CO-VARIATION OF

BLOOD PRESSURE AND MOOD

IN THE NATURAL ENVIRONMENT

By

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Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfullment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Psychology

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August, 1985

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ABSTRACT

Current clinical diagnostic procedures may lead to an over-identification of hypertension. The lack of a comprehensive assessment may also lead to difficulty in timing cognitive-behavioral interventions to coincide with periods when blood pressure is most elevated. The goals of the current study were (a) to determine if a laboratory relaxation procedure would be capable of discriminating those individuals who generally have elevated blood pressure from those who react with increased blood pressure specifically to laboratory assessment, and (b) to identify "markers" of emotional states which would enable individuals to determine when their blood pressure was elevated.

Fifty-one undergraduate students at Virginia Tech volunteered to participate in a two-hour laboratory session consisting of baseline blood pressure measurements, a relaxation procedure and a battery of psychological questionnaires assessing anger, anxiety and Type A. This was followed by a two-day self-monitoring period consisting of approximately twelve self-reports of mood state concurrent with blood pressure measured by a portable, semi-automatic monitor.

Results suggested that blood pressure response to the laboratory relaxation procedure was associated with the difference between average ambulatory blood pressure and laboratory blood pressure for diastolic blood pressure only. Anger arousal and anger expression were unrelated to either average ambulatory blood pressure or high versus low ambulatory blood pressure readings. Perceptions of the environment as hostile and demanding did discriminate between high versus low systolic blood pressure and diastolic blood pressure readings. A cluster of negative moods discriminated between high and low systolic blood pressure readings. A cluster of moods characteristic of the Type A behavior pattern also discriminated high versus low systolic blood pressure readings as well as high versus low heart rate readings.

One of the clearest findings of the study was the relationship between the type of analysis used and the probability of finding an association between psychological variables and blood pressure. In general, across subject analysis yielded fewer significant relationships than analyses emphasizing within subject variation. Exploring this further, two case studies are presented which illustrate statistical procedures for analyzing the relationship between blood pressure and mood in single case designs.

ACKNOWLEDGEMENTS

The pursuit of knowledge is rarely a singular effort. This research is no exception. I wish to thank my committee chairman, Dr. Richard Eisler, for his insight, critical evaluation and commitment to insuring that this study reached successful completion. I would also like to express my gratitude to Drs. Winett, Ollendick, Labbe', Herbert, and Hendricks for their support and guidance. The assistance provided by my friend and colleague is especially noted. Finally, I wish to extend my deepest gratitude to my wife, whose love and support has sustained me throughout this project.

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PREFACE

"The doctor of the future will give no medicine, but will interest his patient in the care of the human frame, in diet, and in the cause & prevention of disease."

Thomas Edison

Health care is in transition. Through the science of modern medicine, many of the once catastrophic diseases such as the plague, small pox, yellow fever and polio have been eliminated as major public health problems. This breakthrough has been permitted by the development of public sanitation procedures and agent-specific drugs capable of destroying the micro-organisms responsible for these diseases.

Health care now faces a different challenge. While the elderly once died of pneumonia - the old man's friend, they now suffer from a series of chronic disorders, most notably cardiovascular disease. Cardiovascular disease, and the related problem of cerebrovascular disease, also strike the young and middle-aged. Despite the best efforts of the medical community, it has proven difficult to stop the progression of such disease states and even more difficult to reverse the damage already incurred.

The most notable characteristic of cardiovascular disease is its complexity. It may arise from the singular presentation, or a combination of a wide variety of etiological agents. Rather than

micro-organism, many of these agents are best described as patterns of interaction between the individual and the environment. Risk factors for cardiovascular disease include hypertension, cigarette smoking, hypercholesterolemia, the male sex, age, a sedentary lifestyle, diabetes mellitus, and a "coronary-prone behavior pattern". Research suggests that these risk factors are additive and that they often occur in combinations.

The focus of this proposal will be on one of the major risk factors for cardiovascular disease: hypertension. Hypertension has traditionally been viewed as a medical problem. This was supported by the wide variety of medical conditions whose signs include elevated blood pressure. However, only a small percentage of individuals with elevated pressures had co-existing medical problems that could be identified. A large proportion of the hypertensive population was therefore labeled "essential hypertensives" meaning chronically elevated blood pressure of unknown cause.

> "It is much more important to know what sort of patient has a disease than what sort of disease a patient has."
>
> Sir William Osler

Clinicians and researchers interested in the development and progression of hypertension have long suspected its association with specific personality characteristics. Perhaps most notable is Alexander's "suppressed hostility" hypothesis. More recent investigators have focused on how the individual interacts with the environment, particularly in socially stressful situations.

Cognitive/behavioral treatment approaches have generally focused on decreasing blood pressure through relaxation, biofeedback and other stress management procedures.

Findings from the field of psychophysiology have helped to bridge the gap between the pathophysiology of hypertension and psychological functioning. Particularly important are schema such as Schwartz's systems' approach to blood pressure regulation, which enhance our ability to place data from interdisciplinary research into perspective.

> "No greater popular fallacy exists about medicine than that a drug is like an arrow that can be shot at a particular target. Its actual effect is like a shower of porcupine quills."
>
> Norman Cousins

In contrast to the microbial agents, which are generally susceptible to one or more specific pharmacological treatments, the complex pathophysiological basis of hypertension requires greater pharmacological sophistication. Due to variations in pathophysiology, what is effective for one person may not be effective for another. Side effects of medications also vary from one person to another and may be such that either the physician or the client discontinues treatment.

Cognitive/behavioral approaches to hypertension suffer few negative side effects. They do however, suffer from the same lack of specificity. This is a consequence of an incomplete conceptualization of the psychophysiology of hypertension as well as from a lack of

tailoring treatment to the individual's specific needs. Both concerns suggest the need for a more thorough assessment of the relationship between psychological variables and blood pressure from both a nomographic and idiographic approach.

It will be the task of this proposal to review psychological aspects of hypertension's development and progression. From this review, a research proposal will be put forth.

Section I

AN OVERVIEW OF PRIMARY HYPERTENSION

Hypertension designates a chronic elevation of arterial blood pressure (BP) above age-sex norms. Considerable epidemiologic evidence exists documenting the increased risk for both coronary heart disease and cerebrovascular disease attributable to hypertension (Kannel, 1977; Pooling Project Research Group, 1978; Society of Actuaries, 1980). In approximately 5 - 10 % of all cases, the etiology of hypertension can be traced to renal, endocrine or vascular deficits and is therefore labeled "secondary hypertension" (Kaplan, 1982). In the remaining 90 - 95% no direct etiological linkage can be made. Thus, the majority of hypertensive cases are described as primary or essential hypertension (see Table 1). For the purposes of clarity and consistency, the term "primary hypertension" will be used throughout this paper when reference is being made specifically to this subset, whereas "hypertension" will indicate a reference to elevated blood pressure with no distinction as to etiology.

The Diagnosis of Hypertension

Considerable debate has centered around attempts to distinguish normal from abnormal blood pressure. Epidemiological data from the Framingham Study strongly suggests a continuum of risk between blood pressure and mortality (Kannel & Sorlie, 1975). Such data led Sir George Pickering to argue that "there is no dividing line. The relationship between arterial pressure and mortality is quantitative; the higher the pressure, the worse the prognosis" (Pickering, 1972).

Table 1

Types of Hypertension

Primary Hypertension

Proportion of all hypertensive cases: 90-95%

Etiology: No specific etiologic abnormality identified.

Secondary Hypertension

Proportion of all hypertensive cases: 5-10%

Etiology: A wide variety of renal, endocrine and neurological disorders including renal parenchymal disease, hyperthyroidism, Cushing's syndrome, coarctation of the aorta, increased intracranial pressure and acute stress such as alcohol withdrawal and surgery.

Note: Adapted from Kaplan, N. M. (1982). Clinical Hypertension, p.13, Table 1.5.

Despite such evidence, the medical community in a search for a pragmatic method of distinguishing normal from abnormal blood pressure levels, has struggled to adopt clear guidelines. The World Health Organization's official criteria are outlined below.

Normotension: Systolic <140 and Diastolic <90 mm Hg

Borderline: Systolic 140 - 160 and Diastolic 90 - 95 mm Hg

Hypertensive: Systolic >160 and/or Diastolic >95mm Hg

Thus, an artificial yet somewhat functional set of criteria are used to diagnose hypertension. It should be noted that these criteria do not adjust for age or sex. Based on data demonstrating significant increases in mortality at different blood pressure levels for various age and sex groups, Kaplan (1982) suggests somewhat different criteria. According to Kaplan's criteria, hypertension should be considered to exist when:

Males: Under 45 years old, blood pressure >140/90 mm Hg

Males: Over 45 years old, blood pressure >140/95 mm Hg

Females: All ages, blood pressure >150/95 mm Hg

The ultimate criteria to which all pragmatic definitions should adhere is that suggested by Rose (1980). "The operational definition of hypertension is the level at which benefits ... of action exceed those of inaction". Such a definition recognizes both the continuum of risk associated with increases in blood pressure as well as the potential for harm associated with most if not all medical intervention. Thus, refinements in the diagnostic criteria for hypertension will have to be made as controlled clinical trials demonstrate the benefits of various interventions along the spectrum of the blood

pressure distribution.

Prevalence of Hypertension

Prevalence data is available from the U.S. Public Health Service Health and Nutrition Examination (HANES) survey from 1971 - 1974 (Roberts, 1977) and the Community Hypertension Evaluation Clinic Program (Stamler, Stamler & Riedlinger, 1976). The HANES survey reported a prevalence rate of 15-20% of the adult U.S. population based on the frequency of elevated systolic (SBP) as well as diastolic blood pressure (DBP). The Community Hypertension Evaluation Clinic Program found that 24.7% of the 1 million persons they studied had diastolic blood pressures elevated above 90 mm Hg.

The Hypertension Detection and Follow-up Program (1977) screened 158,906 individuals age 30-69 and found that approximately 25.3% had a DBP exceeding 90 mm Hg at the initial home screening. Those with initial pressures above 95 mm Hg were invited to a clinic for an additional measurement. About 1/3 of these had rescreening pressures below 90 mm Hg. This left an estimated 6.4% of the originally screened population with DBP equal to or greater than 95 mm Hg.

These surveys suggest that approximately 15-20% of the U.S. adult population will exhibit elevated blood pressure at initial screening. When a second screening is performed there is a dramatic fall in the percentage of individuals diagnosed as hypertensive (HDFP, 1977). Thus, the true prevalence of hypertension may be less than initial screenings suggest.

The Public Health Challenge

Current estimates suggest that 25-30% of all hypertensive

individuals are unaware of their condition and that only 35-45% of the total hypertensive population is adequately controlled (HDFP, 1977; Stamler et al., 1976). This problem is probably most noted in those with minimal elevations.

Diastolic blood pressure in the mildly elevated range is clearly a public health concern. It is estimated that about 71% of all hypertensive individuals fall into the 90-104 mm Hg range (HDFP, 1977). Approximately 42% of the total deaths due to hypertension can be attributed to this category of hypertensives (HDFP, 1977).

Borderline or mild hypertension also represents a therapeutic challenge. Recent clinical trials have clearly documented the long-term value of treating diastolic values consistently greater than 90 mm Hg (HDFP, 1979; V.A. Cooperative Study Group on Antihypertensive Agents, 1970 & 1972). However, the costs and benefits of pharmacological therapy for men under 50 years of age and for women has not been clearly delineated (Kannel et al., 1984). Concern also remains as to the value of treating those whose blood pressure only occasionally ventures into the mildly hypertensive range.

Pharmacologic interventions to lower blood pressure are not without their drawbacks. Most antihypertensive agents have several short-term side effects and the long-term adverse consequences of their use have not yet been clarified. Frequent reasons for discontinuation of antihypertensive medication include fatigue, cold peripheries, sedation, mental depression and impotence (Taylor, 1984). The long term administration of diuretics and beta-blocker agents is also related to a potentially deleterious change in the HDL/LDL profile

(Taylor, 1984). Finally, there is evidence from the MRFIT study that at least one class of commonly used antihypertensive agents (diuretics) may be related to higher cardiovascular risk in those with resting EKG abnormalities (MRFIT, 1982).

There is, therefore, reasonable doubt that the benefits of pharma-therapeutic intervention for individuals with blood pressures only occasionally in the hypertensive range will outweigh the potential adverse consequences inherent in such treatment. This poses a considerable therapeutic dilemma for the average practicing physician. The remainder of this review will focus on such clinical presentations.

Borderline Primary Hypertension

As noted above, borderline hypertension is defined by the World Health Organization as systolic values between 140-160 mm Hg and diastolic values between 90-95 mm Hg. Some researchers and clinicians however, utilize different categorizations. Hence, clear data on the prevalence of borderline versus mild hypertension are not easy to find. Julius and Schork (1971, P.750) suggests that "the prevalence of borderline hypertension is substantial and the practicing physician can expect to face this therapeutic dilemma in at least 10% of all his patients." Julius and Schork's statements are based on single or average BP between 90-110 mm Hg diastolic and 150-160 mm Hg systolic with occasional readings in the normal range. Also required was the lack of target organ damage. Other data cited in the Hypertension Detection and Follow-up Program Cooperative Group report of 1979, suggest that about 70% of all hypertension can be considered mild. Mild was defined as DBP between 90-104 mm Hg.

The distinction between mild and borderline hypertension is also confused by the changing level of blood pressure within individuals. A recent consensus on the diagnostic workup for hypertension is included in the "Guidelines for the Treatment of Mild Hypertension: A WHO/ISH Memorandum" (1983). They define mild hypertension as diastolic pressure (phase V) between 90-105 mm Hg on a persistent basis. Guidelines are provided for securing repeated measurements so that only those with DBP which persist in this range are considered mildly hypertensive. Those whose DBP reverts to the 90-95 mm Hg range are considered "borderline" cases in whom clinical judgement must determine the therapeutic focus.

Despite the difficulties of determining who has borderline versus mild hypertension, it is clear that those whose blood pressure periodically reaches the hypertensive range are at greater risk of subsequently developing hypertension than those whose blood pressure does not venture over the 90 mm Hg mark. Estimates by Julius et al. (1980) suggest that about 20% of those with occasional mild elevations of blood pressure will go on to developed fixed elevations. In a prior review (Julius and Schork, 1971), it is suggested that this is twice the rate at which those with normal blood pressure subsequently develop fixed elevations. Additional support arises from the study by Paffenbarger, Thorne and Wing (1968) which found that the best predictor of future hypertension is the current blood pressure level.

Pathophysiology and Natural History

Again, the lack of clarity regarding the precise definition of borderline hypertension makes it difficult to generalize as to

the differential pathophysiology and natural history of borderline hypertension. In the review below, borderline hypertension is generally described as transient elevations of blood pressure into the mild hypertensive range (i.e. 140-150/90-100 mm Hg).

In order to adequately review the information to follow, one must be aware of a few basic relationships.

Blood pressure = (Cardiac Output) (Total Peripheral Resistance)

Cardiac Output = (Heart Rate) (Stroke Volume)

Total Peripheral Resistance = Resistance of total vascular space which is determined by arterial vasoconstriction.

Sympathetic Nervous System Overactivity. The hemodynamic abnormalities noted in borderline hypertensives may have their roots in an overactive sympathetic nervous system. Spontaneously hypertensive rats have a rapid increase in sympathetic activity with age (Judy, Watanabe, Henry, Besch, Murphy & Hockel (1976). This is countered by baroreceptor feedback in those rats less than 16 weeks old. However, in older rats, the ability of baroreceptors to control sympathetic activity diminishes with subsequent increases in blood pressure.

Kaplan (1982) reviewed the role of sympathetic activity in primary hypertension in humans. The evidence includes higher plasma norepinephrine levels in some hypertensives (Engelman, Portnoy, & Sjoerdsma, 1970), enhanced pressor reactivity to exogenous norepinephrine in young hypertensives (Gramm, Weidmann, & Keusch, 1980), and enhanced postjunctional alpha-receptor-mediated vasoconstriction (Ammann, Bolli, & Kiowski, 1981).

Hemodynamics. Julius, Hansson, Andren, Gudbrandsson, Sivertsson and Svensson (1980) reviewed the pathophysiology of borderline as compared to fixed hypertension. In most studies of borderline hypertensives, blood volume is normal or slightly reduced. In approximately 30-50% of borderline patients, cardiac output exceeds that found in control subjects by 2 standard deviations of more. It remains unclear whether this increased cardiac output is due to an increase in heart rate or an increase in stroke volume. Both mechanisms however, are heavily influenced by the balance of sympathetic and parasympathetic activity. Julius et al. (1980) suggest that the high cardiac output is mediated centrally by an increase in sympathetic and a decrease in parasympathetic stimulation rather than by local changes in sensitivity to cardiac stimulation. Thus, CNS mediation may be an important factor in those patients with a high cardiac output.

The review by Julius et al. (1980) also finds that peripheral resistance is normal or only slightly reduced in most borderline hypertensives. This is an important finding since homeostatic feedback loops would generally lower the peripheral resistance to return the system to normotensive levels. Thus, peripheral resistance is "inappropriately" high given the elevated cardiac output.

Historically, blood pressure lability was seen as a unique characteristic of borderline hypertension. More recent evidence questions this association. Analyzing data from the Framingham Study, Kannel, Sorlie and Gordon (1980) found that those with more severe hypertension had greater lability in their pressures than those with borderline pressures. Horan, Kennedy and Padgett (1981) using 24-hour ambulatory

monitoring techniques found that the blood pressure of borderline hypertensives was no more labile than that of normotensives or those with moderate to severe hypertension.

A number of studies have noted a direct relationship between age and blood pressure lability (Kannel, Sorlie & Gordon, 1980; Horon, Kennedy & Padgett, 1981; Drayer, Weber DeYoung & Wyle, 1982). The significance of such lability remains unclear however, since the variability of blood pressure during a one hour observation period did not add to the ability of baseline blood pressure to predict subsequent hypertension in the Framingham population (Kannel, Sorlie & Gordon, 1980).

An understanding of the pathophysiology of borderline hypertension may be enhanced by a system's level approach. One of the most complete conceptualizations is Schwartz's model of blood pressure disregulation.

Disregulation. Schwartz et al. (1979) provided an integrated systems model of blood pressure regulation. This model is designed to make a conceptual linkage between the psychological and biological basis of hypertension.

Five levels of analysis are described (see Figure 1).

Level 1 consists of the blood pressure parameter itself.

Level 2 describes the hemodynamic patterns, such as cardiac output and peripheral resistance, which produce various blood pressure levels.

