deliberately presented in such a way as to elicit a style of speech that is considered indicative of coronary prone behavior.

The Framingham Type A scale is a self-report measure that contains 10 items that assess the individual's competitive drive, sense of time urgency, and perception of job pressures (Haynes, Levine, Scotch, Feinleib, & Kannel, 1978).

The Jenkins Activity Survey (JAS), Form C, is a self-report multiple-choice questionnaire of 52 items designed to measure the Type A behavior pattern found to be strongly associated with the increased risk of developing coronary artery disease. The test is scored on four scales: the Type A scale, which assesses the multifactorial clinical construct of the coronary prone behavior pattern, Type A; and three factorially independent components of this broader construct: Speed and Impatience (S), Job Involvement (J), and Hard Driving and Competitive (H).

TYPE A MEASUREMENT VALIDITY

Correlations of Type A behavior with the rate of coronary heart disease have been established in several retrospective and prospective studies. Strong relationships have been demonstrated between Type A levels and some CHD precursors such as serum cholesterol level, catacholamine blood levels and blood clotting (Freidman, Byers, Diamant & Rosenman, 1975). One large prospective research project, the Western Collaborative Group Study (WCGS), carried out over an 8.5 year period with over 3,000 men, found that individuals with high Type A scores at the beginning of the study had nearly double the risk of eventual CHD (Rosenman, et al. 1976). The mediating mechanisms did not appear to be exclusively physiological factors, such as serum cholesterol or serum lipids. The Type A pattern appeared to have an influence independent of all other factors, correlating with an almost two-fold the risk of coronary breakdown. Studies such as this are strong support for accepting Type A tests as predictive.

It is known that the Type A behavior pattern is associated with increases in catecholamines, cortisol and blood lipids. In combination with the common stress responses of increased tissue oxygen demand, heart rate and blood pressure, the total physiological trend leads ultimately to arterial injury, athersclerosis, and damage to the myocardium (Williams, 1975).

It is important to keep in mind that Type A measures appear to be valid and reliable, however, the association between them leads one to believe that they are measuring different constructs (Matthews 1982). The JAS and SI are in agreement when classifying Type A and B behavior only 60-70% of the time whereas, by chance, they would be in agreement at least 50% of the time (Haynes, Levine, Scotch, Feinleib, & Kannel, 1978). Thus it is incorrect to assume that the various instruments used to measure Type A characteristics are assessing the same aspects of coronary prone behavior and may, in fact, be demonstrating minimal overlap.

More recently, Lane et al., (1984) presented evidence assessing physiological responses that differentiated Type A women and men as measured by the JAS. In his study Type A subjects were given an arithmetic task. Female subjects responded with increases in HR, blood pressure and forearm blood flow with no change in forearm vascular resistance, while males had significant decreases in forearm vascular resistance. It was also noted that within their female subject population there was a group of subjects that demonstrated an interaction effect between a family history of hypertension and hyper-responsiveness to the task.

PURPOSE AND MAJOR HYPOTHESES

The purpose of this research is two-fold. First, it is to examine the cardiovascular responses to dynamic exercise stress alone and in combination with psychological and cold pressor stressors. The use of impedance cardiography will allow us to measure stroke volume, cardiac output, contractility, and total peripheral resistance in addition to the more traditional measure of heart rate. Blood pressure and peripheral skin temperature will also be monitored. Thus, does exercise attenuate or potentiate the physiological response patterning when in combination with psychological (cognitive) or physical (cold pressor) stressors?

The second purpose of this study is to examine the relationship(s) between personality (behavioral) measurements associated with coronary artery disease and various cardiovascular responses elicited by discrete stressors during a standardized psychophysiological stress evaluation.

Thus, two general hypotheses are generated as follows:

1. Cardiovascular responses that are elicited by a psychological stressor will correlate with Type A personality patterns.

2. Dynamic exercise, in combination with a psychological or physical (cold pressor) stressor, will obscure the idiosyncratic effects attributed to either stressor when acting alone.

CHAPTER II

METHODS

Dependent Measures

The psychophysiological measures that were monitored consist of *heart rate*, *systolic and diastolic blood pressure*, and *hand temperature*; as well as indices of: *cardiac output*, *stroke volume*, *myocardial contractility*, and *total peripheral resistance*. These indices were obtained from formulae which were developed for use with the derivative impedance cardiogram (Mohapatra, 1981). Thus in addition to the four traditional psychophysiological measures there are four new variables which reflect cardiac performance that are computed.

Cardiac output is the amount of blood which is pumped per unit of time and is expressed in terms of liters per minute. *Stroke volume* is the amount of blood, in milliliters, which is pumped with a single heartbeat. Cardiac output is the product of stroke volume times heart rate. *Myocardial contractility* is the vigor, or force, of the heart's contraction and is frequently indexed by the maximal instantaneous rate of change of the ventricular pressure curve (dP/dt) (Berne & Levy, 1981).

Cardiac output is pumped against the total peripheral resistance (the force opposing the flow of blood) of the body, and those two factors jointly affect the arterial blood pressure. Peripheral skin temperature has been proposed as an indirect index of peripheral resistance and increased hand and/or foot temperature is frequently the target of clinical biofeedback training for hypertension (Fahrion, 1983).

Apparatus

Blood pressure, in this series of studies, was determined by applying a manual sphygmomanometer to either the subject's right arm as in the first study or left arm in experiments 2 or 3. In the case of the non-exercise evaluations, subjects were seated upright in a padded chair with the right arm elevated to the about the level of the heart. The cuff was rapidly inflated during the final 20 seconds of each recording period. The systolic blood pressure was recorded as the point at which the first sounds of blood passing through the brachial artery were heard (Korotkoff phase I). The diastolic blood pressure was identified as the pressure at which the last sounds were heard (Korotkoff phase V). Only during the initial non-exercise assessments was blood pressure data collected with the use of an automated sphygmomanometer (Dimamap model 850). The decision to adopt the manual blood pressure procedure was due to the variability of the time involved in obtaining the automated reading. It was difficult to coordinate the blood pressure determination with the end of the condition using the automated cuff. This problem was generally due to artifact rejection circuitry which was prone to triggering during the cold pressor test.

Peripheral skin temperature was determined with the use of an Autogenic Systems model 2000 skin temperature monitor. A thermistor was taped to the dorsal surface of the distal phalange of the middle digit on the nondominant hand. The sensor was placed proximal to the fingernail with the thermister lead secured to the finger at a second location in order to minimize movement artifact. Readings were made to the nearest tenth of a degree Fahrenheit during the end of each condition. In the exercise subject population both right and left peripheral skin temperatures were measured.

The other hemodynamic variables measured by impedance cardiography were recorded with the use of an Instrumentation for Medicine model 400 impedance cardiograph. This device passes a 4 mA, 100 kHz, sinusoidal signal across electrodes encircling the subject's neck and thorax. A constant-current signal is passed across the chest cavity and the resulting voltage is detected by a second pair of electrodes placed between the two excitation electrodes. See Figure 1 for a schematic illustration of this procedure. This voltage signal is synchronous with