Level 3 describes the regulation of these hemodynamic patterns by peripheral organ activity such as the heart, kidneys

and vasculature.

Level 4 consists of peripheral humoral and neural mechanisms which determine organ activity. These mechanisms include the sympathetic and parasympathetic nervous systems and circulating hormones.

Level 5 describes central nervous system processes which generate the peripheral neural/humoral activity.

Each of these subsystems plays a role in the regulation of blood pressure. Feedback loops within and between subsystems provide communication regarding the current status of each component of the system. Such feedback provides the basis for homeostatic regulation of blood pressure at Level 1. It must be remembered, however, that blood pressure is not the sole product of such regulatory systems, but rather is one of many physiological parameters operating at Level 1.

Schwartz's concept of blood pressure disregulation describes the failure of the subsystems to maintain blood pressure homeostasis. Such failure may result in an increase in blood pressure. Although disregulation may be initiated in any or several of the 5 subsystems, negative feedback loops will attempt to maintain homeostasis.

To override the homeostatic mechanism, a very strong destabilizing factor must occur at one level or several agents must act simultaneously at multiple levels. An example of the former would be pheochromocytoma, a tumor located in or next to the adrenal gland. By disregulating the hormonal system at Level 4, this localized agent can produce severe hypertension. An example of several agents acting at different levels might be exemplified by excessive anger arousal (Level 5) superimposed

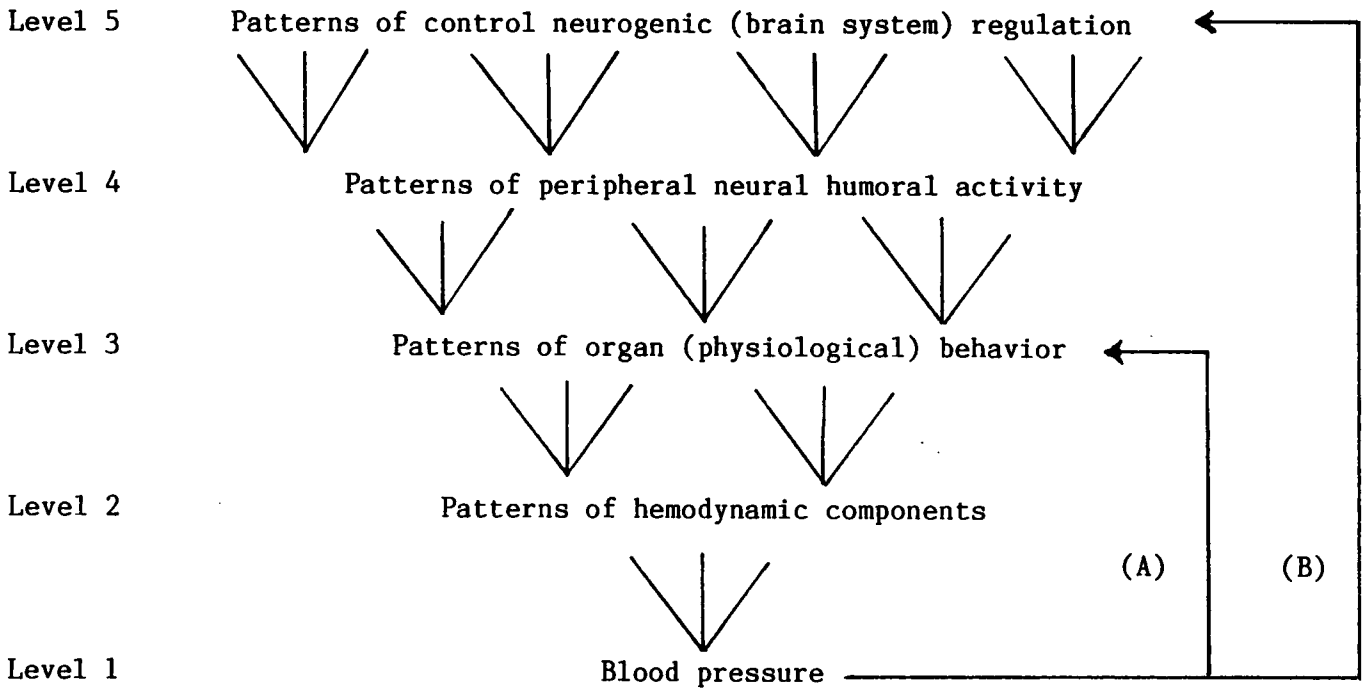

Figure 1. Regulation of blood pressure: Levels of analysis. From "Cardiovascular psychophysiology: A systems perspective", by G. E. Schwartz, in J. T. Cacioppo & R. E. Petty (Eds.), Perspectives in Cardiovascular Psychophysiology, 1982, p. 358. New York: The Guilford Press.

upon a genetic predisposition to sodium sensitivity (Level 3).

This etiologic heterogeneity has important implications for the study of hypertension. Not only are there dozens of potential causes for secondary hypertension, there are also numerous pathways in which primary hypertension can develop. In addition to the etiologic heterogeneity, the physiological basis of elevated blood pressure may change as the disease progresses. Current hypotheses suggest that early borderline hypertension may be characterized by increased cardiac output while fixed hypertension is characterized by increased total peripheral resistance. Hypertension is therefore a heterogeneous disorder both in its etiology and progression.

Schwartz's conceptualization of blood pressure regulation, along with current knowledge of the pathophysiology of hypertension, suggests that many variables influence the current blood pressure level. It is not therefore surprising that blood pressure undergoes considerable variation throughout a 24-hour period. Concern regarding the representativeness of casual blood pressure readings led to the development of alternative measurement techniques and protocols.

Comparison of Casual Blood Pressure and Average Daily Pressures

In the 1960's, investigators began to investigate the relationship between blood pressure levels as measured in the physician's office and blood pressure levels taken while the patient was engaging in his customary activities. Technical considerations tended to be the limiting factor in the development of this field of investigation.

One of the first lines of assessment taken was the direct measurement of arterial blood pressure via an indwelling catheter

(Bevan, Honour & Stott, 1969; Littler, Honour, Sleight & Stott, 1972; Wertheimer, 1976). These studies documented a considerable variation in blood pressure throughout the day (Mancia et al., 1983). Bevan, Honour and Stott (1969) reported that the highest blood pressure was usually more than twice the lowest blood pressure. Several of these studies also reported that casual blood pressure measurements in the physician's clinic did not reflect the patient's average daily blood pressure and in most cases was actually lower (Irving, Brash, Kerr & Kirby, 1976; Littler, Honour, Pugsley & Sleight, 1976).

These observations have been supported by studies using an indirect monitoring procedure. Recognizing the limitations of invasive techniques such as the indwelling catheter, investigators in the 1960's were also developing portable devices which assessed blood pressure via a cuff and microphone arrangement (Kain, Hinman & Sokolow, 1964; Harshfield, Pickering & Laragh, 1979a; Harshfield, Pickering & Laragh; 1979b; Sheps, Elveback, Close, Kleven & Bissen, 1981; Corsi, Germano, Appolloni, Ciavarella, de Zorzi & Calcagnini, 1983; Gould et al., 1983).

One of the clearest findings of these studies is that ambulatory blood pressures are generally lower than casual readings taken in the medical office (Kain, Hinman & Sokolow, 1964). Floras, Jones, Hassan, Osikowska, Sever and Sleight, (1981) found that 20 out of 59 "hypertensive subjects" had ambulatory pressures in the normotensive range. McCall and McCall (1981) found that 32 out of 62 individuals having blood pressures greater than 140/90 mm Hg in the office had normotensive ambulatory monitoring.

Further work by Harshfield, Pickering, Kleinert, Blank and Laragh (1982) showed that although the Pearson correlation coefficients between clinic blood pressure and ambulatory blood pressure are high ($r=0.54$ for systolic and $r=0.61$ for diastolic; $p < 0.01$ for both), such correlations explain less than 37% of the variance. They concluded that "casual or clinic pressures are in fact relatively poor predictors of the average 24-hour pressures (p. 242)." This conclusion is supported by the work of Des Combes, Porchet, Waeber and Brunner (1983) who found that "individual ambulatory pressures could not be predicted from office readings (p. 110)" and Des Combes, Porchet, Biollaz, Schaller and Brunner (1984) who found that only 39% of 245 "hypertensive" patients had elevated ambulatory systolic blood pressures and only 44% had elevated ambulatory diastolic pressures.

One potential objection to the use of ambulatory blood pressures in clinical practice is the predominant use of casual blood pressure readings in prospective epidemiological studies of hypertensive endpoints. Sokolow, Werdegar, Kain and Hinman (1966) studied 124 mild to moderate hypertensive patients to find out if ambulatory blood pressures truly reflect an individual's risk of hypertensive complications. They found that the severity of complications was significantly correlated with casual blood pressure readings ($r=0.52$) and to an even greater extent with ambulatory blood pressures ($r=0.68$). Thus, ambulatory blood pressures were able to explain approximately 45% of the variance as compared to 27% for casual readings.

Perloff, Sokolow and Cowan (1983) followed this finding with a life-table analysis of the prognostic value of ambulatory pressures.

As expected, a high proportion (78%) of the patients had higher casual blood pressure readings than ambulatory readings. Individuals were classified as having ambulatory blood pressure above or below their casual blood pressure levels. Life-table analysis revealed that those whose ambulatory blood pressures were higher than predicted by their casual blood pressures, had a higher cumulative morbidity and mortality over the subsequent 10 year period. Thus, ambulatory blood pressures may actually be better predictors of cardiovascular risk than casual blood pressures.

Devereux et al. (1983) demonstrated the importance of sampling blood pressure levels from specific parts of a subject's day. They demonstrated that blood pressures taken during the workday had considerably better correlations with left ventricular hypertrophy than blood pressures taken in the physician's office, blood pressure during sleep, blood pressure while at home or 24-hour blood pressure averages. Devereux et al. findings suggest that work blood pressure determinations may represent the best indicator of a person's cardiovascular reactivity to stress in the natural environment.

Clearly, ambulatory blood pressure monitoring provides important insights into an individual's average daily blood pressure as well as the potential to study factors related to variability in blood pressure. The recommendation proposed by most of these investigators is to use ambulatory monitoring as an assessment technique to reduce the high false positive rate of hypertensive screening. Ambulatory monitoring however, is an expensive technique both in terms of the cost of the equipment ($6,000 to $15,000) and in the emotional cost

of carrying a bulky and visible measuring device throughout the day. An alternative technique for assessing daily blood pressures is self-monitoring by the patient.

Self-monitoring of Blood Pressure

Gould, Keiso and Raftery (1980) compared intra-arterial blood pressure recordings with self-monitoring of home blood pressure using anaeroid sphygmomanometers. Findings from 34 subjects suggest that systolic blood pressures are quite comparable between the two types of recordings. Diastolic blood pressures tended to be somewhat higher with self-recording at home. Although the authors do not discuss possible reasons for this, it seems reasonable that this could be due to the use of Phase IV as the diastolic point or the inability of subjects to adequately determine the cessation of Korotkoff sounds.

The relationship between the frequency of intermittent indirect blood pressure measurements and direct intraarterial measurements was studied by di Rienzo, Grassi, Pedotti and Mancia (1983). They found that indirect blood pressure readings as far apart as 1 hour over a 24-hour period were generally within 2-3 mm Hg of the average blood pressure assessed directly from the artery. This study provided important documentation of the capacity of automatically inflated ambulatory blood pressure monitors and self-monitoring techniques to accurately assess blood pressure if measurements are performed as infrequently as every hour.

Findings from self-monitoring studies provide additional support for the observation that clinic pressures of hypertensive patients are generally higher than average daily levels (Julius et al., 1974;

Laughlin, Sherrard & Fisher, 1980; Beckman, Panfilov, Sivertsson, Sannerstedt & Andersson, 1981). The study by Laughlin, Sherrard and Fisher also demonstrated that those having the greatest increase in diastolic pressure from home to the clinic were more likely to be borderline hypertensive rather than moderately hypertensive.

These high diastolic reactors, however, were no more anxious than others when assessed by the Taylor manifest anxiety scale (Laughlin et al. (1980). The study by Julius et al. (1974) failed to find a relationship between heart rate in the physician's office and the likelihood that they would have lower self-monitoring pressures. Heart rate and self-report of anxiety level are therefore, unlikely to be good indicators of an individual's cardiovascular reactivity to blood pressure measurement in the physician's office.

In an attempt to better understand why blood pressure is generally higher in the physician's office, several studies have attempted to examine blood pressure changes during office visits. Mancia et al. (1983) found that blood pressure rose in both normotensive and hypertensives when the physician arrived in the office. The magnitude of the response was unrelated to age, sex, baseline blood pressure or blood pressure variability. The blood pressure generally returned to slightly above pre-visit values by the end of the visit. Subsequent visits by the same physician resulted in almost identical cardiovascular reactivity by the subject. Thus, desensitization seemed to occur within visits but not across visits.

The therapeutic benefits of self-monitoring have been noted for several decades. Self-monitoring of blood pressure may directly

lead to a small reduction in blood pressure (Laughlin, Fisher & Sherrard, 1979; Glasgow, Gaardner, & Engel, 1982). It is unclear whether this represents a desensitization to the instrumentation and assessment process or a simple form of biofeedback (Wadden, Luborsky, Greer & Crits-Cristoph, 1984).

In addition, there is the possibility that self-monitoring will increase an individual's sense of self-control over the disorder and possibly increase compliance to medical prescriptions (Wilkinson & Raftery, 1978). Research has also shown that self-monitoring can be used by the patient to adjust medication dosage in conjunction with the physician (Wilkinson & Raftery, 1978). A survey of 95 hypertensive patients who were self-monitoring their blood pressure found that 48 were willing to continue such self-monitoring indefinitely (Wilkinson & Raftery, 1978).

A potential hazard of self-monitoring is the possibility that patients will develop anxiety regarding their next reading (Lancet, 1975). Initial survey data suggests that this is unlikely (Lancet, 1975).

Section Summary

A large portion of the general population have blood pressures which transiently or consistently exceed the artificial demarcation for hypertension. Borderline or "transient" hypertension is often characterized by an increased cardiac output subsequent to increased sympathetic activity. Debate regarding the diagnosis and treatment of borderline hypertension suggests that it is a therapeutic dilemma. The evidence for treating borderline hypertension is questionable,

particularly in women and young men, and the risks of long-term pharmacologic therapy are not entirely clear.

Casual blood pressure readings taken either in a physician's office or in community screenings are generally higher than blood pressures averaged over a 24-hour period using either ambulatory monitoring or self-monitoring. A brief literature exists suggesting that extended blood pressure monitoring in the natural environment may be a better predictor of cardiovascular organ damage than casual readings.

Section II

PSYCHOLOGICAL ASPECTS OF ARTERIAL BLOOD PRESSURE

Conceptual Framework

Although the purpose of most investigations has been to demonstrate statistically significant relationships between psychological variables and blood pressure, it must be remembered that the nature of such relationships can vary. Knowledge of the type of relationship as well as its clinical significance can greatly increase understanding of the hypertensive process. There are four basic types of associations.

1. The association is etiological. The psychological variable is causal in the development of hypertension.
2. The association is one of co-variation only. Some "Factor X" may lead to the development of both hypertension and the psychological variable.
3. The psychological variable mediates the development of hypertension. Thus, it acts to exacerbate or inhibit the development and progression of elevated blood pressure.
4. The psychological variable is a product of the disease process. Such psychological products of physical disease are not unusual. There may be a direct relationship such as the hormonally generated depression related to some cancerous growths or there may be indirect relationship such as depression secondary to cardiac disability.

An attempt will be made to integrate this perspective throughout

this review of the literature relating psychological variables to blood pressure.

Methodological Considerations: Measurement

The appropriate method of assessing psychological variables is perhaps more difficult to define than that for physiological variables such as blood pressure. There are four basic types of psychological assessment techniques which have been used in the hypertension literature: questionnaires, structured interviews and behavioral observation, self-monitoring and imagery. The advantages and disadvantages of each will be briefly reviewed. To simplify this review, the construct of anger/hostility was chosen to illustrate the various methodological approaches.

Questionnaires. Questionnaires provide an easily administered assessment device which can be given in a standard format to a large number of people over time. Such assessment instruments can be orientated toward the current state or the long-term trait status of a given psychological variable. The one-time use of state questionnaires provides only a single data point for each individual. The use of state questionnaires on a repeated basis will be covered under self-monitoring.

Questionnaires assessing trait characteristics tend to suffer from recall bias on the part of the subject. Such bias may develop due to poor memory, inaccurate perception of usual condition, or the subject's wish to appear socially acceptable.

Questionnaires are not always a valid measure of the construct being examined. Megargee and Mendelsohn (1962) attempted to

cross-validate 12 indices for hostility developed from the MMPI. Each had been labeled as a measure of hostility expression or hostility control. Megargee and Mendelsohn utilized a subject population composed of criminals referred to a probation department guidance clinic. Subjects were assigned to groups according to their past history of aggressive behavior. They found that none of the 12 scales was adept at reliably discriminating assaultive from non-assaultive individuals.

Biaggio (1980) reviewed four anger inventories (Buss Durkee Hostility Inventory, Reaction Inventory, Anger Self-report, and the Novaco Anger Inventory) and found little validation data to support their use. Particularly noted was a lack of predictive validity studies.

Stauder et al. (1983) reported a factor analysis of measures used in anger research with hypertension. Their primary finding was that multiple dimensions were being assessed by these anger instruments. In addition, there was overlap between measures of anxiety and measures of anger. The inter-correlations between the instruments ranged from 0.01 to 0.62. Stauder et al. concluded that these anger instruments may be assessing "a general construct of negative emotional arousal rather than the specific construct of anger (p. 5)."

Given the findings above, the paucity of consistent findings between blood pressure and anger arousal/expression may, in part, be due to the lack well validated anger instruments.

Structured Interviews and Behavioral Observations. Several studies have utilized structured interviews or behavioral observations of individuals engaging in role-play situations. Such assessments provide

an important view of how subjects are overtly responding in a given situation. Although this removes subject self-report bias, it has the potential to introduce observer bias (e.g. Wheatley et al., 1975) if observers are not carefully blinded to the subject's diagnosis or group assignment. It is also difficult to use behavioral observations when one is attempting to examine a concept such as "suppressed hostility". In such cases it is necessary to imply the presence of hostility and then observe for the absence of its expression.

Finally, the need for specificity is no less with behavioral observations than it is with questionnaires. Linden and Feuerstein (1983) discuss this problem as a possible reason for their failure to find a specific behavioral deficit in hypertensives.

Imagery. The use of imagery to induce specific psychological states has been used with some success (Schwartz, Weinberger & Singer, 1981). Advantages of this approach include the potential for experimental manipulations within subject as well as maximizing the chance that each subject will truly experience each emotion.

The primary disadvantage is the uncertainty as to which emotion and how much of it the subject is experiencing at any given time. Thus, imagery suffers from the same difficulty with the subject's subjective evaluation of their experience as do the self-report measures.

Self-monitoring of Psychological State. Self-monitoring will be considered as the subject's perception and recording of psychological status over time. Self-monitoring of emotions such as anger, allows the subject to keep a record of perceived emotional state while

undergoing daily activities. This technique has been used with some success in the study of situational determinants of blood pressure (Sokolow et al., 1970; Southard et al., 1984).

As a technique it suffers from low compliance rates and reactivity. The inconvenience of taking time out to self-monitor as well as the emotional cost of "being seen" self-monitoring are both potential reasons for non-compliance. Additional possibilities include lack of rationale, lack of sufficient instructions and lack of follow-up by the investigator. Such rationale and instruction, along with behavioral contracting and adequate follow-up, may increase compliance to acceptable levels.

Reactivity denotes changes which occur in the subject's behavior due to the self-monitoring procedure (Ciminero et al., 1979). Generally, feedback from self-monitoring results in a change in the frequency or intensity of the recorded behavior. In self-monitoring of emotional states and blood pressure, this phenomenon might occur if the subject altered self-report of emotional state to "fit" the blood pressure levels observed. Alternately, after seeing a past association between anger arousal and increased blood pressure, subject expectations may promote increased blood pressure when anger is again perceived. Reactivity may be decreased by separating the recording of blood pressure from recordings of mood states.

There is also concern that subjects may be unwilling or unable to report specific mood states. Those heavily influenced by social desirability may report low overall levels of "negative emotions". Others may have difficulty recording such constructs as "inward

expression of anger".

Finally, statistical methodology for analyzing repeated measures within an individual is not commonly known in the psychological community. Thus, studies using mood ratings have generally used simplistic techniques with low power. More sophisticated techniques are available (Kazdin, 1984).

Psychological Constructs Associated with Hypertension

Anger/Hostility. One of the first attempts at relating the development of hypertension to a psychological variable was Alexander's "suppressed hostility" hypothesis (Alexander, 1950). Alexander proposed that hypertensives experience a conflict between hostile impulses and the desire to be submissive and dependent. This results in episodes of unexpressed aggression with concurrent elevations in anxiety and blood pressure. Such episodes, when repeated on a frequent basis, result in a sustained elevation of blood pressure or hypertension.

A number of the early psycho-analytically oriented studies found a positive association between hypertension and suppressed hostility (Binger, Ackerman, Cohn, Schroeder & Steele, 1945; Wolf, Pfeiffer, Ripley, Winter & Wolff, 1948; Hambling, 1951 & 1952; Reiser, Brust & Ferris, 1951; & Van der Valk, 1957). In one of the first attempts to distinguish subgroups of hypertensives, Moses, Daniels and Nickerson (1956) found that mild hypertension was characterized more by anxiety while more severe hypertension was associated with anger and hostility.

Unfortunately, many of these studies were based on rather questionable methodology with considerable threats to the validity of their findings (Diamond, 1982). Particularly noted was a lack of

adequate control groups, the use of psychiatrically referred cases, lack of age, sex and socioeconomic data, and failure to utilize interviewers blind to the patient's diagnosis (Diamond, 1982).

In contrast to the case study approach generally characteristic of the early work above, much of the subsequent research utilized either projective techniques or objective testing. Using a non-clinical population, Hamilton (1942) found a relationship between susceptibility to anger and blood pressure. Kemple (1945) and Matarazzo (1954) utilized projective techniques in their research on hypertensives with results providing support for the "suppressed hostility" hypothesis. A more recent study by McClelland (1979) demonstrated the ability of the "inhibited power motivation syndrome" as measured by the TAT to predict the development of subsequent hypertension. The "inhibited power motivation syndrome" is theoretically associated with suppressed hostility.

Harris, Sokolow, Carpenter, Freedman, and Hunt (1953) identified a population of female undergraduate students with high normal blood pressures. Using the Adjective Check List and a series of psychodramas, they found that the "prehypertensives" were more tense, hot-headed and rash than normotensives. Also noted was the tendency of these "prehypertensives" to label themselves as submissive and passive. Additional analysis of the Adjective Check List and extensive interviews led these investigators to conclude that these "prehypertensive" subjects directed anger and hostility inwardly with subsequent development of anxiety (Kalis, Harris, Bennett & Sokolow, 1961). The psychodrama approach was also performed with female hypertensive

patients by Kalis, Harris, Sokolow and Carpenter (1957). They also found increased hostility and aggressiveness in the hypertensive group.

By using content analysis of subject's verbalizations and dreams, Kaplan, Gottschalk, Magliocco, Rohovit, and Ross (1961) found greater hostility among hypertensives then normotensives. Mattson (1975) used the Gottschalk-Glesser Content Analysis Scales as well as the Hostility and Direction of Hostility Questionnaire to demonstrate that outward expression of anger was related to lower blood pressure among hypertensives.

Hokanson, Burgess and Cohen (1963) attempted to demonstrate that the opportunity for anger expression would be associated with an decrease in blood pressure relative to experimental conditions where anger could not be expressed. Using an experimental design consisting of various levels of frustrating experiences and several levels of opportunity to express aggression, Hokanson et al. were able to show that aggression aimed directly at an individual causing frustration significantly reduced systolic blood pressure.

Using a sample of 335 hypertensive and 332 normotensive subjects, Baer, Collins, Bourianoff and Ketchel (1979) attempted to develop a self-report instrument specifically designed to discriminate between them. The instrument consisted of attention seeking, anxiety, anger arousal and resentment subscales. Baer et al. found that hypertensives had greater anxiety and anger arousal levels. They acknowledge that the nature of this relationship is unknown and that no casual implications can be made.

Steptoe, Melville, and Ross (1983) exposed subjects with a wide

range of blood pressures to laboratory stressors requiring both active coping (Stroop interference task with video game) and passive coping (distressing movie). They found that anger arousal, as measured by the Hostility and Direction of Hostility Questionnaire, was related to both systolic and diastolic blood pressure reactivity to the active coping task. No relationships based on anxiety levels were observed.

Holroyd and Gorkin (1983) placed 35 normotensive male subjects in role play situations simulating conflictual social interactions. They assessed cardiovascular reactivity and assertiveness as a function of anger expression. They found that subjects who expressed anger (as assessed by the Novaco Anger Inventory) had lower heart rates and systolic blood pressures during these role-plays than those who inhibited anger. There were no significant differences across groups in diastolic blood pressure.

In contrast to the studies above, some investigations have not found a clear relationship between hostility (suppressed or expressed) and hypertension. Using both the Minnesota Multiphasic Personality Inventory and the Rorschach, Ostfel and Lebovitz (1959) failed to distinguish hypertensives from normotensives. Drummond (1982) examined normotensive subjects and found no relationship between blood pressure and hostility arousal and expression as measured by the Hostility and Direction of Hostility Questionnaire.

Mann (1977) found no relationship between blood pressure and psychiatric symptomatology on the General Health Questionnaire when a screening survey was done. However, when a sample of diagnosed hypertensives and a sample of normotensives were given a structured

psychiatric interview, the hypertensives demonstrated more hostility and were less self-critical. The authors suggest that these symptoms may be related to the diagnostic process rather than the hypertensive process.

Goldberg, Comstock and Graves (1980) carried out a community-wide blood pressure screening program in a population whom they had screened for psycho-social factors 1-3 years previously. In those individuals not under treatment for hypertension, there was no relationship between blood pressure and hostility, depression, or psychosomatic reactions to stress. However, those individuals who were under treatment for hypertension did have an excess of psychosomatic symptoms. After a careful review of alternative explanations, Goldberg, Comstock and Graves conclude that the most likely explanation for these findings is that psychological complaints are the result of a hypertensive diagnosis and treatment rather than being etiologically involved.

Shekelle, Gale, Ostfeld and Oglesby (1983) followed 1877 employed middle-aged men initially free of coronary heart disease over a 10 year period. They found a lack of relationship between hostility as measured by the Cook and Medly Scale on the MMPI and systolic blood pressure. As noted below, however, hostility scores were related to coronary heart disease and total mortality. This discrepancy may point to the psychophysiological role anger/hostility may play in the development of coronary heart disease through processes other than blood pressure.

Data from the Framingham Study support the relationship between anger and blood pressure in women only (Haynes, Levine, Scotch, Feinleib & Kannel, 1978). Diastolic blood pressure was associated with anger

expressed inwardly, anger discussed, anger symptoms and symptoms of anxiety. Only symptoms of anxiety correlated with systolic blood pressure. No relationship between anger arousal or expression and blood pressure was found in men.

Siegel (1984) examined anger and cardiovascular risk in 213 adolescents. A variety of psychological questionnaires and some behavioral observations were utilized. Siegel found that when age and sex were controlled for, expressing anger outwardly was associated with higher systolic and diastolic blood pressures. There was, however, no relationship between a subject's endorsement of anger arousal in anger provoking situations and blood pressure.

Anger and Coronary Heart Disease. An associated area of study is the relationship of anger/hostility and coronary heart disease. Several prospective studies have linked anger measures to an increased risk of atherosclerosis (Williams et al. 1980), coronary heart disease (Haynes, Feinleib & Kannel, 1980; Shekelle, Gale, Ostfeld & Oglesby, 1983; Barefoot, Dahlstrom & Williams, 1983) and total mortality (Shekelle, Gale, Ostfeld & Oglesby, 1983; Barefoot, Dahlstrom & Williams, 1983). Anger would therefore appear to be a significant risk factor for those who actually suffer cardiovascular endpoints. This is an important linkage since many individuals with hypertension never become symptomatic. Thus, anger may not only be related to hypertension, but may be predictive of a relatively poor prognosis as well.

Assertiveness. Research into anger expression and its potential relationship to hypertension has expanded into the area of assertiveness. The hypothesized relationship is that inhibited anger results

from difficulty in asserting one's self.

Holroyd and Gorkin's (1983) role-play of conflictual social interactions also examined the relationship between assertiveness and anger expression. Their results suggest that individuals who express anger outwardly tend to be more assertive during initiation scenes but are no more assertive than anger inhibiters during refusal scenes. No data was reported on the relationship between assertiveness in these scenes and blood pressure/heart rate response.

Keane et al. (1982) compared the performance of 12 hypertensive patients from a V.A. Medical Center on a series of extended role-play scenes incorporating the expression of positive and negative emotional states with that of non-hypertensive and non-patient control groups. They found that both the hypertensive and non-hypertensive patient groups were less assertive than the non-patient controls. Keane et al. suggest that a relative lack of assertiveness is characteristic of medical patients in general and is not specific to essential hypertension.

Depression. Periodic reports suggest a relationship between depression and hypertension. As noted before when investigating anger and anxiety, it is important to clarify whether depression arises before or after the diagnoses of hypertension.

Lyketsos, Arapakis, Psaras, Photiou and Blackburn (1982) studied all hypertension and ulcer admissions into a general hospital over a 2-year period. They found that the depression and anxiety levels were higher in the hypertensive group as compared to the group of ulcer patients and a control group composed of patients with

"non-psychosomatic" illness. Due to their research design, they were unable to establish whether this was a cause or result of the hypertensive process.

Rabkin, Charles and Kass (1983) reviewed the DSM III diagnosis of 452 outpatient psychiatric cases and compared the frequency of depression in those with hypertension and those normotensive. They found a higher rate of depressive disorders among hypertensive patients even after correction for age, sex and presence of a chronic medical condition. Rabkin et al. call for more longitudinal cohort studies to uncover the nature of this relationship.

In one of the classic prospective studies, Thomas and Greenstreet (1973) demonstrated that questionnaire measures of anxiety, anger and depression were not predictive of subsequent development of hypertension in a population of Johns Hopkins Medical students.

Wheatley et al. (1975) utilized physician interviews of 348 patients to screen for anxious, depressed and hostile symptomatology and relate it to blood pressure levels. They found a lack of relationship between hypertensive status (old, newly diagnosed, or non-hypertensive) and any of the above symptoms.

A lack of a concurrent relationship between diastolic blood pressure and scores on the Zung Depression Inventory in a large population of V.A. outpatients was reported by Friedman and Bennet (1977). A similar finding was reported by Monk (1980) who utilized data from the Health and Nutrition Examination Survey. Monk found that there was no relationship between blood pressure and a questionnaire measure of tension, depression and stress at home and work. Both studies

insured that blood pressure was taken after the questionnaires had been filled out and that the subjects had not diagnosed as hypertensive prior to the study.

Bloom and Monterossa (1981) found that, upon rescreening, individuals who had previously been falsely identified as hypertensive had higher scores on a brief depression inventory than a normotensive control group. Bloom and Monterossa conclude that depression is associated more with the diagnosis of depression than with the hypertensive process itself. Unfortunately, they were did not have depression measurements for these false positives when they were originally diagnosed. Thus, it remains unclear as to whether the depression arose prior to or since the hypertensive diagnosis.

Anxiety. Numerous studies have explored for a relationship between anxiety and hypertension. An example is Friedman and Bennet's (1977) finding of a significant association between diastolic blood pressures greater than 100 mm Hg and a clinical diagnosis of anxiety in a population of male V.A. outpatients. Due to overlap with many studies also studying anger or depression, only a summary statement regarding the remaining studies will be given here. As with anger and depression, there is support for and against a significant relationship between anxiety and hypertension. Studies providing evidence for such a relationship include Baer et al. (1979), Haynes, Levine, Scotch, Feinleib and Kannel (1970), Lyketsos et al. (1982), Moses et al. (1956); while those suggesting no relationship include Steptoe et al. (1983), Thomas and Greenstreet (1973) and Wheatley et al. (1975). The inconclusiveness of these results is apparent.

In addition, there is some controversy as to whether hypertensives present with more complaints in general. In contrast to some of the above studies suggesting an increased level of emotional complaints amongst diagnosed hypertensives, Meyer, Derogatis, Miller and Reading (1978) found that hypertensive patients presenting to their clinic reported significantly lower levels of psychological distress than those individuals suffering from other medical disorders.

The Type A behavior pattern. The Type A or coronary-prone behavior pattern is a well documented risk factor for coronary-heart disease (Haynes, Feinleib & Kannel, 1980; Kornitzer, Kittel, DeBacker & Dramaix, 1981; Rosenman, Brand, Jenkins, Friedman, Straus & Wurm, 1975). It has repeatedly been studied in terms of its relationship to blood pressure. Some studies have documented a relationship between the Type A behavior pattern and cardiovascular reactivity (Dembroski, MacDougall & Shields, 1977; Dembroski, MacDougall, Shields, Pettitto, Lushene, 1978; Pittner & Houston, 1980) while others have found no relationship or an inverse relationship (Scherwitz, Berton, & Leventhal, 1978; Southard, 1984; Steptoe, Melville & Ross, 1984). Part of this inconsistency in the data may be due to the specific circumstances under which a differential response can be noted between Type A and Type B individuals. Glass (1982) needed a combination of harrassment and competitive tasks to elicit greater responsivity in Type A subjects.

Evidence is also conflicting regarding the relationship between the Type A behavior pattern and baseline or resting blood pressure. Rosenman, and Friedman (1961) studied 257 women and found that Type A women were three to seven times more likely to have diastolic

hypertension than Type B women. Shekelle, Schoenberger and Stamler (1976) found a correlation between the Type A behavior pattern and blood pressure in older women but not younger women or men. Smyth, Call, Hansell, Sparacino and Strodtbeck (1978) searched for the same relationship among inner-city black women. They found that a greater proportion of Type A's were hypertensive, but the chi square was not significant ($p<.20$). Although these studies provide some support for a relationship between Type A and blood pressure in women, the relationship remains unclear.

Stress, Coping and Blood Pressure. A series of studies in Detroit have examined the relationship between socio-ecological stress, suppressed hostility and blood pressure. Harburg et al., (1973) reported survey data suggesting an interaction between race, suppressed hostility, stress level and blood pressure. They found that suppressed hostility was related to increased diastolic blood pressure in general, but particularly among black individuals from high stress areas of the survey and white individuals from low stress areas.

Harburg, Blakelock and Roeper (1979) investigated the role of coping styles and blood pressure further by examining the relationship between being resentful (anger in), expressing anger outwardly, and using a reflective response. Subjects were asked to respond to questionnaire items describing their potential reaction to a confrontation with an angry boss. Anger in was operationalized as "to ignore or walk away from the conflict situation", an example of anger-out was "going over the boss's head to someone higher up", and reflection was operationalized by answers such as attempting to analyze

the problem and "restore a fair job situation" (p. 191).

In general, the highest blood pressures were recorded among those individuals indicating they would use an anger-in or resentment strategy. Individuals using an anger-out strategy had blood pressures below the anger-in group but above those individuals who expressed an reflective approach. Utilizing data collected from these Detroit studies, the odds ratio of being classified as hypertensive based on expressing anger inwardly versus outwardly was calculated at 1.64 (Gentry, Chesney, Gary, Hall & Harburg, 1982).

Linden and Feuerstein (1981) hypothesized that mild hypertensives could be characterized by an inappropriate coping response to interpersonal stress, increased social anxiety and a negative cognitive set. They found that questionnaire scores on trait anxiety, social anxiety and social distress did not differ between hypertensives and normotensives (Linden & Feuerstein, 1983). Untreated hypertensives had lower depression and higher defensiveness scores than medicated hypertensives and normotensives. An analysis of a 2-week self-monitoring period showed that untreated hypertensives reported fewer interpersonal distressing situations but similar levels of overall distress as compared to treated hypertensives and normotensives. All groups demonstrated similar competence during role plays situations requiring social skills.

Linden and Feuerstein (1983) summarize these findings by suggesting that the untreated hypertensives are more defensive and attempt to present themselves in a positive light. Hence, they report fewer interpersonal distressing situations and lower levels of depression. The

authors feel that this is consistent with their "social coping behavior deficit model" of hypertension as opposed to a specific personality defect such as excessive anger arousal.

A second part of this study examined the cardiovascular reactivity of these same subjects to laboratory role-play stressors. To insure that the stressors would indeed be stressful, they were individually tailored to the each subject based on the results of their two-week self-monitoring period. Linden and Feuerstein found that both treated and non-treated hypertensives had greater systolic blood pressure reactivity as compared to the normotensive group. In addition, recovery of systolic blood pressure to baseline levels was longest in the untreated hypertensives, shorter in the medicated ones, and shortest in the normotensives.