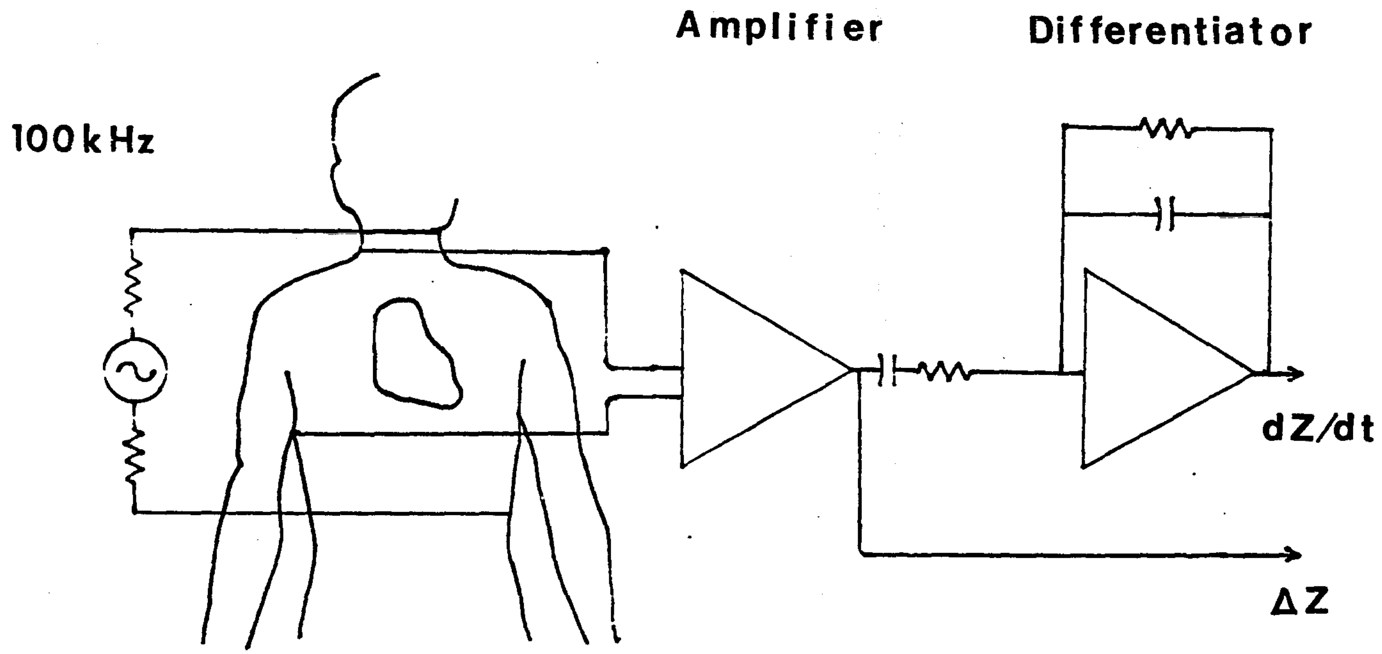

Figure 1. Schematic Diagram of Impedance Cardiograph

both the heartbeat and respiration. Changes in tissue volume and displacement within the thorax are responsible for the fluctuations in the impedance signal (Karnegis & Kubicek, 1970). The first derivative of the impedance signal (dZ/dt) is then computed and recorded on a chart recorder. By recording only during the same point in the respiratory cycle, respiration artifacts can be virtually eliminated (Miller & Horvath, 1978). All cardiograph recordings were obtained during respiratory apnea following a full exhalation.

The electrodes employed in impedance cardiography are bands of aluminized mylar tape which encircle the subject's body. The first excitation electrode is placed high on the subject's neck parallel with the floor. The second electrode is used for reception and is placed parallel to and at least 2.5 cm below the first one. The third electrode is also receptive and is placed parallel to the first two at the level of the xiphosternal joint at the base of the sternum. The fourth electrode is excitatory and it is placed at least two inches below, and parallel to, electrode three.

The dZ/dt signal and an electrocardiogram (ECG) were recorded on a thermal strip chart recorder at a chart speed of 50 mm/sec. Many of the records initially made in the non-exercise (first experiment) population were recorded at a speed of 25 mm/sec. to conserve materials. The two waveforms were manually scored to determine the following measures: interbeat interval, ventricular ejection time, maximal height of the dZ/dt waveform, and the interval between the R spike of the ECG tracing and the maximal height of dZ/dt (R-Z interval). The dZ/dt waveform, its relationship to the ECG, and the measurements involved in scoring the waveform are represented in Figure 2. The fact that some of the records in the first study were recorded at half-speed was unfortunate, since changes in the two important systolic time intervals became more difficult to determine (i.e., VET and the R-Z interval). During each condition the last three consecutive waveforms were measured and averaged. A calibration signal was recorded prior to and at the conclusion of each subject run.

Measures taken from the impedance cardiograph waveforms were then entered into the appropriate formulae to estimate the hemodynamic parameters of _heart rate_, _stroke volume_, _cardiac output_, and _myocardial contractility_ (Kubicek et al, 1966, 1970; Mohapatra, 1981). Heather's index of myocardial contractility was used for estimating contractile force (Heather, 1969). Total peripheral resistance was estimated by calculating the ratio of mean arterial blood pressure to cardiac output. Mean arterial blood pressure was estimated by adding one third of the pulse pressure (systolic minus diastolic) to the diastolic blood pressure (Berne & Levy, 1981).

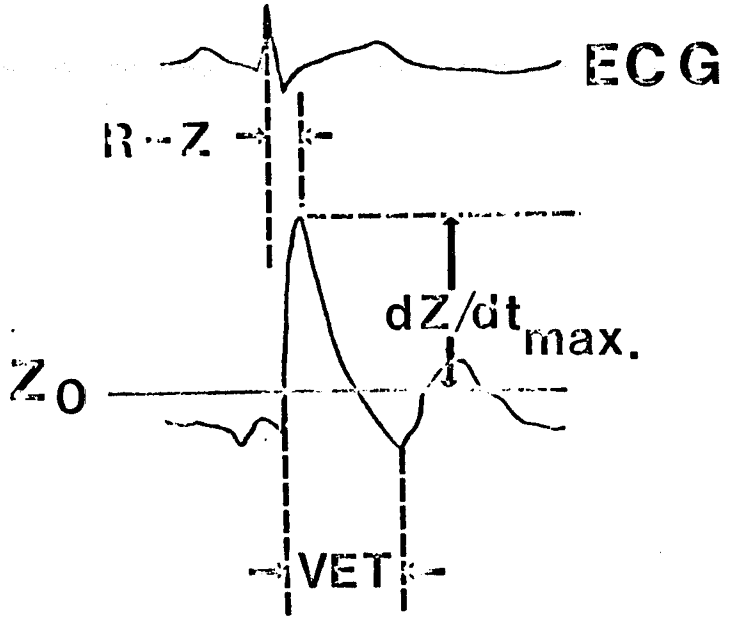

Figure 2. Measurements Taken from the Impedance Cardiogram

Experiment 1

Design - This experiment was designed to examine the relationship between coronary prone behavior patterns and cardiovascular response patterns produced by a psychological and a cold pressor stressor. The psychological stressor was a tape recorded quiz of several cognitive abilities including: general knowledge, arithmetic skills and reasoning. This task (ECG Quiz) was developed for studying the effects of emotional stress on angina patients (Schiffer, Hartley, Schulman, & Abelmann, 1976). These investigators found that the quiz produced ECG changes similar to those induced by exercise stress. The quiz was preceded by an instructional set which explained that it was an assessment of mental ability and that the subject's score would be compared with the scores of other individuals of his/her own age. The questions were then presented under a time pressure that allowed only five seconds for responding (see Appendix 1). Hemodynamic patterns which occurred in response to the two stress conditions were examined to determine if either the cognitive or the cold pressor patterns had been replicated.

Subjects - The 30 subjects that participated in this first experiment were drawn from two different subject populations. The first group consisted of 22 police officers, from the Stamford, Connecticut Police Department who were recruited to participate in the stress test. They consisted of 21 males and 1 female with a combined average age of 34.8. The second group of subjects was drawn from an anxiety study being run at the Milhauser Clinic, New York University and included 6 females and 2 males with a combined average age of 36.8. Ideally we would have preferred using only one group, however, not enough police officers returned the JAS to enable us to perform the statistical procedures. No selection process was utilized other than screening individuals for existing or potential cardiac problems or symptoms of cardiovascular disease.

Procedure - The experiment was conducted in a private room which was assigned to the project, within the police station or Milhauser Clinic. The subjects sat upright in a padded conference chair throughout the entire procedure and were first interviewed to obtain demographic and medical history data while the various electrodes were being attached by a second experimenter. Before the start of the experiment, the subjects were instructed in a respiratory pause on command procedure in order to minimize impedance recording artifacts. They were requested to hold their breath following a full, but not forced, exhalation. A trial cardiograph recording was made prior to the start of the experiment to ascertain that each subject comprehended the instructions and could produce the desired respiratory manipulation. An impedance calibration signal was also recorded at the beginning and the conclusion of each session.