Although the authors cite these results as support for their "social coping behavior deficit model" of hypertension, they dutifully noted that social skills were not significantly different across groups. They argue that the rating scale they used (Shepherd's Rating of Behavior in Social Situations) may be too general to pick up the specific behavioral deficit characteristic of hypertensives. In particular, they describe the hypertensive deficit as "withholding expressions of affect, avoiding conflict, being overadjusted and passive-submissive (p. 30)". They suggest further research using more behaviorally specific rating scales.

Psychophysiology. Schachter (1957) utilized a series of laboratory stressors to investigate the psychophysiological relationship between blood pressure and feelings of pain, anger and fear. His findings

suggest that fear is associated with an epinephrine-like response, pain is associated with a norepinephrine-like response and anger is associated with both an epinephrine and a norepinephrine response. In contrast with expectation, the hypertensives in his study did not inhibit anger expression as compared with normotensives. In fact, the average anger expression score for the hypertensives was greater than that for normotensives, though not significantly so. Mean blood pressure for all subjects was positively correlated with both anger and fear expression.

A comparative study of acute cardiovascular changes in a psychotherapy population experiencing emotional expression was conducted by Forbes and Chaney (1980). They found that depressive patients exhibiting acute depressive symptoms had heart rate and blood pressure elevations similar to anxiety patients exhibiting anxiety and anger patients exhibiting anger. Forbes and Chaney conclude that it may be difficult to differentiate these emotional disturbances. In particular, many patients who predominantly suffer from depression also experience anxiety.

Schwartz, Weinberger and Singer (1981) examined the cardiovascular correlates of imagery induced anger, fear, relaxation, sadness and happiness. Anger was associated with greater increases in diastolic and mean arterial blood pressure than other emotions during imagery. Analysis of the cardiovascular patterning suggested that anger was primarily associated with increases in peripheral vasoconstriction rather than increased cardiac output. Schwartz et al. note that this is consistent with other physiological changes which prepare an animal

for a physical fight. Also noted was a high positive correlation between anger and blood pressure when subjects were required to be stationary but a negative correlation when subjects were allowed to exercise. Schwartz et al. suggest that this is consistent with the hypothesis that elevated blood pressure is a consequence of inhibited anger expression.

Situational Determinants of Blood Pressure

Most investigations, whether utilizing epidemiological approaches in the field or the experimental approaches in the laboratory, have focused on single determinations of trait variables. Few studies have examined the co-variation of psychological variables and blood pressure.

One of the earliest studies of mood and blood pressure co-variation was performed by Sokolow, Wedegar, Perloff, Cowan and Brenenstuhl (1970). They studied 50 untreated hypertensives who underwent ambulatory monitoring of blood pressure at 30-minute intervals over a 2 day period. The mood rating forms included anxiety, depression, alertness, hostility, time-pressure and contentment. A "positive emotion" scale was derived from the adjectives consistent with alertness and contentment. A "negative emotion" scale was derived from the anxiety, depression, hostility and time-pressure ratings.

Sokolow et al. first analyzed their data by comparing mood ratings for the five highest and five lowest blood pressure values for each subject. They found that high SBP and DBP values were associated with anxiety, time-pressure and (for SBP only) alertness. Neither hostility or depression were correlated with blood pressure. Sokolow et al. later analyzed the data based on the average intra-individual correlations

between mood ratings and blood pressure. They again found that anxiety and time-pressure were positively related to both SBP and DBP, while contentment was negatively related to both parameters. In addition, negative affect was positively related to both measures of blood pressure and heart rate. When these data were analyzed by sex, it appeared that anxiety was more closely tied to blood pressure in females while a sense of time pressure was most highly related in the male subjects. Finally, Sokolow et al. correlated the mood score for each subject averaged over the 2-day period with the severity of hypertensive complications. They found that averaged scores on anxiety, depression, hostility and negative affect all correlated significantly with severity of complications. daily blood pressure.

Sokolow et al. conclude that "our data showing significant relationships between rise in pressure and `negative affect states' during ordinary daily life are at least consistent with the hypothesis that the patients who view life situations as stressful and as occasions for such emotional responses are the more likely to have elevated blood pressures" (p. 186). This emphasis on "negative affect states" is consistent with that voiced by Forbes and Chaney (1980) in their discussion of the difficulty in separating symptoms of anxiety from depression in clinical populations. It is also consistent with Stauder et al.'s (1983) observation that anger questionnaires used in hypertensive research may be assessing "a general construct of negative emotional arousal rather than the specific construct of anger" (p. 5).

An additional investigation of emotional correlates of hypertension was performed by Whitehead, Blackwell, DeSilva and Robinson (1977) who

studied 29 patients with borderline to moderate hypertension. Subjects were recruited to take part in a tranquilizer treatment study for "nervous" hypertensives. Included in the subject population were 13 females and two blacks. Twelve were taking antihypertensive medication and fifteen were not. Medication data on two subjects was not available. Each subject was asked to self-monitor blood pressure four times per day over a 7 week period. In addition, at each blood pressure reading, subjects were instructed to assess their current anxiety and anger state by marking "a point on each of two 10-cm lines labeled `anxiety' and `anger'" (p.385). Also given was the Spielberger State-Trait Anxiety Inventory and the Buss-Durkee Hostility Inventory.

Pearson correlation coefficients for anger and systolic blood pressure ranged from -0.01 to 0.51 with a median of 0.19. Coefficients for anger and diastolic blood pressure ranged from -0.07 to 0.51 with a median of 0.17. Across subjects, anxiety was more highly correlated with both systolic and diastolic blood pressure than was anger ($p<.01$). Pearson correlation coefficients for anxiety and systolic blood pressure ranged from 0.05 to 0.79 with a median of 0.36. Coefficients for anxiety and diastolic blood pressure ranged from -0.05 to 0.66 with a median of 0.27. The authors dutifully note that the recruitment of "nervous" subjects into this tranquilizer treatment study makes generalization of this finding questionable.

Harshfield et al. (1982) also studied the relationship between daily activities and ambulatory blood pressure monitoring. They found that diastolic blood pressure was at it highest levels during social interactions, eating and smoking. Diastolic levels during these

activities were higher than during exercise where systolic blood pressure showed it greatest increases. This suggests that some social interactions may influence blood pressure via increases in total peripheral resistance as opposed to the increased cardiac output mechanism characteristic of hyperkinetic borderline hypertensives.

A much smaller study conducted by Pennebaker, Gonder-Frederick, Stewart, Elfman, and Skelton (1982) investigated the relationship between self-monitored blood pressure and concurrently assessed mood and symptom ratings. Each of nine normotensive subjects, age 20-45, completed the self-monitoring process 8-15 times per day for 4-5 days. Unfortunately, the subject pool included both the primary investigator as well as a number of faculty, graduate and undergraduate assistants. In addition, only summary data is presented regarding the relationship between mood states and blood pressure for each individual. Of the eight individuals for whom a comparison could be made, mood states with the highest within individual correlations with SBP were tense (2), afraid, angry, sadness, guilty, and energetic (2). Although an interesting study from the viewpoint of its within subject approach, the lack of statistical control for the within subject design as well as incomplete documentation of results limits its usefulness.

A recent report examined the relationship between mood ratings and ambulatory blood pressure in a population of 28 adolescents (Southard, Coates, Parker, Kolodner, Padgett & Kennedy, 1984). Systolic blood pressure averaged over a 24-hour period was associated with higher tense, depressed, hostile and worried mood ratings. Averaged diastolic blood pressure was associated with higher upset, hostile and depressed

mood ratings. Competitive and aggressive mood ratings were not associated with blood pressure. An analysis of intercorrelations between mood ratings suggested three possible clusters of mood ratings: negative moods (worried, depressed etc.), positive moods (interested, patient etc.) and outgoing moods (competitive, aggressive etc.). Particularly noted was that all significant correlations between mood ratings and blood pressure came from the negative mood cluster.

One study noting a lack of relationship between mood and blood pressure has also been reported. Rose and Krug (1985) studied 208 like-sex co-twins ranging in age from 16 to 35 years. Each subject self-monitored blood pressure six times daily for 2-4 weeks. In addition, each subject kept a daily log of mood and health related variables. Blood pressure readings and mood ratings however, were not concurrently assessed. Initial findings suggested that intra-individual SBP variation was not reliably correlated with mood ratings.

In summary, there is a brief literature on situational or day-by-day co-variation between mood states and blood pressure. Initial studies suggest that mood ratings of anxiety, time-pressure and possibly negative emotions in general may be related to situational or increased daily blood pressure averages. Considerable variation in methodological techniques and analysis is evident among these early studies.

Predicting Blood Pressure

A small but intriguing literature has developed regarding the ability to estimate current blood pressure levels. Such direct estimations may compliment or surpass the predictiveness of emotional

markers of elevated blood pressures discussed previously. One of the earliest studies examined 6 subjects in a laboratory setting (Shapiro, Redmond, McDonald & Gaylor, 1975). While undergoing a series of relaxation and stressful procedures, each subject was asked to indicate whether their current blood pressure was up or down from the previous value. Overall, subjects were able to predict the direction of change in 46% of the cases while 36% would have been expected by chance alone.

A second study by Luborsky et al. (1976) found that a mixed sample of 21 normotensive and hypertensive subjects was able to estimate systolic blood pressure (SBP) within $\pm$ 12.4 mm Hg even before receiving any feedback regarding current levels. With the provision of feedback regarding overall blood pressure range as well as immediate feedback on their daily blood pressure for 15 days, subjects were able to decrease their error to $\pm$ 7.4 mm Hg. This was not only a statistically significant reduction in predictive error, but is within the range of the actual variation in SBP ($\pm$ 5.8 mm Hg) from one minute to another. Luborsky et al. concluded that the improvement was probably due to increased knowledge of their blood pressure range.

Cinciripini, Epstein and Martin (1979) studied 17 normotensives in the natural environment and found similar findings. Their study design however, permitted them to conclude that immediate feedback regarding current blood pressure levels provided discriminative ability in addition to that provided by knowledge of their general blood pressure range. Cinciripini et al.'s findings also extended these relationships to DBP as well as documented the ability to maintain high levels of predictive accuracy over a two week post-intervention period.

The ability to predict blood pressure therefore appears to be due to three different factors. First, it is important to have knowledge of one's general blood pressure range. Second, feedback regarding current blood pressure levels and comparison to predicted level appears to provide additional information for future predictions. Finally, use of internal cues such as mood states, muscle tightness etc. may enable the subject to assess general physiological arousal and possibly a symptom complex associated with blood pressure variation (Pennebaker, 1982). The clinical usefulness of such estimations is yet to be determined.

Psychological Treatment for Hypertension

Psychological approaches to treatment include those aimed at improving compliance to antihypertensive medication, physical exercise and sodium restriction as well as direct intervention with relaxation, biofeedback and stress management procedures. This brief review will focus on these direct approaches. An extensive literature has developed which outlines the advantages and limitations of direct psychological interventions in primary hypertension. Reviews by Shapiro and Goldstein (1982) and Wadden, Luborsky, Greer and Crits-Christoph (1984) will be used to summarize the findings in this area.

Behavioral treatments consisting of relaxation and/or biofeedback therapy are generally more effective than no treatment or self-monitoring of blood pressure alone (Wadden et al., 1984). Preliminary studies, such as the one performed by Southam, Agras, Taylor and Kraemer (1981), have begun to demonstrate that relaxation training can produce a lowering of blood pressure during the workday as well as in the laboratory. This is an important finding since failures in

clinical practice often appear related to the individual's inability to practice the procedure during daily activities. Finally, Engel, Glasgow and Gaarder (1983) have demonstrated the ability of behavioral treatments to induce blood pressure lowering for up to 18 months.

In general, relaxation and biofeedback have similar levels of effectiveness though some debate continues regarding the potential for using the procedure which is most specific for the patient's pathophysiology (Shapiro & Goldstein, 1982; Wadden et al., 1984). This, of course, requires sophisticated assessment procedures.

Behavioral treatments are generally less effective in lowering blood pressure than pharmacological therapy. Behavioral treatment in combination with pharmacological therapy only occasionally offers additional blood pressure lowering (Wadden et al., 1984).

Behavioral treatment do however, have several advantages over pharmacological therapy. In general, they have few adverse side-effects as opposed to the frequent problems encountered with drug therapy. In addition, relaxation procedures may reinforce patient adherence by decreasing anxiety and depression (Wadden et al., 1984) and providing some measure of self-control (Wilkinson & Raftery, 1978).

Given the positive side-effects associated with the use of behavioral approaches, it would be clinically useful if those individuals who potentially respond well to such treatments could be selected in advance. Unfortunately, no questionnaire assessment of subject characteristics has been consistent in predicting successful lowering of blood pressure through behavioral interventions (Wadden et al., 1984).

Section Summary

Despite numerous investigations, no single psychological variable has been consistently related to either hypertensive status or blood pressure variability. One possible explanation for this lack of consistency is that the general physiological arousal associated with negative emotion explains more of the variance in blood pressure than any arousal associated with a specific mood. This could be a consequence of a larger physiological arousal with negative emotions in general or it could be due to the more frequent elicitation of negative emotions as compared to a specific emotion.

This latter perspective is particularly interesting and points to the important limitations inherent in the use of the laboratory environment rather than examining subjects as they engage in their customary daily activities. There may be a significant association between anger arousal and increases in blood pressure in the laboratory, but it may occur infrequently in the subject's customary activities. Hence, its contribution to average blood pressure levels is small.

It is suspected that sympathetic hyperactivity is an important factor in the etiology and progression of borderline hypertension. Thus, the role of psychological factors mediated by the CNS may be greater in this hypertensive subpopulation than in hypertensives in general.

Behavioral approaches to the treatment of primary hypertension have demonstrated moderate, though clinically significant, reductions in blood pressure levels. A potential problem encountered in such therapy is the lack of generalization of blood pressure control learned

in the laboratory to the patient's daily activities.

Section III

CLARIFICATION OF THE PROBLEM

Epidemiological evidence indicates that chronically elevated blood pressure is a major public health concern. Debate regarding the diagnosis and treatment of borderline hypertension suggests that it is a therapeutic dilemma. The evidence for treating borderline hypertension is questionable, the risks of long-term pharmacologic therapy are not entirely clear, and alternative therapies have experienced variable success.

Studies examining the relationship between casual blood pressure reading taken in the medical environment and readings taken in the natural environment suggest that the latter are generally lower. Additional work has shown that such natural environment readings may actually be better predictors of the cardiovascular complications of hypertension. The variability of blood pressure over a 24-hour period is consistent with the complex regulatory system and multiple levels of input which characterize blood pressure regulation.

The relationship between psychological variables and blood pressure has been assessed by questionnaires, mood ratings and behavioral assessments across a variety of populations. Studies utilizing questionnaires suffer from both a lack of questionnaire validity and a considerable temporal gap between the rating of psychological status and blood pressure measurement. Those studies relying on behavioral measures find it difficult to assess constructs such as suppressed hostility and are generally, though not necessarily, limited to the

laboratory environment. The few studies on the relationships between emotional states and blood pressure variation in the natural environment have used methodological approaches to data analysis which have limited statistical power. Most investigators have focused on anger arousal, anger expression and anxiety. Other researchers have examined such variables as depression, the Type A behavior pattern and negative emotions in general. This field of study is generally characterized by a lack of conclusive results.

In addition to the inconsistent associations, the nature of such relationships remains in question. Several authors suggest that emotional manifestations are etiologic while others argue that such factors are a consequence of the diagnostic process.

Current cognitive/behavioral interventions for primary hypertension include biofeedback, relaxation and other stress management procedures. In general, these procedures appear capable of a modest but clinically significant decreases in blood pressure. Problems with these interventions include considerable individual variation in response to therapy, compliance to long-term cognitive/behavioral interventions, and the need in many to continue pharmacologic treatment.

These observations suggest a series of assessment questions for those contemplating the treatment of borderline hypertensives with cognitive/behavioral interventions as well as those interested in the basic psychophysiology of cardiovascular regulation.

1. Is the patient's blood pressure elevated consistently or is the casual blood pressure reading a transient phenomenon? More specifically, does the patient react to the clinic

assessment environment in a manner which is not characteristic of his reaction to his customary activities? Can a clinic procedure be developed which will help to identify those individuals who have "overreacted" to the clinic setting?

2. Does blood pressure co-vary with mood states as opposed to trait measures of psychological variables? A related question is the specificity of psychological variables. Although the research suggests that no one specific psychological factor is related to blood pressure, there does seem to be a consistent association with "negative" emotions. This cluster appears to be characterized by anxiety, anger, time-urgency and related emotions. Might blood pressure increases be related to the general increase in sympathetic activity associated with negative emotion arousal?
3. Can cognitive/behavioral intervention protocols be individualized? In addition to searching for psychological variables which are consistently associated with blood pressure across individuals, perhaps more specific relationships within individuals can be identified. This idiographic approach might lead to the identification of individualized "mood markers" of blood pressure rises. Such markers would be useful in determining when cognitive/behavioral interventions would be most appropriate.

The purpose of this research project was to address the assessment issues outline above. The specific aims are outlined below.

1. The study assessed the potential co-variation of blood

pressure and mood ratings as subjects engage in their usual activities in the natural environment.

Specific hypotheses included:

a. Ambulatory blood pressure will be associated with anger arousal and expression as well as a perception of the environment as hostile and demanding.

b. Ambulatory blood pressure will be associated with negative emotions in general.

c. Ambulatory blood pressure will be associated with adjectives characteristic of the Type A behavior pattern.

2. The study compared the value of questionnaires in predicting ambulatory blood pressure to that of self-monitoring of mood states.

Specific hypotheses included:

a. Questionnaire measures of psychological constructs will not be associated with ambulatory blood pressures.

b. Self-monitoring of mood states will be associated with the corresponding construct as assessed by questionnaire measures.

3. The study determined if the blood pressure response to a laboratory relaxation procedure is correlated with the initial response to the laboratory environment. Such an initial response would be represented by the difference between the subject's average blood pressure in the field and their baseline laboratory blood pressure. That is, do individuals reacting with the greatest blood pressure increases to the laboratory environment have the greatest decreases during a relaxation procedure in that environment? If so, this might

provide an easily administered and therapeutically consistent assessment device.

4. The study determined the ability of individuals to predict their own blood pressure levels as they pursued their daily activities.

5. The literature on situational determinants of blood pressure suggests that research designs emphasizing within subject variation will be more productive in identifying relationships than designs which emphasize across individual comparisons. This study investigated the methodological issues involved in designing single case research for studying mood and blood pressure co-variation and provided an illustrative example.