The first four minutes of the stress test was a resting baseline period, during which the subjects were instructed to remain quiet. This was followed by a two-minute self-relaxation condition in which the subjects were instructed to close their eyes and allow themselves to become as relaxed as possible. The quiz was administered next, and the two-minute trial began as soon as the subject had heard ten questions or made three errors, whichever occurred first. A two-minute recovery period followed the quiz condition. Subjects were then instructed to immerse their right hand up to the wrist with fingers spread in a bucket of ice water for 60 seconds. This was followed by a four minute recovery period. The cognitive and cold stress conditions were not counterbalanced due to the extreme effects the cold stressor produced on hand temperature in the opposite limb. In similar protocols used in our laboratory, the two-minute recovery period was sufficient for all other variables to return to approximately their original levels.

Experiment 2

Design - This experiment was designed to examine the response patterns produced by exercise stress and the possible interactive effect produced by combining exercise stress with either a psychological or cold pressor stress.

Subjects - A single group of 14 healthy volunteers, 8 males and 6 females, were recruited for experiment 2. Subjects for this experiment were drawn from an adult population of undergraduate and graduate students. The average age was 25.5 years, which is considerably younger than that observed in the first study.

Procedure - The experimental procedure involved subjects sitting on an exercise bicycle while undergoing 12-condition assessment procedure as follows:

1. Initial Resting Baseline: 5 recordings at 2-minute intervals; subjects seated as comfortably as possible on a stationary exercise bicycle, and instructed to remain quiet with eyes closed (10 minutes total).

2. Self-Relaxation: 2 recordings at 2-minute intervals; subjects were requested to relax as completely as possible.

3. Cognitive Stress: Each subject was instructed to answer aloud the questions directed to them (from the pre-recorded ECG quiz mentioned previously). Physiological data recordings were made following the delivery of noxious instructions (2 minutes into the recording). Additional recordings were made upon completion of the first 2 minutes of the quiz (4 minutes total).

4. Recovery I: 5 recordings at 2-minute intervals;

subjects were instructed to sit quietly with their eyes closed (10 minutes total).

5. Cold Pressor Stress: Standard cold pressor stress (as mentioned in experiment 1), where one hand was immersed in ice water to the wrist for 60 seconds. Three subsequent readings were taken at 20 second intervals (1 minute total).

6. Recovery II: 5 recordings at 2-minute intervals; subjects were instructed to sit quietly with their eyes closed (10 minutes total).

7. Exercise Stress: The exercise conditions consisted of pedaling on a stationary exercise bicycle to a target heart rate of approximately 75% of maximum. Sub-maximum target heart rates were determined by the formula: 220 Beats Per Minute minus age times .70 (for a 20-year old individual 220-20=200, 200x.70=140). The ergometer was usually set at approximately 75 newton meters with subjects maintaining 60 revolutions per minute once titration to target heart rate was established (usually taking between 3-5 minutes). The use of the bicycle has several advantages in this type of testing. The patient's thorax and arms are relatively stable, thus allowing for more efficient recording of physiological measures. The patient's body weight does not influence his/her exercise capacity appreciably and sitting on the bicycle often produces less anxiety than walking on a mechanically driven treadmill. In addition, the bicycle requires less space in

the laboratory and is less expensive. Three readings were taken every 2 minutes plus an initial reading when the target heart rate was reached. In order to avoid movement artifacts, subjects were asked to stop pedaling briefly while a blood pressure and an impedance measurement were obtained. The subject was then requested to continue pedaling to target speed (60 RPM). A finger photoplethysiomograph was used to determine heart rate for titration purposes, however, some of the recordings during the exercise conditions were laden with artifact due to this device. The use of the device was discontinued and ongoing impedance tracings taken at slower recording speeds were used to determine heart rate.

8. Recovery III: Subjects were instructed to stop pedaling and sit quietly. Five readings were taken every two minutes (10 min. total).

9. Exercise + Cognitive Stressor: Subjects were asked to start pedaling the bicycle and their target heart rates were titrated in the same way as in the first exercise condition. After 2 minutes of exercise, readings were obtained, and the subject listened to a second version of the oral quiz. The second quiz had the same instructional set followed by new questions. Pilot work done in our lab demonstrated that the second version elicited similar responses therefore maintaining reliabiltiy. Measurements were taken both after the instructions and 2 minutes of questions. All subjects remained pedaling during the quiz

condtion.

10. Recovery IV: Subjects were instructed to stop pedaling and sit quietly. Five readings were taken every 2 minutes (10 minutes total).

11. Exercise + Cold Pressor: Subjects exercised to target heart rates as in the previous exercise conditions. After 4 minutes of exercising the subjects were requested to immerse their right hands into ice water and continue pedaling. Readings were obtained every 20 seconds except blood pressure, which was taken only at the end of the 1-minute immersion.

12. Recovery V: Subjects were instructed to stop pedaling and sit quietly. Five readings were taken every two minutes (10 min. total).

Experiment 3

Design - This experimental procedure was designed to further ascertain the interaction effects of exercise stress when combined with the quiz and the cold pressor independently. Specifically, intrasubject response patterning was assessed by having the subjects continue to exercise after the quiz and cold pressor conditions had ended, thus allowing for further documentation of stressor effect.

Subjects - 6 subjects, from the same group as mentioned in experiment 2, were asked to continue to exercise upon completion of the oral quiz and cold pressor test. These included 4 males and 2 females with a combined average age of 30.8.

Procedure - The procedure was identical to that used in experiment 2 except for the exercise conditions. Specifically, the first exercise condition was extended to five 2-minute readings for a total of 10 minutes. The exercise + quiz, and exercise + cold pressor conditions were altered by having each subject continue to exercise for 4 minutes with readings being taken every 2 minutes (10 minutes total). Lastly, to ensure complete recovery, the time between the first and second exercise sets was increased to 1 hour, with readings being taken every 2 minutes for the first 20 minutes. If the subject's heart rate at the end of the 20 minute period had recovered, that is, within one standard deviation of baseline heart rate, he/she was allowed a 40 minute break from the experiment. This was frequently appreciated by most subjects for they were getting a little uncomfortable sitting on the bicycle seat. If the heart rate had not returned to one standard deviation of the baseline, the subject was asked to remain seated with 2-minute readings being taken so that full recovery data could be obtained. The remaining two recovery periods (after the exercise + quiz and exercise + cold pressor) were 20 minutes each in length with readings being taken every 2 minutes. Once the 20-minute recovery period was over, provided heart rate was recovered, the next condition was begun immediately.

CHAPTER III

RESULTS

EXPERIMENT 1: PSYCHOPHYSIOLOGICAL CORRELATES OF CORONARY PRONE BEHAVIOR UNDER VARIOUS CONDITIONS

Experiment 1 was designed to examine the relationship between Type A behavior patterns and cardiovascular response patterns produced by psychological and cold pressor stressors. In addition to these stressors, data was obtained for baseline and self-relaxation conditions. The general hypothesis was supported as the physiological responses brought about by the psychological (cognitive) stressor significantly correlated with various indicies of the coronary prone behavior pattern as measured by the Jenkins Activity Survey.

The data obtained from experiment one were entered into a stepwise multiple linear regression in order to analyze the collective and separate contributions of the physiological variables and how they relate to Type A personality characteristics. The physiological data included age, gender and percent changes from baseline values for systolic and diastolic blood pressure, heart rate, stroke volume, Heather's index of myocardial contractility, total peripheral resistance, and peripheral skin temperature. These variables were monitored across self-relaxation, psychological and cold pressor stress conditions. The dichotomous variable (gender) was entered in as a dummy variable where 1's were male and 2's were female. Fortunately, multiple linear regressions are well suited to handle these variables with equal facility (Kerlinger & Pedhazur 1973).

In the initial regression anlaysis, cardiac output was left out because it appeared to be functioning as a suppressor variable which it in fact was. This is not surprising since cardiac output is the product of heart rate and stroke volume, both of which are impedance measures which tend to act in opposite and compensatory fashions.

The personality variables entered into the analysis included the raw scores for the Jenkins Activity Survey (J.A.S.), Form C. This included the overall score for Type A behavior and its three component factor scores, speed and impatience, job involvement and hard driving and competitive behavior. Raw scores were used to ensure equal weight distribution between each numerical unit value of the J.A.S. (which is not the case with the J.A.S. percentiles).

Variance of Coronary Prone Behavior Measures

An initial concern was to determine whether there was representative and sufficient variability on the personality measure for coronary prone behavior. In fact, the mean raw scores obtained from the J.A.S. were characterized by a large degree of variance, therefore our sample was representative of the wide range of scores that would be normally found in the population as a whole. Table 1. shows the wide dispersal of mean raw scores and associated percentiles along with the standard deviations of dependent variables.

Step-wise Multiple Linear Regression Analysis of the J.A.S. and Psychophysiological Responses

Many highly significant relationships were found between coronary prone personality measures and the various psychophysiological variables (see Table 2). Overall Type A behavior correlated strongly with gender (multiple R = .57) and to a lesser extent, changes in stroke volume during the psychological stress (multiple R = .67) Together these two variables accounted for 45% ($p<.001$) of the variance. The influence of the psychological stressor on stroke volume was quite ubiquitous, for it also surface as a significant variable accounting for a large proportion of the variance in both job involvement and hard driving and competitive behavior. This significant influence made by the psychological stressor is in strong support of the initial hypothesis, for the cognitive stressor apparently represented a realistic goal to compete with and overcome,

TABLE 1

EXPERIMENT ONE

MEANS AND STANDARD DEVIATIONS OF THE JENKINS ACTIVITY SURVEY FACTOR SCORES USED IN THE STEP-WISE MULTIPLE LINEAR REGRESSION

TYPE A VARIABLES	N	MEAN RAW SCORE	STANDARD DEVIATION	MEAN PERCENTILE	STANDARD DEVIATION
TYPE A OVERALL SCORE	30	215.6	73.06	45.66	25.02
SPEED AND IMPATIENCE	30	179.7	89.33	47.27	32.66
JOB INVOLVEMENT	30	225.3	55.74	59.48	21.33
HARD DRIVING AND COMPETITIVE	30	119.6	41.97	44.57	30.99

TABLE 2

EXPERIMENT ONE

STEP-WISE MULTIPLE LINEAR REGRESSION ANALYSIS RELATING JENKINS ACTIVITY SURVEY SCORES TO PSYCHOPHYSIOLOGICAL RESPONSES AND EXPERIMENTAL CONDITIONS

TYPE A VARIABLE	PHYSIOLOGICAL VARIABLES & EXP. CONDITIONS	*r*	MULT R	VAR (RSQ)	SIGN
TYPE A OVERALL SCROE	SEX	.57	.567	.320	.001
	STROKE VOLUME DURING QUIZ	.56	.670	.450	<.001
SPEED & IMPATIENCE	SEX	.37	.375	.140	.040
	HEART RATE DURING QUIZ	-.37	.509	.259	.010
	HEART RATE DURING COLD PRESSOR	.04	.632	.399	.004
	SYSTOLIC B.P. DURING SELF-RELAX	.24	.716	.512	.001
	SKIN TEMPERATURE DURING QUIZ	.17	.863	.745	<.001
HARD DRIVING & COMPETITIVE	STROKE VOLUME DURING QUIZ	.50	.502	.250	.005
JOB INVOLVEMENT	TOTAL SYSTEMIC RESISTANCE DURING QUIZ	.56	.564	.318	.001
	STROKE VOLUME DURING QUIZ	.50	.685	.469	<.001
	HEART RATE DURING QUIZ	.24	.734	.538	<.001
	SYSTOLIC B.P. DURING COLD PRESSOR	.44	.780	.609	<.001

*ONLY SIGNIFICANT CORRELATIONS P<.05 REPORTED therefore, cardiovascular mobilization responded accordingly.

Further evidence linking the psychological stress responses to the Type A measures is revealed in looking at the regression weights provided in Table 3. These beta values are an estimation of the effect that each physiological variable has in the regression equation. In theory, they should represent the population regression weight, however, since this is unknown, they are based upon sample regression data. Five of the seven highest beta weights are the result of physiological measures taken during the quiz, which further increases confidence in our assumption that the cognitive stressor is a realistic and challenging goal to overcome. The two exceptions in the beta values are changes in heart rate during the cold pressor stress and gender effect.

The change in heart rate evidenced during the cold pressor is not unexpected for it replicates earlier findings where Type A subjects, when compared to Type B's, showed significantly greater increases in heart rate when exposed to a cold pressor stress (Dembroski et al., 1979; Holmes, 1983). Also, recent literature suggests differences may exist between Type A men and Type A women (Lane et al., 1984; Gastorf, 1981; Manuck et al., 1978). The results of the regression analysis support the existence of gender

TABLE 3

EXPERIMENT ONE

MULTIPLE LINEAR REGRESSION BETA VALUES FOR THE JENKINS ACTIVITY SURVEY SCORES AND PSYCHOPHYSIOLOGICAL RESPONSES AND EXPERIMENTAL CONDITIONS

TYPE A VARIABLES	PHYSIOLOGICAL VARIABLES	BETA VALUES
TYPE A OVERALL SCORE	SEX	+0.5671
	STROKE VOLUME DURING QUIZ	+0.3947
SPEED & IMPATIENCE	SEX	+0.3746
	HEART RATE DURING QUIZ	−0.3447
	HEART RATE DURING COLD PRESSOR	+0.5099
	SYSTOLIC B.P. DURING SELF-RELAX	+0.3438
	SKIN TEMPERATURE DURING QUIZ	+0.6459
HARD DRIVING & COMPETITIVE	STROKE VOLUME DURING QUIZ	+0.5023
JOB INVOLVEMENT	TOTAL SYSTEMIC RESISTANCE DURING QUIZ	+0.5640
	STROKE VOLUME DURING QUIZ	+0.5016
	HEART RATE DURING QUIZ	+0.2723
	SYSTOLIC B.P. DURING QUIZ	+0.4433

differences, and require further determination. Fortunately, it appears that the addition of cardiac impedance derived variables may help extend our knowledge of contributing variables that differentiate gender effects.

When looking at the Jenkins factor score, speed and impatience, 74.5% ($p < .001$) of the variance was accounted for by the combined step-wise effects of gender, increases in heart rate (during the psychological and cold pressor stressors), peripheral skin temperature (during the psychological stress) and systolic blood pressure (during self-relaxation). Within this relationship, the fact that heart rate change during the cold pressor had an initial correlation of .04, yet was significant in the regression at the .004 level, is interesting. Apparently the change in heart rate (decrease) during the psychological stressor covaries with a direct increase in heart rate during the cold pressor test. This strong reciprocal relationship accounts for cold pressor induced heart rate changes entering into the regression equation. It is also interesting to note that such a reciprocal relationship is in support of Lacey's (1972) work on cardiovascular response to internal and external tasks. Internal tasks such as the psychological stressor causes heart rate decreases while external, such as the cold pressor test, correlate with heart rate acceleration.

The fact that the cognitive stressor, as opposed to the cold pressor, induced correlated cardiovascular changes in an impedance derived measure (stroke volume) may provide further elucidation of Lacey's (1953) concept of individual response specificity. This concept, which states that an individual will respond to various stressors with the same idiosyncratic pattern, was formulated using the traditional measures of autonomic arousal such as heart rate. The addition of impedance derived measures appears to allow the researcher to differentiate out the effects of a psychological and physical stressor, thus affording support for the use of impedance derived measures in assessing the effects of varying tasks as related to response specificity as well as directional fractionation (Lacey, 1959).