Section IV

METHODS

Study Design

This proposal describes a combined laboratory and field study designed primarily to examine the relationship between emotional states and blood pressure. The study design will rely on the Correlational Model. Health histories were taken on each participant and appropriate informed consent procedures were followed. Subjects underwent a laboratory relaxation procedure designed to assess the individual's potential for cardiovascular reactivity. Each participant was then asked to complete a series of questionnaires assessing psychological variables commonly associated with blood pressure variation. In addition to these laboratory studies, each subject was asked to self-monitor their blood pressure and emotional state over a 2-day period.

Subjects

The study population consisted of 51 undergraduate students at Virginia Tech. An attempt was made to recruit both normotensive and borderline hypertensive subjects. Forty-nine of the fifty-one subjects were recruited from the Introductory Psychology experiment pool. Each received 5 credits for successful completion of the study. Two subjects were identified through blood pressure screenings held at a student dining hall and subsequently referred to the study by the Student Health Services (SHS).

Participation in this study was open to members of either sex. It was recognized that the inclusion of female participants might make

interpretation of the results more difficult. Preliminary evidence suggests that women may be less reactive to stressors during the follicular phase of the menstrual cycle (Hastrup, Light & Obrist, 1980). However, recruitment of sufficient subjects necessitated the inclusion of both sexes. This of course, also increases the external validity of the findings.

Recruitment of subjects for the single case designs was based on their ability to comply to an extended self-monitoring procedure as well as a past history of elevated blood pressure readings. Two subjects were selected who met these criteria. Subject characteristics as well as the results of their self-monitoring are described in Appendix 1.

Questionnaire Measures

Health History. A health history questionnaire was developed to assess the potential co-variation of personal and family history of cardiovascular disease or its risk factors with current blood pressure levels. The questionnaire and its associated coding system are presented in Appendix 2.

Anger/Hostility. Anger/hostility arousal and expression was assessed by the Seigel Anger Inventory (SAI; Seigel, 1983). This is a 38 item Likert scale instrument assessing both anger arousal and anger expression. The alpha coefficient for internal consistency is 0.86 in a college population (Seigel, 1983). Anger arousal as assessed by the SAI is highly correlated with other questionnaire measures of anger (Seigel, 1983).

Anxiety. Anxiety was assessed by the State/Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983). This is a

40 item, Likert scale instrument which asks the subject to respond to anxiety related questions as they currently feel and as they feel in general. Test-retest reliability for the trait-anxiety scale is 0.76 (Speilberger et al., 1983). In college populations, the alpha coefficient for internal consistency is 0.90 for the trait-anxiety scale and 0.93 for the state-anxiety scale (Speilberger et al., 1983).

Type A Behavior Pattern. The 21 item Type A scale from the Jenkins Activity Survey (JAS), Form T, was utilized to assess the Type A behavior pattern (Krantz, Glass, & Snyder, 1974). The strength of the JAS is in gathering self-report data regarding achievement orientation and daily response patterns. Its weakness is primarily that it is a self-report rather than a behavioral observation of daily activities related to the Type A concept. Estimates of the test-retest reliability over a 4-6 month interval range between 0.65 and 0.82 (Jenkins, Zyzanski, Rosenman, 1979). The correlational coefficient for internal consistency is approximately 0.84 (Jenkins et al., 1979).

Depression. The Beck Depression Inventory is a 21 item multiple choice instrument assessing cognitive and behavioral aspects of depression (Beck, 1972). Internal consistency has been assessed at 0.86 and construct validity has been well documented (Beck & Beamesderfer, 1974).

Social Insecurity. The Social Avoidance and Distress Scale (SAD) is a commonly-used scale exploring social anxiety and avoidance behavior (Arkowitz, 1981). It consists of 28 true/false questions divided into two subscales (Watson & Friend, 1969). The following definitions were used for the subscales. "Social avoidance was defined as avoiding

being with, talking to, or escaping from others for any reason. Social distress was defined as the reported experience of a negative emotion, such as being upset, distressed, tense, or anxious, in social interactions, or the reported lack of positive emotion, such as being relaxed, calm, at ease, or comfortable" (Watson & Friend, 1969). For the purposes of this study, the SAD will be used as a single factor scale.

Test-retest reliability coefficients for the SAD over a 1 month interval were 0.68 for a sample of 154 students subjects and 0.79 for a second sample of 29 students (Watson & Friend, 1969). Concurrent validity of the SAD was demonstrated in a number of correlational and experimental studies (Watson & Friend, 1969). High SAD scorer's tended to score low on questionnaire measures of social affiliation and high on a questionnaire assessing reaction to social-evaluative situations. High SAD scorer's also demonstrated avoidance to experimentally induced social situations and expressed higher state anxiety during these studies.

Fear of Negative Evaluation. Developed by Watson and Friend (1969) at the same time as the SAD, the Fear of Negative Evaluation (FNE) scale assesses "apprehension about others' evaluations, distress over their negative evaluations, avoidance of evaluative situations, and the expectation that others would evaluate oneself negatively" (p. 449). Test-retest reliability over a 1-month duration was 0.78 in a sample of 154 subjects and 0.94 in a sample of 29 subjects (Watson & Friend, 1969).

Gambrill-Richey Assertion Inventory. This 40 item self-report

inventory examines an individual's degree of discomfort and probability of engaging in assertive behavior across a broad range of interpersonal situations (Gambrill & Richey, 1975). Test-retest correlational coefficients were 0.87 for degree of discomfort and 0.81 for probability of assertive behavior (Gambrill & Richey, 1975). Observer ratings of subject discomfort in social interactions have been found to be correlated ($r=.46, p < .05$) with changes in scores on the Assertion Inventory (Gambrill & Richey, 1975).

Self-monitoring of Emotional States

Mood states and perceptions of the environment were assessed via a self-monitoring form designed for this study (Appendix 3). Specific mood ratings were selected based on their prior use in the blood pressure literature (Herman, Blumenthal, Black & Chesney, 1981; Linden & Feurstein, 1983; Sokolow, Werdegar, Perloff, Cowan & Brenenstuhl, 1970; Southard, Coates, Parker, Kolodner, Pagett & Kennedy, 1984). Exercise, cigarette, caffeine and alcohol intake in relation to blood pressure readings were also monitored on this form.

Mood Clusters

In addition to examining the relationship between individual mood ratings and blood pressure, three mood clusters will also be examined. Assignment of individual mood ratings to the three mood clusters was based on face validity, correlations between the Adjective Check List and the Type A behavior pattern (Herman et al., 1981), and the work by Sokolow et al. (1970) and Southard et al. (1984) with co-variation between mood states and blood pressure. The content of the negative, positive and Type A mood clusters is presented in Table 2. It should

Table 2

Mood Clusters and Their Components

Type A Behavior Pattern	Negative Moods	Positive Moods
Anxious/Tense	Worried	Interested
Active	Depressed	Energetic
Aggressive	Time pressure	Patient
Assertive	Hostile/Angry	
Hard-driving	Anxious/Tense	
Self-confident		

be noted that the Type A cluster does not include the angry/hostile mood rating. This cluster was derived from adjectives endorsed by individuals scoring high on the Structured Interview, the primary standard of reference for Type A (Herman et al., 1981). Thus, it was empirically derived rather than relying solely on face validity. The reluctance of Type A individuals to endorse the anger/hostile mood rating may reflect its connotation as social undesirable.

Cardiovascular Measures

Blood pressure and heart rate was taken in accordance with the assessment procedures outlined by the American Heart Association (Kirkendall, 1980). Measurement of mid-arm circumference was performed on all subjects, one of which was rejected from the study since his arm circumference exceeded the 24-34 cm range. After a 5 minute rest in the seated position, measurements were taken with the left arm at heart level. The cuff was placed approximately one inch above the antecubital space over the brachial artery. The first Korotkoff sound was taken as the SBP, the fifth Korotkoff sound as the DBP. Laboratory blood pressures along with arm circumference and height/weight were recorded on the physical exam form presented in Appendix 4.

Assessments in the laboratory utilized the mercury sphygmomanometer as well as a Norelco Electronic Digital Blood Pressure Meter (Model HC3500). Documentation for this devise reveals an blood pressure accuracy of $\pm$ 3 mm Hg at 15-25 degrees Celsius and a pulse rate accuracy of $\pm$ 5% (Manual for Norelco Electronic Blood Pressure Meter, 1983). Initial testing by this investigator finds that the pressure calibration is within $\pm$ 2 mm Hg. Testing also suggests that the systolic readings

are indeed within $\pm$ 3 mm Hg of those auscultated. After correction for calibration, simultaneous validity checks against a mercury manometer (n=6) suggested a very high level of validity (r= .99, $p \leq .0001$). There is some indication that diastolic readings provided by the Norelco are below that auscultated in some, but not all individuals. Simultaneous validity checks (as above) resulted in a moderately strong Pearson correlational coefficient (r= .88, $p \leq .02$). It should be noted that this is the opposite of the problem identified by Gould, Keiso and Raftery (1980) who found that self-monitoring using anaeroid sphygmomanometers had higher diastolic pressures than that recorded intra-arterially. It is possible that the microphone sensitivity of the Norelco meter allows it to more precisely identify the true intra-arterial diastolic blood pressure.

As an additional examination of the validity of the Norelco 3500, correlations during the laboratory baseline procedure were generated between the first 2 readings taken with a mercury manometer and the second 2 readings taken with the Norelco. It must be remembered however, that there was approximately a 5 minute interval between the initial two readings and the second set. Thus, some reduction in reliability is expected. The correlational coefficient was r= .91, $p \leq .0001$ for SBP, and r= .78, $p \leq .0001$ for DBP. Finally, inter-unit reliability of the two Norelco units was examined by a t-test. The distribution of blood pressures measured by the two Norelco units were not found to be significantly different (Means: t= -.97, $p \leq .34$ for SBP, t= -.13, $p \leq .90$ for DBP, t= -.78, $p \leq .44$ for HR; Variances: F=1.31, $p \leq .55$ for SBP, F= 1.23, $p \leq .63$ for DBP, F= 1.1,

$p \leq .83$ for HR).

Relaxation Procedure

After the initial baseline blood pressure readings, each subject underwent a 15 minute structured relaxation procedure (Appendix 5). This provided an opportunity to assess the subject's potential for relaxation induced blood pressure decreases. The relaxation procedure was a passive technique utilizing yogic suggestions (Patel, 1984) and focused attention on breathing. Similar procedures have been utilized in the treatment of hypertension (i.e. Patel, 1984), however, no mention of its use as an assessment devise has been noted in the literature.

Operating Protocol

The following assessment protocol was utilized.

8:00am -Introduction and completion of informed consent.

8:05am -Two blood pressure measurements spaced 2 minutes apart. (using standard mercury sphygmomanometer)

8:10am -Two blood pressure measurements spaced 2 minutes apart. (using Norelco automated meter)

8:20am -Begin Relaxation Procedure

8:35am -Relaxation period ends
-Blood pressure measurement (Norelco automated meter)

8:40am -Review monitoring of moods
-Instruction and practice with blood pressure self-monitoring
-Discuss compliance to requested behaviors
-Subject takes practice self-monitoring reading
-Question and answer period

9:00am -Administer series of questionnaires
-Jenkins Activity Survey
-State/Trait Anxiety
-Seigel Anger Inventory
-Beck Depression Inventory
-SAD/FNE
-Assertion Inventory

10:00am -Subject leaves clinic and proceeds with self-monitoring every two hours on assigned schedule.

Instructions for Self-Monitoring

Considerable effort was given to gaining the subject's committment regarding adherence to the self-monitoring procedure. Compliance was promoted by insuring that the subject read and understood the study requirements specifically outlined in the informed consent form (Appendix 6). It was anticipated that the laboratory relaxation procedure would be a positive experience for each subject and that it would encourage them to fully participate in the study. In addition, part of the laboratory relaxation procedure emphasized getting "in touch" with your body sensations and emotions. Hopefully, this provided some practice in "sensing one's internal state" even to the most stoic of subjects. The self-monitoring form was designed to be both readable and appropriate to the study population. It had undergone extensive pilot work and appropriate revisions had been made based upon pragmatic as well as conceptual concerns.

Clear and concise instructions regarding the operation of the blood pressure equipment and completion of the monitoring forms was provided on the cover sheet of the self-monitoring booklet (Appendix 7). After initial instruction, all subjects practiced the use of the Norelco 3500 prior to leaving the clinic. The subject was also informed that the investigator could be contacted at home as well as at the clinic should problems develop with the Norelco 3500 or with the self-monitoring process. Reliability of blood pressure measurements was promoted by regular maintenance of the blood pressure equipment including

replacement of batteries and printer paper.

Single Case Designs

Two additional subjects volunteered to self-monitor blood pressure and mood state over an extended period of time. Both self-monitored mood and blood pressure using the Norelco 3500 but did not complete the questionnaire measures or the laboratory relaxation procedure. The self-monitoring procedure was similar to that used in the main study with the exception that monitoring was done once a day over a 30-day period. This provided equal intervals between all blood pressure measurements which is an assumption for the use of autocorrelational analysis. Further description of these cases and an analysis of their blood pressure monitoring is presented in Appendix 1.

Section V

RESULTS

Organization of Results Section

1. Data Processing
2. Results from Blood Pressure Screenings
3. Subject Characteristics
4. Compliance to Self-Monitoring
5. Blood Pressure Data
    a. Means and Standard Deviations
    b. Pearson Correlations between Ambulatory BP and Baseline Laboratory (total & by sex)
6. Tests of Hypotheses
    I. Ambulatory Blood Pressure and Moods, Perceptions of Environment
        a. Means and Standard Deviations
        b. Pearson Correlations (total and by sex)
        c. Stepwise Regression Analysis (total and by sex)
        d. T-tests Across High/Low BP Individuals (total and by sex)
        e. T-test Across High/Low BP Readings (total and by sex)
    II. Ambulatory Blood Pressures, Moods and Questionnaires
        a. Pearson Correlations
    III. Ambulatory Blood Pressure and Cardiovascular Reactivity
        a. Pearson Correlations
7. Accuracy in Predicting Blood Pressure
    a. Means and Standard Deviations
    b. Pearson Correlations
        - with Ambulatory BP

- with Moods and Perceptions of Environment

c. Plots and Correlations

- Improvement in Prediction of BP over Time

Data Processing

Of the 51 subjects entering the study, 48 completed at least 10 or more ambulatory blood pressure observations over the two day period. Two subjects completed 2 and 3 readings respectively. One subject was unable to complete the readings due to reported malfunction of the Norelco 3500. The second subject discontinued monitoring upon arrival of out-of-town friends, and a concurrent decision to drop-out of his psychology class.

All questionnaires and self-monitoring data were hand scored and keypunched into datasets for subsequent analysis by the Statistical Analysis System (SAS; SAS Institute, 1982). For the correlational and regression analyses each individual's blood pressure and mood ratings were averaged across the 2-day period. An alpha level of .05 was utilized throughout the analyses as the level for Type 1 error. Table 3 contains a listing of abbreviations utilized throughout the results section.

Results from Blood Pressure Screenings

Blood pressure screening was performed at a Virginia Tech student dining hall with the goal of identifying potential study participants with high normal or elevated blood pressures. Approximately 300 students were screened of whom 27 had a blood pressure exceeding either 140 mm Hg systolic or 90 mm Hg diastolic. All 27 were given appointments at the Student Health Center for a second blood pressure check.

Table 3

List of Abbreviations

Abbreviations	Variable Label
Mood Ratings (Bipolar)	
Anxious	Anxious/Tense - Calm
Happy	Happy - Depressed
Interest	Interested - Bored
Quiet	Quiet - Active
Impatient	Impatient - Patient
Cautious	Cautious - Aggressive
Assertive	Assertive - Passive
Competitive	Competitive - Cooperative
Low Time Pressure	Low Time Pressure - High Time Pressure
Energetic	Energetic - Tired
Unsure	Unsure - Confident
Lonely	Lonely/Rejected - Accepted
Angry	Angry/Hostile - Friendly
No Worries	No Worries - Worried
Easy Going	Easy Going - Hard-driving
Anger-in	Hold Anger In - Express Anger
Frustrate	Frustrated - Care-free
Free floating	Free floating thoughts - Concentrated thoughts
Mood Clusters	
Negative	Negative Moods (worried, depressed, high time-pressure, hostile/angry, anxious, tense)
Positive	Positive Moods (interested, energetic, patient)
Type A	Type A Moods (anxious/tense, active, aggressive, assertive, hard-driving, self-confident)
Perceptions of the Environment	
E Demand	Non-Demanding - Demanding
E Hostile	Non-Threatening - Threatening/ Hostile
E Comf	Uncomfortable - Comfortable
E Noisy	Quiet - Noisy
E Flex	Structured - Flex-time

List of Abbreviations (continued)

Abbreviations	Variable Label
Questionnaires	
JAS	Jenkins Activity Survey
STAIS	State-trait Anxiety Inventory - State
STAIT	State-trait Anxiety Inventory - Trait
SAI	Siegel Anger Inventory - Arousal
SAII	Siegel Anger Inventory - Anger In
SAIO	Siegel Anger Inventory - Anger Out
Beck	Beck Depression Inventory
SAD	Social Anxiety & Distress Inventory
FNE	Fear of Negative Evaluation Inventory
GR Response Probability	Gambrill Richey Assertion Inventory - Response Probability
GR Discomfort	Gambrill Richey Assertion Inventory - Response Discomfort
GR Difference	Gambrill Richey Assertion Inventory - (Response Probability - Response Discomfort)
Subject Characteristics	
PHx High BP	Past history of at least one high BP reading
PHx Hypertension	Past history of hypertensive diagnosis
FHx Hypertension	Family history of hypertension
FHx CHD	Family history of Coronary Heart Disease
Exercise 1	Jogged or walked briskly
Exercise 2	Climbed a flight of stairs
Exercise 3	Other exercise

Of the 27 for whom an appointment was made, 12 completed the second screening exam. Physicians from the Student Health Center identified four individuals from this population as having borderline elevated or high normal blood pressure and who were willing to consider participation in this study. Of these four, two participated in the study.

Subject Characteristics

Table 4 presents characteristics of the final subject pool. As is evident from this data, the population is best characterized as a predominantly caucasian, undergraduate population. Sixty-one percent were male and thirty-nine percent female. Approximately one third provided some history of having at least one elevated blood pressure reading. Ambulatory blood pressure means and standard deviations for this subject pool suggest that it is best described as a normotensive population. Histograms of SBP and DBP distributions for this population are presented in Figures 2 and 3.