In sumarizing the results of the step-wise regression analysis, several significant trends emerged. First, gender has a profound influence in accounting for a large proportion of the variance in both overall Type_A_ and speed_and_impatience behavior patterns. The psychological stressor, as hypothesized, was the most reliable condition in eliciting significant changes that were found in the regression analysis for all four personality measures. This was especially true for changes in stroke volume during the quiz condition. Unfortunately, there appears to be no direct homeostatic relationships between the quiz induced cardiovascular variables that correlate with the speed_and impatients and job_involvement measures. Perhaps an increased sample size would lend itself in defining such relationships.

EXPERIMEN 2 AND 3: THE INTERACTION OF DYNAMIC EXERCISE WITH PSYHOLOGICAL AND COLD PRESSOR STRESSES

Experiments 2 and 3, were designed to examine the response patterns produced by exercise and the possible interactive effects produced by combining exercise with either a psychological or cold pressor stress. The findings did not support the general hypothesis that dynamic exercise will obscure the idiosyncratic effects of the psychological or cold pressor stressors. Both experiments involve subjects participating in a 12 condition psychophysiological profile from which data collected for 7 of the conditions was analyzed. These conditions were baseline, self-relaxation, psychological stress, cold pressor stress, exercise alone, exercise plus quiz and exercise plus cold pressor. No Type A personality data was used in these two experiments. The difference between the two experiments is that experiment 3, in which 6 of the 14 subjects from experiment 2 participated, involved having the subjects continue to exercise after the psychological and cold pressor stressor conditions ended. This allowed for further documentation of a stressor effect in that a return to exercise baseline became available.

The data from both experiments 2 and 3 was statistically examined using a single factor repeated measures analysis of variance followed by Duncan post hoc tests. Table 4 shows the mean values of hemodynamic variables across all psychophysiological conditions.

It is important to note that the data obtained for peripheral skin temperature (an indirect measure of sympathetic nervous system activity), is suspected of being unreliable in experiments 2 and 3. Unfortunately, the C.C.N.Y. laboratory is centrally air-conditioned with no local thermostatic intervention possible. As a result, even when we tried to maintain temperature with electric heat, several subjects complained it was too cold in the summer, too hot in the winter, and drafty. In addition, some subjects were sweating profusely during exercise which may have induced a cooling effect due to evaporation. For these reasons, confidence in peripheral skin temperature measurements is questionable and will not be included in the analysis of experiments 2 and 3.

Exercise Effect

The first analysis demonstrated that, as expected, patterns of physiological response emerged that fit with what was expected to be found comparing measures taken during baseline and active physical exercise (see Tables 5 and 6).

TABLE 4

EXPERIMENT TWO AND THREE

MEAN VALUES OF HEMODYNAMIC VARIABLES ACROSS ALL EXPERIMENTAL CONDITIONS

	CONDITIONS						
VARIABLE	BASELINE	SELF RELAX	QUIZ	COLD PRESSOR	EXERCISE	EXERCISE QUIZ	EXERCISE COLD PRESSOR
SYSTOLIC B.P. mm Hg	110.4	112.1	117.7	125.9	127.9	132.1	135.4
DIASTOLIC B.P. mm Hg	75.5	79.6	80.6	91.4	69.4	72.9	83.5
HEART RATE B.P.M.	82.6	85.8	82.5	81.4	116.8	115.3	117.9
STROKE VOLUME ml	65.1	67.6	71.6	64.3	75.1	81.2	76.2
CARDIAC OUTPUT l/min.	5.3	5.7	5.8	5.2	8.7	9.5	9.1
CONTRACTILITY Heather's Index	15.3	16.1	17.7	13.9	32.2	34.3	35.0
TOTAL PERIPHERAL RESISTANCE M.A.P/CO	20.0	20.2	20.0	23.6	14.3	14.3	15.7

N=14 Ss

TABLE 5

EXPERIMENT TWO AND THREE

SINGLE FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF SIGNIFICANT CHANGES ACROSS ALL EXPERIMENTAL CONDITIONS

VARIABLE	F	DF	PROB.
SYSTOLIC B.P. mm Hg	23.15	6/97	.001
DIASTOLIC B.P. mm Hg	7.93	6/97	.001
HEART RATE B.P.M.	27.23	6/97	.001
STROKE VOLUME ml	2.87	6/97	.05
CARDIAC OUTPUT l/min	11.81	6/97	.001
CONTRACTILITY Heather's Index	28.86	6/97	.001
TOTAL SYSTEMIC RESISTANCE	16.65	6/97	.001

N=14 Over seven experimental conditions.

TABLE 6

EXPERIMENT TWO AND THREE

MEAN DIFFERENCES AND POST HOC ANALYSIS OF PHYSICAL EXERCISE COMPARED TO A RESTING BASELINE

VARIABLE	N	MEAN DIFFERENCE FROM BASELINE	SIGNIFICANCE
SYSTOLIC B.P. mm Hg	14	+17.5	.001
DIASTOLIC B.P. mm Hg	14	- 6.1	.001
HEART RATE B.P.M.	14	+34.2	.01
STROKE VOLUME ml	14	+10.0	.05
CARDIAC OUTPUT l/min	14	+ 3.4	.01
CONTRACTILITY Heather's Index	14	+16.9	.001
TOTAL SYSTEMIC RESISTANCE M.A.P./CO	14	- 5.7	.05

DUNCAN PROCEDURE

Significant _increases_ in systolic blood pressure, heart rate, stroke volume, cardiac output, and the Heather index of myocardial contractility along with associated _decreases_ in diastolic blood pressure and total systemic resistance occurred during sub-maximal exercise. This replicates the findings of others (Ellestad, 1984) and thus, increases our confidence in the impedance derived measurements during dynamic exercising.

Self-Relaxation Effect

At the begining of the self-relaxation condition, subjects were asked to close their eyes and relax to the best of their ability. The effect of these simple instructions are of particular interest, for the ability to relax predisposes successful intervention in the treatment of stress-related disorders. Many people think that attempting to relax induces specific changes indicative of low arousal (such as decreased sympathetic toning). It has been observed here, and in other studies from our laboratory, that the instructions to relax, in the absence of training in relaxing, actually functions as a cognitive stressor. _Table 7_ shows how self-relaxation instruction elicited significant increases in both systolic and diastolic blood pressure when compared to a resting baseline condition. Also, as evidenced in experiment 1, changes in systolic blood pressure during the self-relaxation condition entered into the regression equation as a significant

TABLE 7

EXPERIMENT TWO AND THREE

MEAN DIFFERENCES AND POST HOC ANALYSIS OF SELF-RELAXATION COMPARED TO A RESTING BASELINE

VARIABLE	N	MEAN DIFFERENCE FROM BASELINE	SIGNIFICANCE
SYSTOLIC B.P. mm Hg	14	+ 1.7	.05
DIASTOLIC B.P. mm Hg	14	+ 4.1	.05

DUNCAN PROCEDURE: Only significant variables reported.

variable predicting speed and impatience. This data substantiates an important difference frequently seen when comparing trained and untrained biofeedback populations. When asked to relax, biofeedback-trained subjects do demonstrate significant reductions in the above-mentioned variables. This is not the case with individuals who have no prior training (Fahrion, 1984). The present findings attend to this phenomenon.

Quiz Effect

The effect of a psychological stressor (quiz) on the cardiovascular system has been documented by many investigators (Wilson et al., 1983; Steiner et al., 1983; Albright et al., 1984; Gilbert et al., 1979). This study replicates their findings in that significant increases in stroke volume, systolic and diastolic blood pressure were recorded in response to the psychological stressor (see Table 8). The above investigators also found significant increases in cardiac contractility which in this study was probably due to the low sample size, and so were not statistically significant. Thus, the quiz appears to be an effective stressor that elicits changes coinciding with the activation of the fight or flight response mechanisms under autonomic nervous system control.

Cold Pressor Effect

The cold pressor test produced significant increases in

TABLE 8

EXPERIMENT TWO AND THREE

MEAN DIFFERENCES AND POST HOC ANALYSIS OF THE PSYCHOLOGICAL STRESSOR, (QUIZ) COMPARED TO RESTING BASELINE

VARIABLE	N	MEAN DIFFERENCE FROM BASELINE	PROBABILITY
SYSTOLIC B.P. mm Hg	14	+ 7.3	.01
DIASTOLIC B.P. mm Hg	14	+ 5.1	.05
STROKE VOLUME ml	14	+ 6.5	.01

DUNCAN PROCEDURE: Only significant variables reported.

total systemic resistance along with systolic and diastolic blood pressure (see Table 9). Wilson demonstrated similiar changes in addition to a significant increase in total systemic resistance and decreases in stroke volume, cardiac output and the Heather's index of myocardial contractility. These changes also occurred in the present study, but failed to reach significance, again probably due to the low sample size. None-the-less, it is apparent that these two stressors (quiz and cold pressor) produced similar changes in the traditional measures of heart rate and blood pressure. However, the measures obtained with impedance cardiography (stroke volume, cardiac output, contractility and total systemic resistance) showed differential patterning between the two stressors.

Exercise Compared To Exercise plus Psychological and Cold Pressor Stressors

These sets of analyses were designed to ascertain the effect of combining dynamic exercising with psychological and cold pressor stressors. The second hypothesis stated that dynamic exercise would block the effect of psychological stress on the cardiovascular system. In point of fact, just the reverse was true. The combined effect of psychological stress and dynamic exercise was significantly greater than the sum of individual effects (the classic definition for a positive interaction).

TABLE 9

EXPERIMENT TWO AND THREE

MEAN DIFFERENCES AND POST HOC HOC ANALYSIS OF COLD PRESSOR STRESSOR COMPARED TO RESTING BASELINE

VARIABLE	N	MEAN DIFFERENCE FROM BASELINE	PROBABILITY
SYSTOLIC B.P. mm Hg	14	+15.5	.01
DIASTOLIC B.P. mm Hg	14	+15.9	.01
TOTAL SYSTEMIC RESISTANCE M.A.P./CO	14	+ 3.6	.05

DUNCAN PROCEDURE: Only significant differences reported.

When compared to exercise alone, the effects of the quiz and cold pressor test combined with exercise produced significant increases in systolic and diastolic blood pressure (see Table 10). These significant findings were further scrutinized by employing the same analysis using a floating baseline to which to make comparisons. This involves comparing measurements during the quiz and cold pressor exercise period with the readings taken just prior to the introduction of each stressor, thus controlling for any incidental baseline shifts that could have occurred after the inital baseline recordings. The results again showed the same variables of systolic and diastolic blood pressure significantly increased.

A final test of confidence in the above findings was addressed in the design of experiment 3. The exercise periods were extended to run beyond the cessation of the cognitive and cold pressor stressors, therefore, affording an opportunity to observe if these variables would return to exercise-alone values.

When comparing pre-exercise with exercise plus quiz conditions, there were significant increases in systolic blood pressure, stroke volume, cardiac output and Heather's index of myocardial contractility (see Tables 11 & 12). The exact opposite trends occurred when comparing exercise plus quiz to post-quiz exercising. Systolic blood pressure,

TABLE 10

EXPERIMENT TWO AND THREE

MEAN DIFFERENCES AND POST HOC ANALYSIS OF EXERCISE PLUS QUIZ AND EXERCISE PLUS COLD PRESSOR CONDITIONS COMPARED TO EXERCISE CONDITION ALONE

VARIABLE	MEAN DIFFERENCE FOR EXERCISE QUIZ CONDITION	PROB	MEAN DIFFERENCE FOR EXERCISE COLD PRESSOR CONDITION	PROB
SYSTOLIC B.P. mm Hg	+4.2	.05	+7.5	.05
DIASTOLIC B.P. mm Hg	+3.5	.05	+14.1	.05

DUNCAN PROCEDURE: Only significant variables reported.

TABLE 11

EXPERIMENT TWO AND THREE

SINGLE FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF CHANGES IN EXERCISE PLUS QUIZ COMPARED TO PRE- AND POST-QUIZ EXERCISING

VARIABLE	F	DF	PROB
SYSTOLIC B.P. mm Hg	6.56	2/20	.05
STROKE VOLUME ml	4.73	2/20	.05
CARDIAC OUTPUT l/min	11.37	2/20	.001
CONTRACTILITY Heather's Index	4.06	2/20	.05

Only significant variables reported

N = 6 Ss who participated in all previous conditions but were the only ones to continue to exercise beyond cessation of stress

TABLE 12

EXPERIMENT TWO AND THREE

DIRECTION OF MEAN CHANGE AND POST HOC ANALYSIS OF EXERCISE PLUS QUIZ CONDITION AS IT RELATES TO PRE- AND POST-QUIZ EXERCISE CONDITIONS

	PRE- TO EXPERIMENTAL CONDITION		EXPERIMENTAL TO POST-CONDITION	
VARIABLE	MEAN CHANGE	PROB	MEAN CHANGE	PROB
SYSTOLIC B.P. mm Hg	increases	.05	decreases	.05
STROKE VOLUME ml	increases	.05	decreases	.05
CARDIAC OUTPUT l/min.	increases	.01	decreases	.01
CONTRACTILITY Heather's Index	increases	.05	decreases	.05

DUNCAN PROCEDURE: Only significant variables reported. N = 6 Ss stroke volume, cardiac output and Heather index of myocardial contractility all significantly decreased. These effects are the same as those elicited by the quiz alone, with the exception of total peripheral resistance, and clearly demonstrated treatment effect.

Impedance cardiography derived variables did not differentiate the cold pressor effect during exercise. When comparing the pre-exercise condition to the stress condition, significant increases in heart rate as well as systolic and diastolic blood pressure were noted. These increases were also reversed during the final exercise-alone condition (see Tables 13 & 14). Thus, the presence of significant changes in stroke volume, cardiac output and contractility during the exercise plus quiz condition did not obscure those changes produced by the exercise. This is strong support for the utility of including impedance cardiography derived variables when assessing cognitive events during exercise. This data suggests a possible sympathetic summation effect when the two stressors are combined.

Interactive Potentiation Effects

Interaction effects due to combinations of psychological and cold pressor stressors with physical exercise has yet to be fully tested. This analysis was performed to ascertain whether the cogntive or cold pressor

TABLE 13

EXPERIMENT TWO AND THREE

SINGLE FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES OF CHANGES IN EXERCISE PLUS COLD PRESSOR COMPARED TO PRE- AND POST-EXERCISE CONDITIONS

VARIABLE	F	DF	PROB
SYSTOLIC B.P. mm Hg	7.97	2/20	.01
DIASTOLIC B.P. mm Hg	5.59	2/20	.05
HEART RATE B.P.M.	5.29	2/20	.05

Only significant variables reported

N = 6 Ss who participated in all previous conditions but were the only ones to continue to exercise beyond sessation of stress

TABLE 14

EXPERIMENT TWO AND THREE

DIRECTION OF MEAN CHANGE AND POST HOC ANALYSIS OF EXERCISE PLUS COLD PRESSOR CONDITION AS IT RELATES TO PRE- AND POST-COLD PRESSOR EXERCISE CONDITIONS

	PRE- TO EXPERIMENTAL CONDITION		EXPERIMENTAL TO POST-CONDITION	
VARIABLE	MEAN CHANGE	PROB	MEAN CHANGE	PROB
SYSTOLIC B.P. mm Hg	increases	.01	decreases	.01
DIASTOLIC B.P. mm Hg	increases	.05	decreases	.05
HEART RATE B.P.M.	increases	.01	decreases	.01

DUNCAN PROCEDURE: Only significant variables reported. N = 6 Ss stressor produced a significant interaction with the effect of dynamic exercise.

In order to answer this question, a series of manipulations were performed on the data before they were entered into the analysis of variance. First, the initial baseline value for each variable were subtracted from their corresponding variables in the quiz, cold pressor and exercise alone conditions. This yielded the effect due to quiz, cold pressor and exercise stressors individually. A prediction of the physiological responses to the quiz and cold pressor stressors during exercise can be made by adding the quiz or cold pressor effects to the exercise effect, respectively.