Compliance to Self-Monitoring

The proportion of assigned self-monitoring observations completed, both total and by portion of the day, are presented in Table 5. The availability of printed output from the Norelco 3500 facilitated the examination of adherence to self-monitoring regimen. Observations were classified as completed if the subject performed the monitoring within $\pm$ 30 minutes of the assigned time or if a missed reading was made up on an extension of the two hour schedule. For example, if an 8 am reading was missed because of waking up late, it could be made up at 10 pm that evening. The same $\pm$ 30 minute criterion was used for these makeup doses. Using these rather liberal guidelines the proportion of overall

Table 4

Subject Characteristics

Total Subject Pool:		51
Total Completing ABPM:		49
Demographics		
Age	Mean:	19.3 years
	Range:	5 (18-23)
Sex	Males:	31
	Females:	20
Race	White:	46
	Black:	4
	Oriental:	1
Past History of BP Problems		
Elevated Reading Only:		14
Diagnosed Hypertensive:		3
Total		17
Current ABP Status		
SBP	Mean:	118.5
	SD:	12.6
	Range:	59.8 (89.1 - 148.9)
DBP	Mean:	68.6
	SD:	7.5
	Range:	37 (51.3 - 88.3)
HR	Mean:	72.7
	SD:	8.8
	Range:	45.3 (47.5 - 92.8)

Note: ABPM = Ambulatory Blood Pressure Monitoring

Subject Characteristics (Continued)

Psychological Questionnaire	Mean	SD
JAS	206.9	73.4
STAIS	34.8	10.7
STAIT	40.9	11.3
SAI	26.7	8.6
SAII	17.2	4.0
SAIO	12.6	2.8
Beck	7.8	7.0
SAD	7.5	5.5
FNE	14.9	8.9
GRRP	104.5	12.9
GRD	99.4	21.8
GRDEL	5.2	19.0

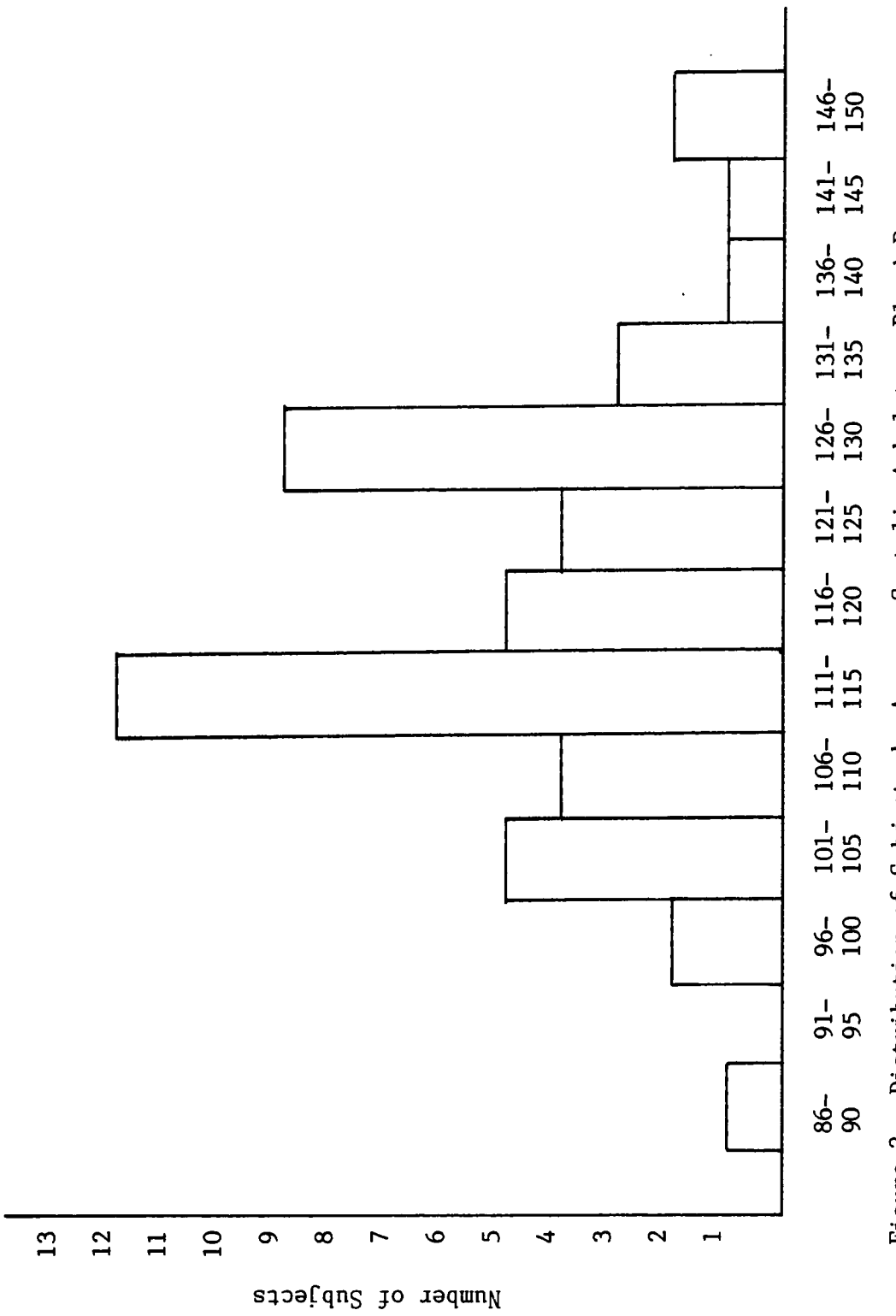

Figure 2. Distribution of Subjects by Average Systolic Ambulatory Blood Pressure

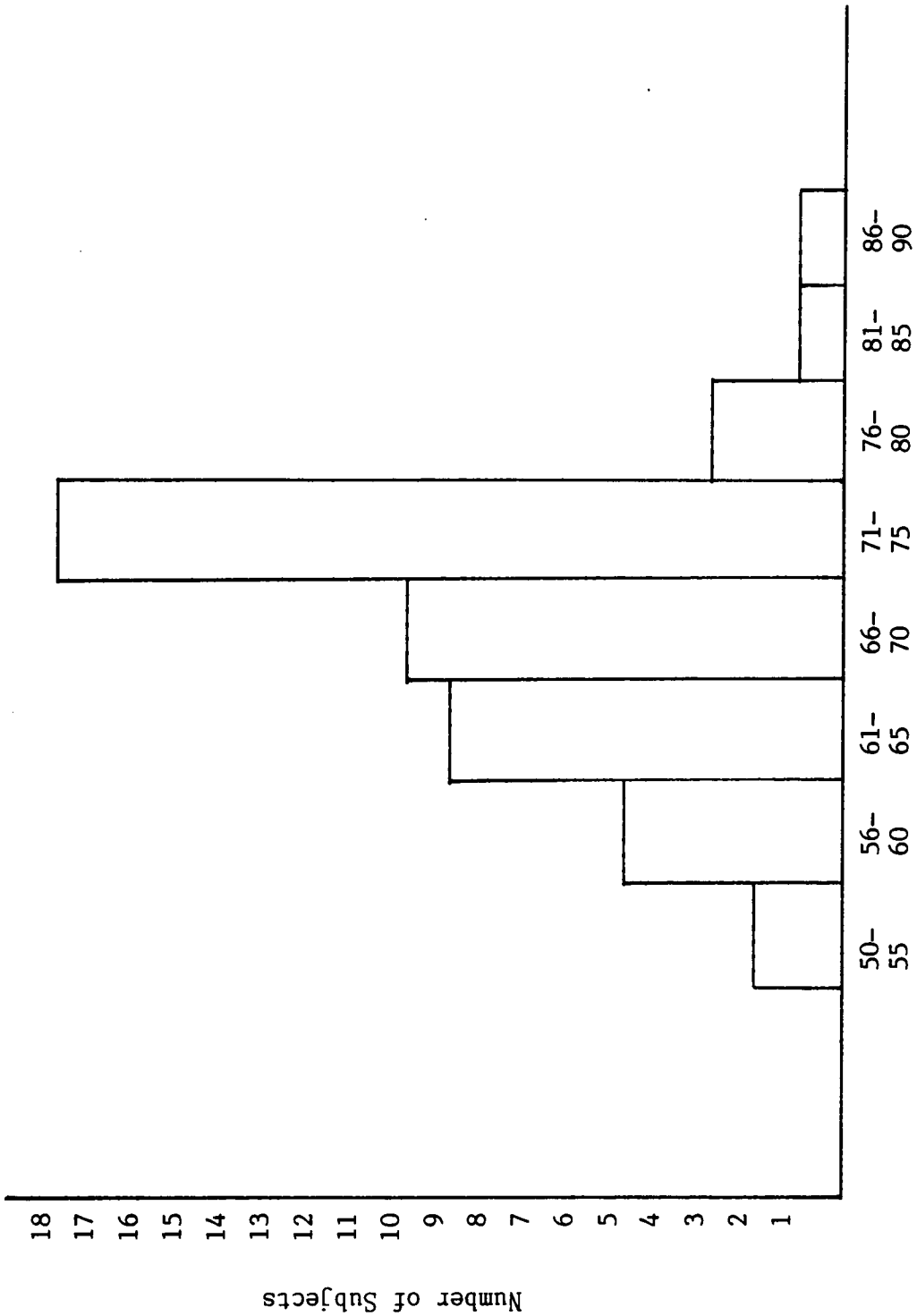

Figure 3. Distribution of Subjects by Average Diastolic Blood Pressure

Table 5

Proportion of Assigned Blood Pressure Measurements Completed

	Number	Proportion Completed
Total Readings Completed	555	93%
Total Readings Assigned	598	
Readings Completed in Morning	131	87%
Readings Assigned in Morning	150	
Readings Completed in Afternoon	187	94%
Readings Assigned in Afternoon	199	
Readings Completed in Evening	228	92%
Readings Assigned in Evening	249	
Proportion of Assigned Reading Completed Within $\pm$ 5 min.	319/519	62%
Proportion of Assigned Reading Completed Within $\pm$ 15 min.	431/518	83%

N = 45

Note: Total Readings Completed contains 9 makeup readings taken out of sequence but on 2 hour schedule. For example, a missed morning reading might be made up at 12 midnight. Thus, sum of readings completed in morning, afternoon and evening do not equal total readings.

observations completed was 93%. Subjects were more compliant with afternoon observations than those assigned in the morning although all proportions are relatively high. In contrast, the proportion of observations completed within ± 5 minutes of the assigned time was relatively low (62%) and rose only modestly when the criteria were set at ± 15 minutes (83%). Clearly, subjects adhered to the overall number of assigned readings better than to the assigned time.

Blood Pressure Data

Means and standard deviations for baseline laboratory and ambulatory blood pressures, both total and by sex, are presented in Table 6. Correlations between average ambulatory blood pressure and its variability are presented in Table 7. Only HR demonstrated a significant correlation between its average and standard deviation. This lack of relationship for SBP and DBP is consistent with the study by Horan, Kennedy & Padgett (1981) who found no relationship between average blood pressure level and lability in a mixed population of normotensives and hypertensive undergoing ambulatory monitoring.

Pearson correlation coefficients between and within baseline blood pressures and ambulatory blood pressures are depicted in Table 8. Although the correlations between laboratory blood pressures and their respective ambulatory pressures are generally high, it should be noted that laboratory measurements only predicted 55% of the variance in ambulatory SBP, 31% of the variance in ambulatory DBP, and 30% of the variance in ambulatory HR. These levels are generally consistent with that found by other researchers (Harshfield et al., 1982).

Table 6

Baseline Laboratory Blood Pressure and Ambulatory Blood Pressures: Means and Standard Deviations

	Total		Males		Females	
	Mean	SD	Mean	SD	Mean	SD
Laboratory Baseline						
SBP	116.3	13.6	122.0	13.1	107.4	8.9
DBP	70.4	10.4	69.7	11.3	71.4	8.0
HR	65.0	8.2	63.1	7.8	68.0	7.9
Ambulatory						
SBP	118.5	12.6	123.5	11.9	110.4	9.0
DBP	68.6	7.5	67.0	7.6	71.2	6.8
HR	72.7	8.8	70.0	8.1	77.1	8.2

N = 49

Table 7

Correlations Between Ambulatory Blood Pressure Means and Variability: Total and By Sex

Blood Pressure Means	Blood Pressure Variability SBP	DBP	HR
Total (N = 49)			
SBP	.04		
DBP		.10	
HR			.41**
Males (N = 30)			
SBP	.26		
DBP		.14	
HR			.33
Females (N = 19)			
SBP	-.36		
DBP		-.14	
HR			.38

** $p \leq .01$

Table 8

Correlations Between Baseline Laboratory Blood Pressure and Ambulatory Blood Pressure

	Baseline Laboratory		Ambulatory		
	BLDBP	BLHR	SBP	DBP	HR
Total (N = 49)					
Baseline SBP	.29*	.07	.79****	.17	-.15
Baseline DBP		.41**	.02	.56****	.27
Baseline HR			-.26	.43**	.71****
Ambulatory SBP				.24	-.20
Ambulatory DBP					.41**
Ambulatory HR					
Males (N = 30)					
Baseline SBP	.48**	.30	.74****	.45**	.16
Baseline DBP		.56***	.19	.56***	.48**
Baseline HR			-.03	.55***	.66****
Ambulatory SBP				.47**	.07
Ambulatory DBP					.44**
Ambulatory HR					
Females (N = 19)					
Baseline SBP	.15	.23	.63**	.19	-.17
Baseline DBP		.10	-.12	.55**	-.22
Baseline HR			-.28	.04	.68***
Ambulatory SBP				.44	-.12
Ambulatory DBP					.14
Ambulatory HR					

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$, **** $p \leq .0001$

Ambulatory Blood Pressures and Moods, Mood Clusters and Perceptions of the Environment

Correlational analyses. Means and standard deviations for the mood and perception of the environment ratings are presented in Table 9. Tables 10, 11, and 12 present the results of correlational analysis between average ambulatory blood pressure and mood ratings, both total and by sex. In general, few significant correlations are noted. For both sexes combined, holding anger in was correlated with SBP while expressing anger was related to HR. No mood rating was associated with blood pressure for males. SBP was positively associated with holding anger in and negatively associated with the Type A mood cluster in females.

For both sexes combined, the variability of SBP was negatively associated with perception of the environment as demanding. When examined by sex, it appears that this finding derived from the males. For females, there were no significant relationships between perceptions of the environment as hostile or demanding and ambulatory blood pressure.

The univariate correlational analysis between average ambulatory blood pressure and self-monitored variables was supplemented by a multivariate stepwise regression analysis which is presented in Table 13. One important limitation of this regression analysis is that it removes from the analysis any case which contains any missing data. This resulted in a substantial reduction in the number of cases under analysis (from 49 to 31 of total, from 30 to 17 of males, from 19 to 14 of females). Given the large number of variables entered

Table 9

Mood and Perception of Environment Ratings Across Subjects: Means and Standard Deviation, Total and By Sex

	Total		Males		Females	
	M	SD	M	SD	M	SD
Anxious	3.7	.7	3.7	.8	3.6	.6
Happy	4.9	.8	5.0	.8	4.8	.6
Interested	4.9	.8	4.9	.7	4.7	.5
Quiet	4.3	.8	4.2	.9	4.3	.7
Impatient	3.8	.6	3.8	.6	3.9	.5
Cautious	3.9	.4	3.9	.4	4.0	.4
Assertive	4.1	.6	4.2	.6	4.0	.6
Competitive	3.7	.6	3.7	.6	3.8	.6
Low Time Pressure	4.0	.7	4.0	.8	3.9	.4
Energetic	4.0	.8	4.1	.8	3.9	.6
Unsure	3.3	.8	3.3	.9	3.3	.6
Lonely	2.8	.7	3.8	.7	2.9	.7
Angry	2.9	.8	3.8	.9	3.1	.6
No Worries	4.0	1.1	4.2	1.1	3.8	1.1
Easy Going	4.4	.8	4.6	.9	4.3	.7
Anger In	4.6	1.5	4.9	1.2	4.3	1.7
Frustration	3.7	.8	3.6	.9	3.8	.7
Free Floating Thoughts	3.8	.9	3.6	.9	4.0	.8
E Demand	4.9	.8	5.0	.9	4.9	.7
E Hostile	5.7	.8	5.7	.9	5.7	.8
E Comfortable	2.7	.7	2.8	.8	2.7	.7
E Noisy	4.5	.7	4.5	.7	4.4	.8
E Flexible	3.7	.8	3.7	.9	3.7	.6

N = 49 M = mean SD = Standard Deviation

Table 10

Correlations Between Ambulatory Blood Pressures and Moods/Perceptions of the Environment: Total

	Cardiovascular Indices					
Mood Rating	SBP M	SBP SD	DBP M	DBP SD	HR M	HR SD
Angry	-.22	-.04	.27	-.01	.27	.13
Anger In	.37*	-.34	-.09	.04	-.39*	-.12
Negative	-.25	-.12	.11	.01	.09	-.00
Positive	.09	-.01	-.23	-.04	-.20	-.20
Type A	-.19	-.12	.04	-.05	-.05	-.10
E Demand	-.10	-.29*	.03	-.01	.05	-.09
E Hostile	.00	-.27	.20	-.16	.10	-.04

* $p \leq .05$

N = 49

Table 11

Correlations Between Ambulatory Blood Pressures and Moods/Perceptions of the Environment: Males

	Cardiovascular Indices					
Mood Rating	SBP M	SBP SD	DBP M	DBP SD	HR M	HR SD
Angry	-.21	-.09	.27	-.26	.34	.01
Anger-in	-.02	-.27	-.04	-.13	-.35	-.39
Negative	-.31	-.18	.08	-.15	.04	-.16
Positive	.13	-.01	-.17	.14	-.24	-.13
Type A	-.18	-.20	.16	-.02	-.04	-.24
E Demanding	-.03	-.41*	.12	-.10	.14	-.17
E Hostile	.00	-.24	.15	-.24	.22	.01

* $p \leq .05$

N = 30

Table 12

Correlations Between Ambulatory Blood Pressures and Moods/Perceptions of the Environment: Females

	Cardiovascular Indices					
Mood Rating	SBP M	SBP SD	DBP M	DBP SD	HR M	HR SD
Angry	.07	.02	.14	.40	-.07	.22
Anger-In	.70**	-.48	.02	.34	-.34	.21
Negative	.11	.02	.07	.31	.03	.17
Positive	-.30	.02	-.29	-.32	.01	-.26
Type A	-.47*	.06	-.13	-.06	.01	.10
E Demanding	-.21	.00	-.19	.11	-.17	-.03
E Hostile	-.02	-.34	.34	-.03	-.10	-.10

* $p \leq .05$, ** $p \leq .01$

N = 19

Table 13

Stepwise Regression for Mood, Perception of Environment and Daily Health Habits in Predicting Ambulatory Blood Pressures

	SBP	SBPSD	DBP	DBPSD	HR	HRSD
Total (N = 31)	E Flexible Anger In R^2 = .35	Anger Out E Quiet R^2 = .27	-----	Quiet R^2 = .16	Free Float Cigarettes Anxious R^2 = .47	Cigarettes Free Float R^2 = .43
Males (N = 17)	E Flexible Accepted R^2 = .51	Easygoing R^2 = .29		-----	Bored E Noisy R^2 = .63	Free Float Cautious Time Pressure R^2 = .66
Females (N = 14)	Anger In R^2 = .54	-----	-----	Angry R^2 = .40	E Uncomfort R^2 = .36	Cigarettes E Hostile Angry Interested Depressed Anger In Low Time Pressure R^2 = .996

Note: Beta coefficient significance of $p \leq .05$ required for entry and maintenance in regression analysis.

into the regression analysis and the relatively small number of subjects, the results should be considered with caution. One advantage of the regression analysis however, is the opportunity to examine for the relative influence of moods versus drug ingestion and exercise in predicting blood pressure. Results of the regression analysis for the total subject pool suggest that high SBP was best predicted by perception of the environment as flexible, and holding anger in. No variables met the criteria for entry into the regression analysis for DBP. Cigarette smoking along with anxiety and free floating thoughts were predictive of HR. One interesting finding is the high amount of variance (R^2 = .996) accounted for in HR variability in females. Even when considering the interpretive cautions noted above, this is a remarkably high level of co-variation. It suggests that HR variability in females may be the most sensitive of the averaged ambulatory cardiovascular indices to mood co-variation.