To summarize, the following manipulations were made:

Quiz - Baseline = Quiz Effect
Cold Pressor - Baseline = Cold Pressor Effect
Exercise - Baseline = Exercise Effect
Ex. Effect + Qz. Effect = Predicted Quiz Effect with Exercise.
Ex. Effect + C.P. Effect = Predicted C.P. Effect with Exercise.
Exercise (quiz) - Baseline = Observed Quiz Effect with Exercise
Exercise (C.P.) - Baseline = Observed C.P. Effect with Exercise

The predicted and observed values were compared using a single factor repeated measure analysis of variance. The results showed a significant positive interaction in the observed exercise for the quiz condition in systolic and diastolic blood pressures ($p < .05$). The interaction, which was unique only for the cognitive stressor, produced results that were over and above linear summation of the two stressors. This interaction may be reflective of hyper-compensatory increases in fight or flight mediated by autonomic nervous system activity. In addition, it lends even stronger support of a distinct psychological stressor effect during the exercise condition that is above and beyond linearly summated effects of the individual stressor. This synergism may offer new insights into why exercise appears to be harmful for some people.

CHAPTER IV

DISCUSSIONS AND CONCLUSIONS

Coronary Prone Behavior and Physiological Measures

The investigation of the Type A behavioral construct as it relates to psychophysiological events has been receiving increasing amounts of attention over the past decade. Type A individuals characterized by a pattern of intense hard-driving competitiveness, a chronic sense of time urgency and aggressiveness and hostility, have been shown by several prospective studies to have enhanced risk of developing coronary heart disease in both males and females. The physiological correlates associated with responses to stress and this behavior pattern are at best elusive. Published research does not reveal consistent evidence that Type A persons, when compared to Type B persons, have higher heart rates or diastolic blood pressures while working on tasks (Holmes 1983). Also, increases in systolic blood pressure have only been moderately linked with differences between Type A's and B's, averaging about 6 mmHg. These inconsistencies in findings and small magnitude differences have been difficult to explain and have left many researchers skeptical of the link between Type A behavior and psychophysiological arousal.

Several investigators (Houston, 1983; Glass, 1977;

Manuck et al., 1978) have suggested that the weak psychophysiological correlates may be due to task difficulty (level of challange). For example, Houston suggested that undifferentiated responses between Type A and B persons may be due to a task being either too easy or too hard. Since an easy task would not offer a Type A sufficient challange and an extremely difficult task would lead to giving up, arousal mechanisms would not be activated. Others have tried to explain the possible inconsistencies by pointing out that subjects were tested in different environments along with technical problems in recording and unreliable scoring.

New Cardiovascular Measurement Techniques for Assessing Response to Various Kinds of Stress

The present work demonstrates a new research paradigm for the non-invasive study of cardiovascular responses to cognitive, physical and dynamic exercise stressors as it is related to coronary prone behavior patterns. To date, no studies have been published where the examination of additional hemodynamic measures (i.e., stroke volume, cardiac output, myocardial contractility and total peripheral resistance) have been related to Type A behavior. The traditional measures of psychophysiological arousal (heart rate, systolic and diastolic blood pressure) appear to be able to reliably discriminate only between stress and non-stress conditions, regardless of personality patterns.

The addition of impedance cardiography derived measures used in these studies was essential in discriminating out specific psychophysiological indicies that contributed to predicting coronary prone behavior patterns. Using a stepwise multiple linear regression, results corroborate and build upon the notion that cardiodynamic response patterns elicited by a psychological stressor are predictive of Type A behavior as measured by the Jenkins Activity Survey. This is in support of the initial hypothesis which stated that an interaction would be quite specific for a psychological stressor as opposed to the physical stressor (cold pressor). The quiz apparently represented a more realistic and progressively more difficult goal to compete with and overcome, therfore, cardiovascular mobilization responded accordingly.

Psychophysiological Inconsistencies

Results from the multiple linear regression analysis point to additional reasons that may facilitate our understanding of the inconsistent findings characterizing the psychophysiological arousal literature related to Type A behavior indicies. That is, a change in stroke volume, as evidenced during the psychological stress (quiz) condition, can result in compensatory reactions mediated by either increases or decreases in heart rate, and/or arterial blood pressure. Thus, unreliable changes in the traditional variables that have been used in previous studies may be reflective of more stable changes in the underlying cardiodynamics, such as those variables revealed by impedance cardiography. Thus, stroke volume and total peripheral resistance substantially contributed to the regression equation. This is strong evidence for the inclusion of measures derived by impedance cardiography in studies assessing psychophysiological arousal.

New Applications

Another important conclusion addressed in experiment 1 was the importance of being able to show relationships with a personality pattern by monitoring cardiodynamic changes that occur predominantly in response to a psychological stressor. This psychophysiological approach suggests that it may be possible to enhance the reliability of a paper and pencil personality tests (e.g. Jenkins Acitivity Survey), which characteristically have inherent limitations, such as reliance on self appraisal, by including relevant physiological variables. Some individuals manifesting Type A characteristics are unaware of them, therefore, reliabiltiy and validity can be biased. Having the ability to confirm the pattern of psychophysiological responses that reliably correlates with a paper and pencil personality measurement may offer an additional tool that will assist in verfying patient reports. This tool could also be valuable in accurately assessing behavioral remediation stradegies. For example, if theraputic efforts were aimed at decreasing or altering physiological responses to situations that elicit inappropriate activation of the fight or flight response, one could empirically verify intervention efficacy by examining psychophysiological retest data.

Gender Differences

It should not be overlooked that gender played a major role in the regression equation obtained for Type A scores, accounting for 32% of the variance. This finding supports a growing field of literature suggesting psychophysiological response differences between male and female Type A populations (Lane et al., 1984). Krantz (1981) tested female Type A and B subjects under a variety of conditions. Unlike males studied, female A's and B's did not differ in their heart rate, systolic or diastolic pressure responses to either a cold pressor test or a reaction time task. Lundberg and Forsman (1979, 1980) found that female Type A subjects secreted less epinephrine and reported exerting less effort during a task than did Type A males. They also reported that both male and female Type A's showed a greater task-related differentiation of cortisol secretion (increases during vigilance and decreases during cognitive work) than Type B's. The results from these studies and others suggest that differences may exist between Type A males and Type A females in response to challenging situations. Frankenhaeuser (1980) suggested that during stress, males characteristically secrete more epinephrine than do females. Since the increased skeletal-muscle vasodilation observed in males is most likely mediated by increased plasma epinephrine, gender differences in epinephrine release could account for the differences in response seen in males and females.

Autonomic Control

Stress responses as controlled by the autonomic nervous system are a product of neural activity from diverse cortical and subcortical nuclei. These nuclei cause the release of epinephrine (adrenalin) and norepinephrine (noradrenalin) from the postganglionic sympathetic fibers. They in turn react with several types of receptor sites which are differentially distributed throughout the cardiovascular and cerebrovascular systems, resulting in complex central nervous system modulation of patterned responses to stressful stimuli.

Researchers identifying differences in plasma catecholamines as the possible reasons contributing to gender differences have not addressed other neurochemical hypotheses. Frequently, it is assumed that the amount of plasma catacholamines is reflective of sympathetic activity. This is not necessarily the case, for two reasons. Increased sympathetic activity will be elicited in response to increased release of epinephrine and norepinephrine at the synaptic level. However, at the same time, plasma levels could be low due to an increase in turn over. This phenomenon is evidenced in animal studies (Iverson and Iverson 1981) and may in fact be more reliable in accounting for changes in sympathetic activity (as opposed to plasma concentrations). And secondly, the apparent differential sympathetic responding between genders may be associated with the availablitiy and receptability of catacholinergic receptor sites.

It is apparent that more research is needed to clarify the possible role of the autonomic nervous system in contributing to the gender differences noted within Type A populations. The results in this study support that there is indeed a gender effect, for it surfaced as a strong predictive factor in Type A behavior scores and associated speed and impatience scores. It is interesting to speculate that significant correlations between gender and J.A.S. variables may in fact have an evolutionary basis. That is to say that primitive man and other primates assumed tasks that were gender specific. An example being hunter-gatherer behavior where the males required a high degree of vigilance and short burst of high amounts of activity (autonomic arousal) to successfully hunt animals. Females on the other hand concentrated their efforts on gathering fruits and roots, etc. which required long and enduring expenditures of energy at a reduced levels of strenght. Thus support for future studies using impedance cardiography measures, may facilitate clarification of gender effects by differentiating cardiovascular psychophysiological responses between males and females. This in turn may yield significant improvements in the prediction, prevention and treatment of coronary disease.

Interactive Effects of Exercise and Stressors: Some Practical Applications

Introducing psychological and cold pressor stressors during dynamic exercise while using impedance cardiography to obtain non-invasive measurements of cardiovascular function is a unique aspect of this study. Exercise-induced stress, when compared to a resting baseline, replicated findings obtained by invasive cardiac catherization procedures during sub-maximal stress testing. This pattern consisted of significant increases in heart rate, stroke volume, cardiac output, myocardial contractility and systolic blood pressure. Total systemic resistance significantly decreased probably in response to adaptive mechanisms known to activate dialation of skeletal-muscle arterial supplies and associated vasoconstriction of peripheral vascular beds for maintainance of the internal milieu during exercise. The decrease in diastolic blood pressure is not unusual and frequently accompanies sub-maximal testing.

Exercise Plus Psychological Stress

The addition of either a psychological or cold pressor stressor to the exercise condition clearly caused significant changes when compared to exercise alone. These results appear to represent an additional autonomic arousal and included increases in stroke volume, systolic and diastolic blood pressure. In fact, significant interactive potentiation (increases) of systolic and diastolic blood pressures during the exercise plus quiz condition was evidenced. This potentiation, which was not present for the exercise plus cold pressor condition, is an important result. The fact that a cognitive stressor in combination with dynamic exercise increases apparent sympathetic effects significantly above and beyond those effects that can be accounted for by either stressor alone is a new finding. This interaction may be indicative of hyper-compensatory increases in either catcholamine release or receptor availability (or both).

Today, many individuals participate in exercise programs designed to enhance the integrity of their cardiovascular systems. Often, these individuals are ruminating over stressful problems or are competing with the clock or other individuals. It is conceivable, in light of these current results, that those individuals may be at risk for developing stress-related cardiovascular problems. This might be due to sympathetic potentiation inducing inappropriate modulation of such parameters as systolic and diastolic blood pressures. Thus, comprehensive exercise programs that promote fitness may well have to address such issues as attitude and cognitive style employed by participants in order to reap the maximum positive effects.

The Paradoxically Stressful Effects of "Relaxation"

Self-relaxation, which involves asking the subject to simply relax using whatever means possible, is assumed by many researchers to be reflective of a decrease in sympathetic tone along with associated increases in parasympathetic activity. Data collected in this study showed significant increases in systolic and diastolic blood pressure from a resting baseline to the self-relaxed condition. These increases, which were similar to those observed during the psychological stressor, replicate the phenomenon that self-relaxation instructions are a form of cognitive stress probably brought about by the demand characteristics of being asked to relax when one has no formal relaxation training. Thus, researchers should treat the initial (pre-training or intervention) self-relaxation instructions as a stressor. This can have applications in behavioral medicine remediation programs, for if a patient were asked to self-relax (without aid) at the beginning of each biofeedback session, one would have a potential way of monitoring learning and self-regulatory abilities over time.

In conclusion, this research demonstrated that if we apply more sophisticated measures to cardiovascular function, as obtained by impedance cardiography, we can clarify more precisely distinctive psychophysiological patterns of arousal that relate to Type A behavior. The use of such measures, which also aid in identifying the role that psychological stress plays during exercise, can enhance our understanding of human response to stress and how this relates to the complex condition known as coronary heart disease.

Appendix 1

Oral Quiz

Instructions: You will now be given an oral test. You will be asked a series of questions, each requiring a short answer. You must tell your response aloud, within the allotted time. After the allotted time, the correct answer will be given, and then a new question will be asked. If you should miss a question, simply go on to attend to the next question. A sample question is: Question: Five plus five equals? (pause) Answer: Ten.

You are asked to make a determined effort to complete the test, but if you wish you may stop at any time. If you develop any discomfort or chest pains, you must report this to the doctor in attendance, immediately.

The test is designed to evaluate your ability to learn and to use information wisely as compared to other individuals your age. A perfect score is indicative of genius, and few are expected to attain that level. If any mental dificiencies are noted you wll be given the opportunity for further evaluation. Your final evaluation will be revealed to you, but only after the completion of all test procedures.

Do you have any questions? (pause) We will now begin.

Oral Quiz Questions

Question number 1: Complete the following sequence: 2, 7, 12, 17 blank? Answer - 22.

Question Number 2: If X is greater than Y, and Y is greater than Z, then X is blank than Z? Answer - Greater than.

Question Number 3: Wheel it to car as blank is to sleigh? Answer - Runner.

Question Number 4: Which is more, ten, or two times 4.5? Answer - Ten.

Question number 5: Music and sculpture are both blank? Answer - Art.

Question number 6: Fill in the blank. Far is to near as tall is to blank? Answer - short.

Question number 7: Which word does not have the same meaning as the other words: eminent, vulnerable, distinguished, outstanding? Answer - Vulnerable.

Question number 8: Repeat backwards: 1, 5, 7, 9? Answer - 9, 7, 5, 1.

Question number 9: If Y is greater than X, and Z is less than X, then Z is blank than Y? Answer - Less than.

Question number 10: H O is to water as CO is to blank?

Answer - Carbon dioxide.

Question number 11: Who wrote the novel A Fable? Answer - William Faukner.

Question number 12: Kite is to fly as boat is to blank? Answer - Sail.

Question number 13: Two-thirds of seven is blank? Answer - Four and two-thirds.

Question number 14: A man earns $75 dollars a week; his wife earns $20 dollars a week. How much do they earn together? Answer - $95.

Question number 15: Who wrote Paradise Lost? Answer - John Milton.

Question number 16: What state borders Colorado on the North-East? Answer - Nebraska.

Question number 17: Who said, "The ballot is stronger than the bullet?" Answer - Abraham Lincoln.

Question number 18: A prerogative is a blank? Answer - A privilege.

Question number 19: Who wrote The Iliad? Answer - Homer.

Question number 20: Complete the following sequence: 7, 9, 13, 19, blank? Answer - 27.

Question number 21: How are the numbers 16 and 121 similar? Answer - 16 if the square of 4 and 121 is the square of 11.

Question number 22: Which of the following words have the same meaning: vascillate, cultivate, hesitate, and matriculate? Answer - Vascillate and hesitate.

Question number 23: The biological function of the fruit of a plant is usually blank? Answer - To distribute the seeds.

Question number 24: If Bob had one-seventh of Mary's amount and Mary had 32, then how much did Bob have? Answer - Four and four-sevenths.

Question number 25: Twenty-five coins consisting of nickels and dimes equals two dollars. How many of each kind are there? Answer - 10 nickels and 15 dimes.

Question number 26: Freedom and justice are both blank? Answer - rights.

Question number 27: The probability of "A" winning a race is one-third; and the probability of "B" winning is one-forth. What is the probability that neither will win? Answer - 50%.

Question number 28: Which two words have similar meanings: greed, stupidity, lavishness, and cupidity? Answer - Greed and cupidity.

Question number 29: Home is to family as school is to blank?

Answer - class.

Question number 30: James Ford Rhodes is a famous blank?

Answer - Historian.

Question number 31: If John had three times as many dollars as Bill, but then gave one-half of his dollars to Bill, the Bill would have how many times his original amount?

Answer - one and one-half times.

Question number 32: In what field did Arthur D. Hershey win the Nobel prize? Answer - Medicine.

Question number 33: Complete the following sequence: C, E, H, L, blank? Answer - Q.

Question number 34: The intensity of the heat of an object is referred to as its blank? Answer - Temperature.

Question number 35: If Y is greater than X divided by 2, and Z is less than X divided by 2Y, then Z must be Blank?

Answer - Less than 1.

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