Comparison of individuals with high versus low ambulatory blood pressures. T-tests were utilized to determine whether individuals with high average blood pressure report greater mood rating magnitudes than those individuals averaging a lower blood pressure. For example, do individuals with higher average ambulatory blood pressure report increased anger or anxiety levels? From the population of 49 subjects, those 15 subjects at the highest end of the average means blood pressure distribution were compared with those 15 subjects with the lowest average mean blood pressure. Mean blood pressure (MBP) was chosen as the discriminating blood pressure since it is a composite of both SBP and DBP. The formula for MBP is: MBP =[DBP + (SBP - DBP)/3]

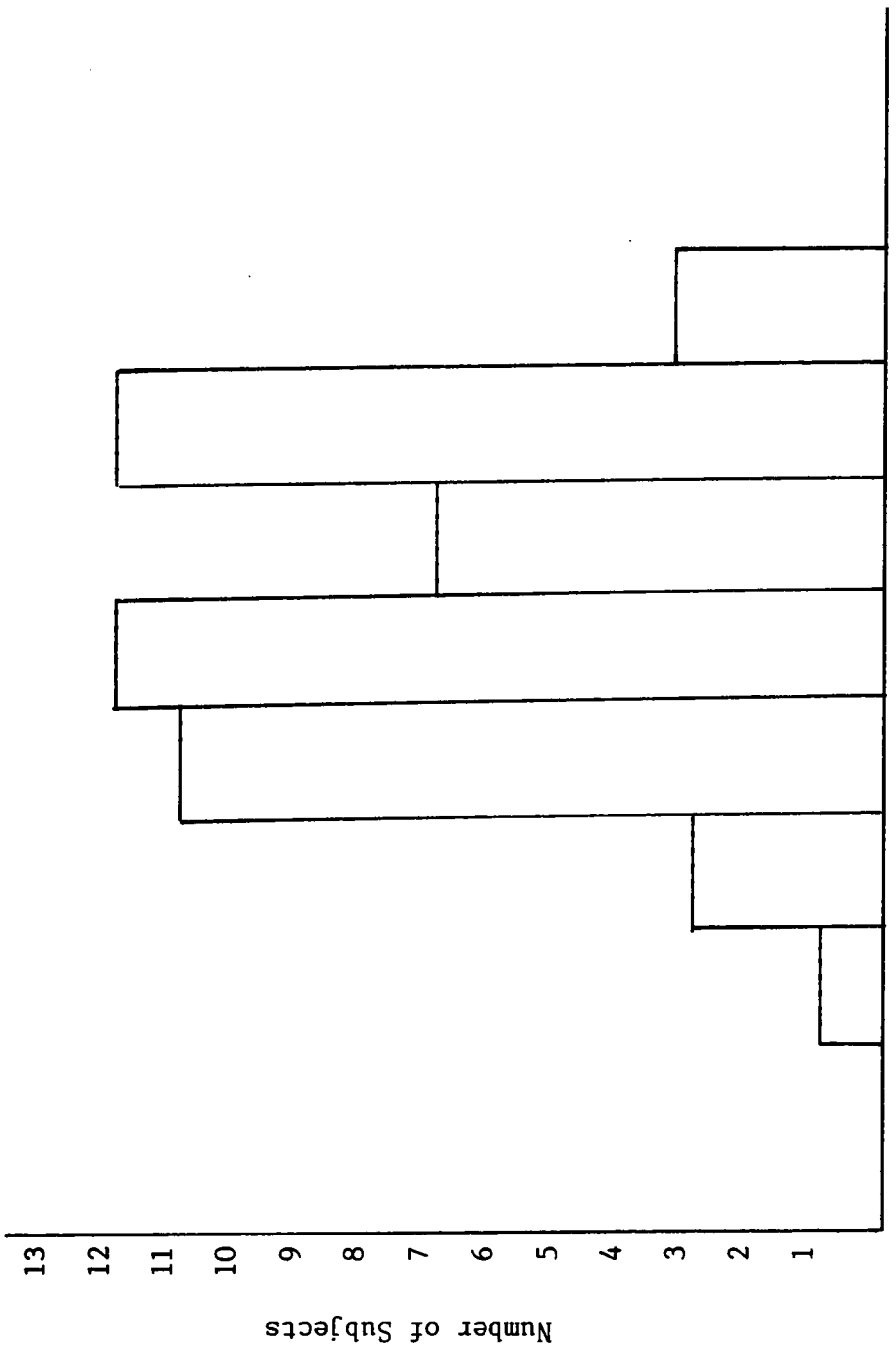

Figure 4. Distribution of Subjects by Average Mean Ambulatory Blood Pressure

(Hutchison, 1975). A histogram of the MBP distribution is presented in Figure 4.

Table 14 presents t-test comparisons for ambulatory blood pressure. As expected, the two groups were significantly different on SBP and DBP. As shown in Table 15 however, the groups did not differ on any of the mood ratings. The only discriminating self-monitoring variable was the low group's perception of the environment as being more comfortable. Finally, Table 16 presents the t-test comparisons for laboratory variables. Of the questionnaires, the high blood pressure group had a lower score on the Fear of Negative Evaluation Inventory. The high blood pressure group also had a lower response probability and lower discomfort rating on the Gambrill Richey Assertion Inventory. However, the Gambrill Richey difference score was not statistically significant between the two groups. In summary, groups composed of individuals with either high or low average ambulatory blood pressures were generally indistinguishable based upon self-monitoring of mood states as well as questionnaire measures of psychological traits.

A combined within subject and across subject analysis. To determine if the mood ratings and perceptions of the environment might be related to high and low blood pressure readings within individuals, two comparison groups were formed. The first group consisted of the three highest readings for each individual. The second group was composed of the three lowest readings for each individual. The three readings were averaged within individuals before being added to the group. Each group therefore had 49 observations consisting of either high or low readings. This analysis emphasized within subject

Table 14

Differences Between High and Low Ambulatory Blood Pressure Groups: Ambulatory Blood Pressure

	Low Group Mean	High Group Mean	T-value
SBP	110.0	130.6	-5.9****
SBPSD	8.5	9.3	-1.0
DBP	60.5	75.3	-8.4****
DBPSD	7.2	7.9	-1.3
HR	69.6	74.4	-1.3
HRSD	9.0	9.6	- .5

**** $p \leq .0001$

Table 15

Differences Between High and Low Ambulatory Blood Pressure Groups: Moods and Perceptions of the Environment

	Low Group Mean	High Group Mean	T-value
Anxious	3.6	3.6	-.1
Happy	5.0	4.9	.2
Interested	5.1	4.7	1.7
Quiet	4.4	4.1	1.0
Impatient	3.7	3.8	-.9
Cautious	4.0	3.8	1.4
Assertive	4.3	4.1	1.5
Competitive	3.8	3.6	1.0
Low Time Pressure	4.0	4.3	-2.0
Energetic	4.0	4.1	-.2
Unsure	3.1	3.1	.2
Lonely	2.8	2.7	.7
Angry	2.8	2.9	-.3
No Worries	3.9	4.4	-1.4
Easygoing	4.2	4.8	-2.0
Anger-in	4.6	5.0	-.6
Frustration	3.5	3.7	-.6
Free-floating	3.6	3.9	-.8
E Demand	2.99	2.85	.5
E Hostile	1.99	2.43	-1.6
E Comfort	5.65	5.00	2.6**
E Noisy	3.32	3.51	- .8

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$, *** $p \leq .0001$

Table 16

Differences Between High and Low Ambulatory Blood Pressure Groups: Laboratory Blood Pressure and Psychological Questionnaires

	Low Group Mean	High Group Mean	T-value
Baseline SBP	108.6	125.7	-4.0***
Baseline DBP	63.5	73.8	-2.7**
Baseline HR	62.6	65.7	- .9
JAS	226.5	188.8	1.4
STAIS	35.0	33.0	.6
STAIT	41.8	36.3	1.8
SAI	28.7	25.9	.9
SAII	17.4	16.7	.4
SAIO	12.4	12.6	- .2
Beck	7.9	5.5	1.0
SAD	7.2	8.1	- .4
FNE	17.5	10.0	2.6*
GR Response Probability	110.5	99.2	2.7*
GR Discomfort	105.4	86.7	2.3*
GR Difference	5.4	12.5	-1.0

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

variability in blood pressure while allowing across individual comparisons. Results of paired t-test comparisons, total and by sex, are presented in Tables 17 through 25.

The observer is immediately confronted with a different pattern of results than that found when performing either the correlational analysis across subjects or the t-test comparison across high and low blood pressure individuals. Particularly noted is the strength of many of the relationships with p values extending to $\leq .0001$. For SBP, the mood rating with the largest T-value is the Type A cluster. The relationship is in the predicted direction with the group of high blood pressure readings having the higher Type A mean. Also distinguishing between high and low SBP readings was the negative mood cluster and perceptions of the environment as hostile and demanding.

Fewer findings are noted for DBP. Here, high readings are characterized by perceptions of the environment as hostile and demanding. Although the relationship between the Type A mood cluster was not significant for the total population, it was for females.

High HR readings were characterized by both the positive and Type A mood clusters. Contributions to the discriminative ability of these two clusters appeared to come from both sexes equally.

Correlations between Questionnaire Measures and Ambulatory Blood Pressure

In general, few significant correlations between questionnaire measures of psychological constructs and blood pressure were noted (see Table 26). Those that were significant had an association opposite to that which would have been predicted by the literature.

Table 17

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory SBP Readings for Each Subject: Total

Mood Rating	Low SBP Group Mean	High SBP Group Mean	T-value
Angry	2.9	3.0	-.5
Anger In	4.7	4.6	.2
Negative	17.0	18.8	-2.5**
Positive	12.8	13.2	-1.0
Type A	22.5	24.8	-5.6****
E Demanding	2.6	3.6	-4.2****
E Hostile	2.1	2.7	-3.6***

** $p \leq .01$, *** $p \leq .001$, **** $p \leq .0001$

N = 49

Table 18

Comparison of Mood Ratings and Perceptions of the Environment with Three Highest and Three Lowest Ambulatory SBP Readings for Each Subject: Males

Mood Rating	Low SBP Group Mean	High SBP Group Mean	T-value
Angry	2.6	3.0	-2.0
Anger In	5.3	4.7	1.0
Negative	16.1	18.7	-2.6**
Positive	13.1	13.2	- .2
Type A	22.3	25.8	-4.0***
E Demanding	2.5	3.6	-4.6****
E Hostile	2.0	2.8	-4.0***

** $p \leq .01$, *** $p \leq .001$, *** $p \leq .0001$

N = 30

Table 19

Comparison of Mood Ratings and Perceptions of the Environment with Three Highest and Three Lowest Ambulatory SBP Readings for Each Subject: Females

Mood Rating	Low SBP Group Mean	High SBP Group Mean	T-value
Angry	3.3	2.9	2.0
Anger In	4.2	4.2	.0
Negative	18.4	18.9	-.6
Positive	12.4	13.2	-1.2
Type A	21.1	25.7	-4.0***
E Demanding	2.8	3.6	-1.7
E Hostile	2.2	2.5	-1.0

*** $p \leq .001$

N = 19

Table 20

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory DBP Readings for Each Subject: Total

Mood Rating	Low DBP Group Mean	High DBP Group Mean	T-value
Angry	3.0	2.9	1.2
Anger In	4.8	4.9	-.0
Negative	17.7	18.4	-.9
Positive	13.0	12.9	.5
Type A	23.4	24.5	-1.6
E Demanding	2.7	3.5	-3.3**
E Hostile	2.3	2.6	-2.7**

** $p \leq .01$

N = 49

Table 21

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory DBP Readings For Each Subject: Males

Mood Rating	Low DBP Group Mean	High DBP Group Mean	T-value
Angry	2.8	2.9	- .0
Anger In	5.1	5.0	.6
Negative	17.2	17.5	- .0
Positive	13.6	13.2	1.0
Type A	24.4	23.6	1.3
E Demanding	2.9	3.3	-1.4
E Hostile	2.3	2.6	-1.2

N = 30

Table 22

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory DBP Readings For Each Subject: Females

Mood Rating	Low DBP Group Mean	High DBP Group Mean	T-value
Angry	3.4	3.0	1.9
Anger In	4.3	4.9	- .6
Negative	18.3	19.7	-1.5
Positive	12.1	12.3	- .4
Type A	21.8	26.0	-3.7**
E Demanding	2.4	3.8	-3.2**
E Hostile	2.1	2.8	-2.8**

** $p \leq .01$

N = 19

Table 23

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory HR Readings for Each Subject: Total

Mood Rating	Low HR Group Mean	High HR Group Mean	T-value
Angry	2.9	2.9	-.2
Anger In	4.4	4.6	-1.0
Negative	17.4	17.7	-.3
Positive	12.6	13.3	-2.0*
Type A	22.6	25.0	-3.6***
E Demanding	3.0	3.1	-.6
E Hostile	2.2	2.4	-1.0

* $p \leq .05$, *** $p \leq .001$

N = 49

Table 24

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory HR Readings For Each Subject: Males

Mood Rating	Low HR Group Mean	High HR Group Mean	T-value
Angry	2.6	2.9	-1.6
Anger In	4.6	5.0	-.3
Negative	16.8	17.2	- .5
Positive	12.8	13.4	-1.4
Type A	22.7	24.6	-2.3*
E Demanding	2.9	3.0	- .7
E Hostile	2.2	2.4	-1.3

* $p \leq .05$

N = 30

Table 25

Comparison of Mood Ratings and Perceptions of the Environment With Three Highest and Three Lowest Ambulatory HR Readings For Each Subject: Females

Mood Rating	Low HR Group Mean	High HR Group Mean	T-value
Angry	3.2	3.0	.7
Anger In	4.3	4.1	1.0
Negative	18.5	18.4	.1
Positive	12.1	13.2	-1.4
Type A	22.3	25.6	-2.8**
E Demanding	3.2	4.7	- .2
E Hostile	2.3	5.7	- .2

** $p \leq .01$

N = 19

Correlation between mood ratings and questionnaire measures. In order to assess the relationship between mood ratings and questionnaire measures of the corresponding construct, Pearson correlation coefficients were generated comparing both measures. The correlation coefficients are presented in Table 27. For the most part, mood ratings correlating significantly with the questionnaire measures were conceptually appropriate. However, a number of conceptually appropriate correlations are not noted. The JAS failed to correlate with aggression, the SAI failed to correlated with anger arousal, the SAII and SAIO failed to correlated with expression of anger and the Beck failed to correlated significantly with depression. Thus, using the questionnaire measures as the criterion, the mood ratings tended to be specific but not sensitive to the prevailing construct. Of course, such a comparison of 2-day self-monitoring of mood state and questionnaire measures of the same construct assumes that the 2-day period was representative. Insuring that there was at least one week-day involved in each 2-day self-monitoring period was an attempt to accomplish this.

Correlation between Blood Pressure Response to Relaxation in Laboratory Environment and Initial Reactivity to that Environment

Cardiovascular reactivity to the relaxation procedure was calculated by subtracting the blood pressure taken immediately after the relaxation procedure from the average of the two blood pressures taken at baseline. Cardiovascular reactivity to the laboratory was calculated by subtracting the 2-day average blood pressure in the field from the averaged baseline blood pressure in the laboratory. A Pearson product

Table 26

Correlations Between Ambulatory Blood Pressure and Psychological Questionnaires

	SBP	SBPSD	DBP	DBPSD	HR	HRSD
JAS	-.30*	.05	-.08	.10	-.16	-1.0
STAIS	-.22	-.29*	.07	.13	-.01	.06
STAIT	-.25	-.23	-.02	.07	-.11	-.05
SAI	-.14	-.07	-.09	-.03	-.13	.01
SAII	-.02	-.21	.00	-.16	-.19	-.20
SAIO	-.19	-.01	.03	-.17	.04	.03
Beck	-.28*	-.05	.08	.02	-.12	-.16
SAD	.06	-.22	.13	-.20	-.18	-.26
FNE	-.24	-.25	-.10	-.16	-.09	-.13
GR Response Probability	.12	-.20	-.43	-.06	-.25	-.06
GR Discomfort	-.13	-.25	-.16	-.21	-.20	-.15
GR Difference	.23	.16	-.11	.20	.05	.13

* $p \leq .05$

Table 27

Correlations Between Mood Ratings, Perceptions of Environment, and Questionnaires Measures

Mood Rating	Questionnaires								
	JAS	STAIS	STAIT	SAI	SAII	SAIO	Beck	SAD	FNE
Anxious	.28*	.43**	.42**	.28*	.16	.06	.39**	.32*	.30*
Happy	-.13	-.45***	-.42**	-.26	-.18	.13	-.28	-.20	-.23
Interested	.27	-.16	.14	.10	.19	.07	.15	.06	.02
Quiet	.03	-.14	-.16	-.24	-.18	-.14	-.09	-.26	-.11
Impatient	.03	.29*	.30*	.16	.09	.00	.20	.23	.19
Cautious	.02	-.10	-.01	-.14	-.06	-.36**	-.02	.02	.11
Assertive	.30*	.26	.42**	.29*	.12	-.04	.38**	.07	.18
Competitive	-.11	.29*	.16	.11	-.05	.17	.26	.00	.10
Low Time Pressure	-.28*	-.22	-.42**	-.18	-.12	.09	-.34*	-.21	-.29*
Energetic	-.06	-.21	-.20	-.12	.03	-.08	-.04	-.08	-.09
Unsure	.03	.23	.27	.04	.08	-.14	.12	.17	.32*
Lonely	-.02	.22	.18	-.03	.07	.11	-.11	.01	.24
Angry	.03	.42**	.36**	.22	.16	.09	.29*	.20	.27
No Worries	-.42**	-.47***	-.68****	-.46***	-.32*	.14	-.51***	-.40**	-.54****
Easygoing	-.50***	-.44***	-.57****	-.33*	-.20	.14	-.49***	-.29*	-.30*

Correlations Between Mood Ratings, Perceptions of Environment, and Questionnaires Measures (Continued)

Mood Rating	Questionnaires								
	JAS	STAIS	STAIT	SAI	SAII	SAIO	Beck	SAD	FNE
Anger In	.07	.07	.06	.22	.30	-.17	.02	.41*	-.12
Frustration	.14	.42**	.44***	.26	.20	-.09	.34*	.34*	.30*
Free Floating Thoughts	-.42**	-.22	-.46***	-.27	-.28*	.15	-.39**	-.36**	-.30*
Perceptions of Environment									
Demanding	-.18	-.35**	-.35**	-.23	-.08	-.05	-.36**	-.24	-.32*
Hostile	-.01	-.40**	-.19	-.18	-.12	-.33*	-.21	-.35**	-.24
Comfortable	-.03	.37**	.20	.03	.01	.08	.07	.14	.06
Noisy	.05	-.11	-.04	-.02	-.13	-.35**	.05	-.02	-.05
Flexible	.53****	.32*	.45***	.22	.13	-.10	.34*	.26	.16

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$, **** $p \leq .0001$

correlation coefficient was used to assess whether the difference between baseline blood pressure in the laboratory and 2-day self-monitoring (Reactivity to Lab) was related to the amount of blood pressure change during the laboratory relaxation procedure (Reactivity to Relaxation Procedure). Results are presented in Table 28. Reactivity to the laboratory was significantly correlated with reactivity to the relaxation procedure for DBP only. No association was noted for either SBP or HR.

Accuracy in Predicting Blood Pressure

An average predicted systolic and diastolic blood pressure and average actual systolic and diastolic blood pressure were calculated for each individual. Correlations between predicted blood pressures and actual ambulatory blood pressures are presented in Table 29. Predicted SBP was associated with approximately 88% of the variance in actual SBP. This relationship was 69% and 83% for DBP and HR respectively.

Table 30 presents the relationship between accuracy in predicting blood pressure (absolute value of actual - predicted) and self-monitoring variables. No mood rating or perception of the environment was associated with accuracy in predicting SBP. Perceptions of the environment as hostile was associated with improved accuracy in predicting DBP. The Type A mood cluster was associated with improved accuracy in predicting HR.

Improvement in accuracy of predicting ambulatory blood pressure was assessed by plotting the absolute difference between predicted and actual blood pressure over time. Plots for SBP, DBP and HR are presented in Figures 5 through 7 respectively. As suggested by these

Table 28

Comparison of Reactivity Measures

	Mean	SD
Reactivity to Lab		
SBP	-2.0	8.4
DBP	1.5	8.7
HR	-7.7	6.5
Reactivity to Relaxation		
SBP	0.9	5.7
DBP	0.2	5.2
HR	1.4	4.8
Correlation of Reactivity Measures (r values)		
SBP	.19	
DBP	.42**	
HR	.06	

N = 49

Note:
Reactivity to Lab = Baseline Laboratory BP - Average Ambulatory BP
Reactivity to Relaxation = Baseline Laboratory BP - Post-relation BP

Table 29

Correlations Between Predicted Blood Pressures and Actual Ambulatory Blood Pressure

Actual Blood Pressure	Predicted Blood Pressure SBP	DBP	HR
Total (N=49)			
SBP	.94****	.10	-.25
DBP	.19	.83****	.50***
HR	-.14	.52****	.91****
Males (N=30)			
SBP	.93****	.37*	.02
DBP	.45**	.82****	.57***
HR	.17	.56***	.90****
Females (N=19)			
SBP	.91****	.37	-.08
DBP	.39	.80****	.11
HR	-.06	.22	.89****

** $p \leq .01$, *** $p \leq .001$, **** $p \leq .0001$

Table 30

Correlations Between Accuracy in Predicting Ambulatory Blood Pressure and Mood Ratings/Perceptions of the Environment

	Accuracy in Predicting Ambulatory Blood Pressure		
Mood Rating	SBP	DBP	HR
Angry	-.00	.17	-.11
Anger In	---	---	---
Negative	.02	.22	.01
Positive	.03	-.07	.06
Type A	.11	.23	.29*
E Demand	.08	.15	.17
E Hostile	.05	.28*	-.08

* $p \leq .05$

N = 49

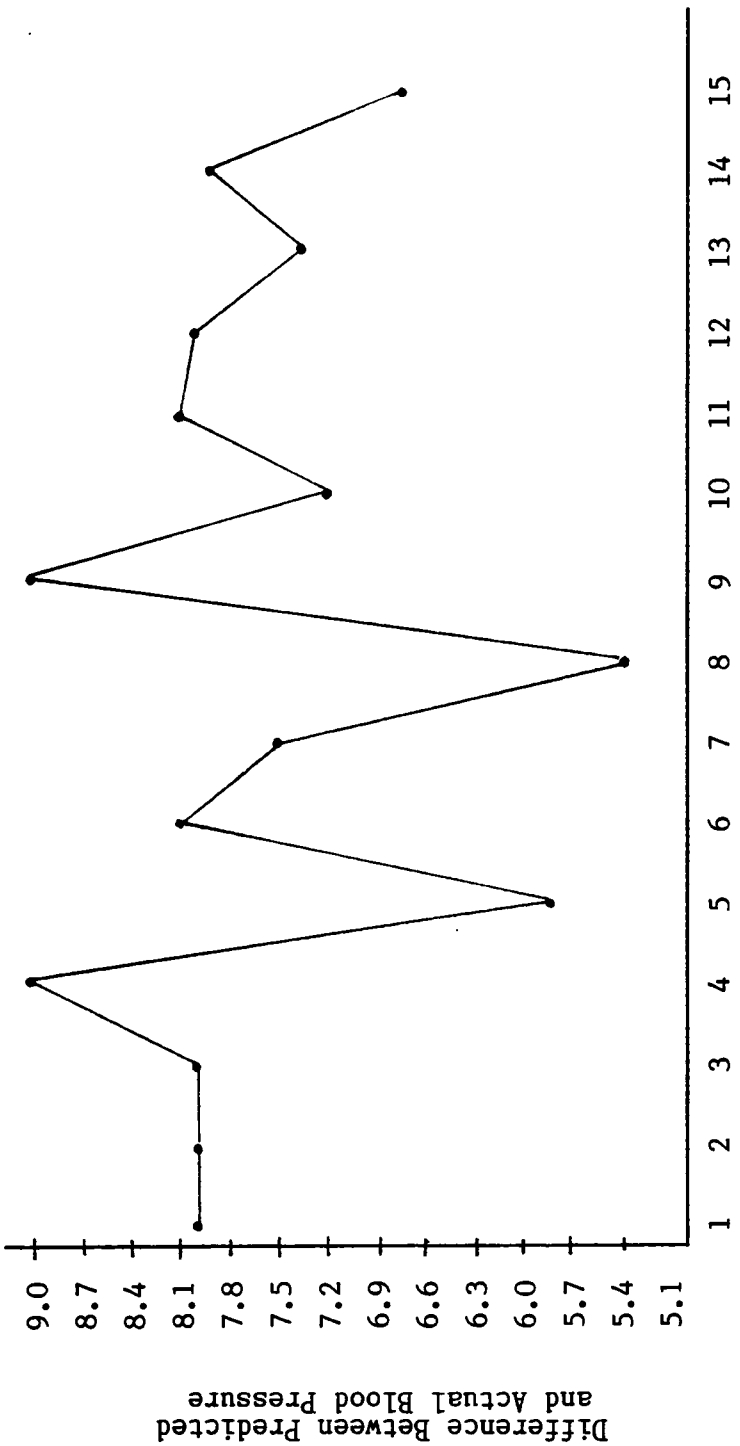

Figure 5. Accuracy in Predicting Systolic Blood Pressure Over Time

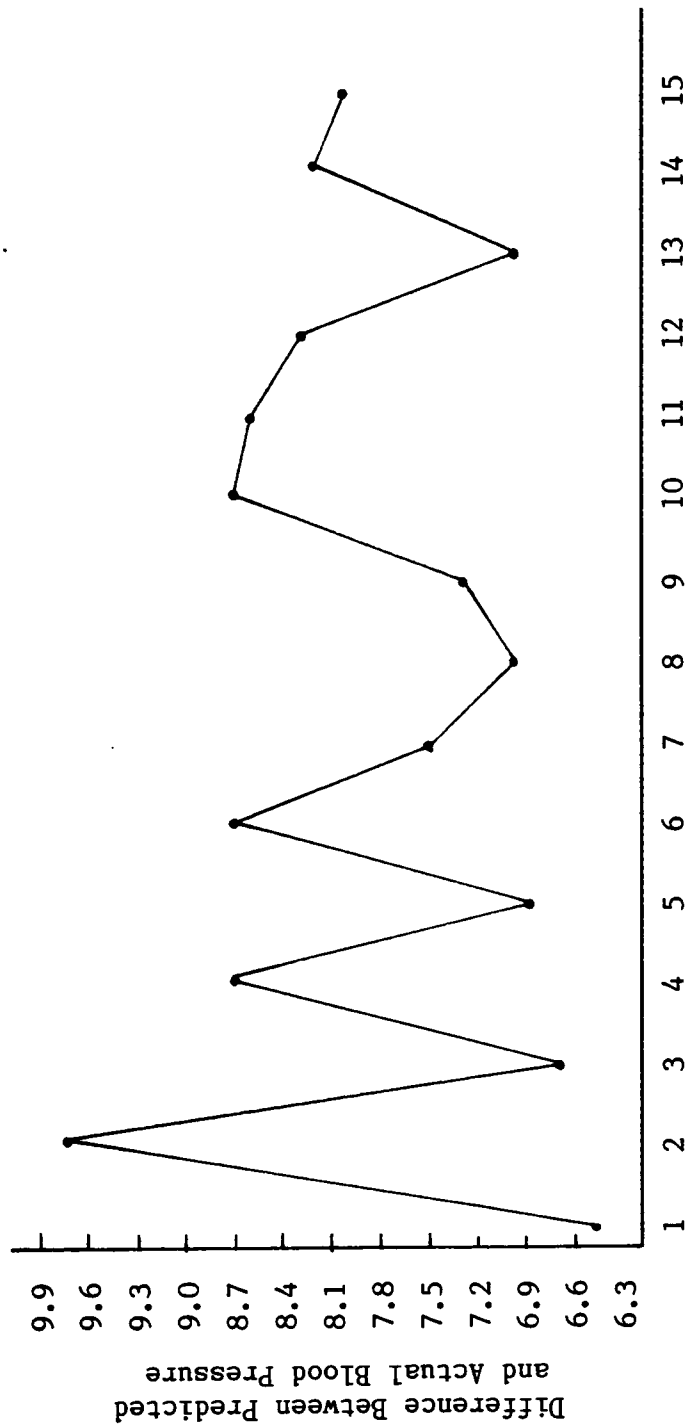

Figure 6. Accuracy in Predicting Diastolic Blood Pressure Over Time

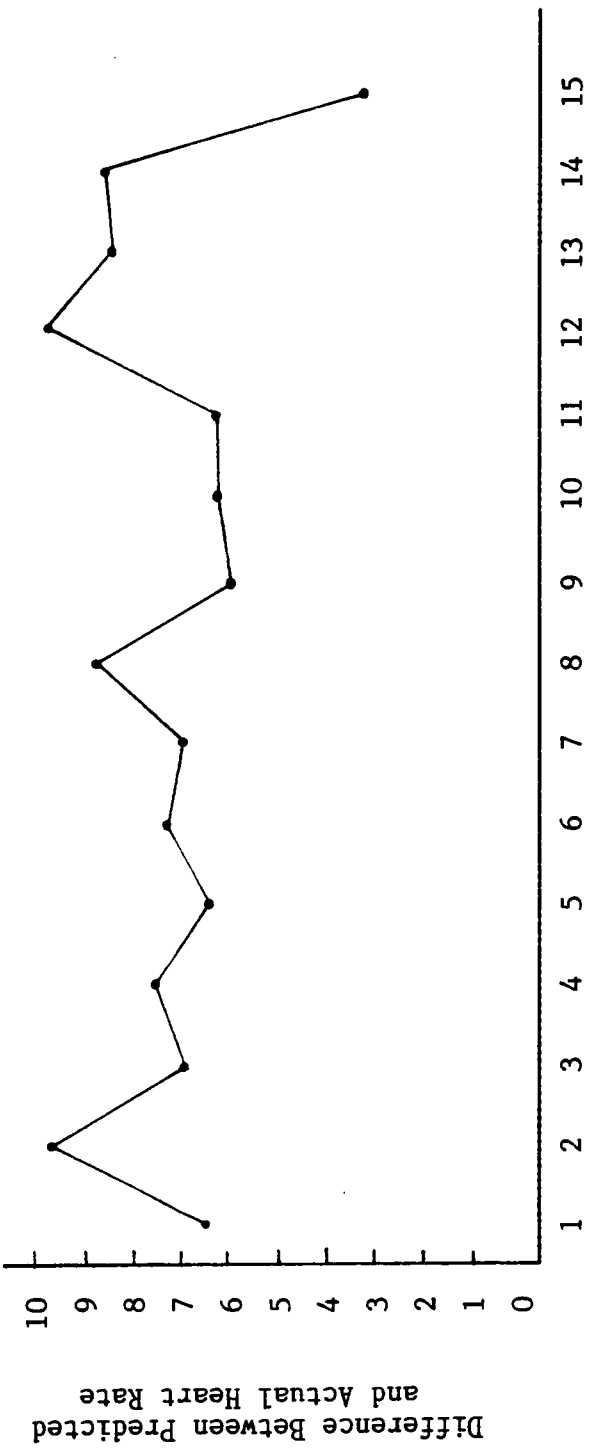

Figure 7. Accuracy in Predicting Heart Rate Over Time

plots, there was no improvement in accuracy over time (SBP: $r=-.15$, $p \leq .60$; DBP: $r=.09$, $p \leq .76$; HR: $r=-.14$, $p \leq .62$).

Section VI

DISCUSSION

This discussion will be organized around the three sets of specific hypotheses presented in Section III. The hypothesis will be stated, followed by a brief summary of the results applicable to that hypothesis. Discussion of the findings will then be presented.

Hypotheses I

Hypothesis A: Ambulatory blood pressure will be associated with anger arousal and expression as well as a perception of the environment as hostile and demanding.

Results. Between subject correlational analysis suggests that holding anger in may be related to average SBP, especially in females. No relationship was seen in males. Anger expressed outwardly was associated with HR (total). Anger arousal was not related to ambulatory blood pressure indices in either sex. Perception of the environment as demanding was negatively associated with SBP variability, particularly in males. No relationships between blood pressure and perception of the environment as hostile were noted. The combined within and across subject analysis suggests that neither anger arousal nor anger expression were related to high versus low ambulatory blood pressure readings. Perceptions of the environment as hostile and demanding did discriminate between high versus low SBP (total and males), and DBP (total and females).

Discussion. The relatively weak relationship between anger/hostility measures and averaged ambulatory blood pressure was

unexpected. The two previous studies (Sokolow et al., 1970, Southard et al., 1984) which addressed similar issues may provide some explanation. Sokolow et al.'s study of 50 hypertensives did not report an across subject correlational analysis using averaged ambulatory blood pressure. They did however, examine the relationship between moods and hypertensive complications and found a positive association for hostility. Given the essentially negative relationship between hostile mood and average blood pressure found in this study, Sokolow's findings suggest that anger arousal may be a response to the clinical progression of the disease rather than a precursor.

Sokolow et al. also performed a within and across comparison similar to the one used in this study. No relationship was found between blood pressure and hostility although a relationship with negative emotions did occur. In the present study there was a relationship between perception of the environment as hostile (SBP, DBP) but no relationship for anger arousal. Based on these two studies, it would appear that anger arousal itself does not seem to be related to either average ambulatory blood pressure or to high versus low ambulatory blood pressure readings. Perceptions of the environment as hostile, however, may be related to high blood pressure readings.

The study of an adolescent population of mixed hypertensive status did demonstrate a relationship between average ambulatory blood pressure and the hostile mood rating as well as a perception of the environment as hostile and demanding (Southard et al., 1984). This supports the above findings regarding perceptions of the environment as hostile but clouds the picture regarding hostile mood. There were however, both

demographic as well as cardiovascular differences between the adolescent population and the current subject pool. Although the mean age was similar for both subject groups (16 versus 19), the adolescent group was predominantly an inner-city black population as compared to the predominantly white college students described in the current study. Harburg et al.'s, (1973) findings that the relationship between hostility and blood pressure is accentuated in black individuals from high stress areas suggests that such demographics may alter mood and averaged blood pressure relationships. Hence, the finding of a specific relationship between hostility and blood pressure in the inner-city adolescent study may be due to the unique population studied. In addition, the similar relationship between blood pressure and depression noted in the adolescent study suggests that a more general negative mood cluster may have been the functional construct rather than anger per se.

Hypothesis B: Ambulatory blood pressure will be associated with negative emotions in general.

Results. Between subject correlational analysis revealed no relationships between the negative mood cluster and average ambulatory blood pressure. The combined within and across subject analysis found that the negative mood cluster discriminated between high and low SBP (total and males).

Discussion. The absence of a relationship between averaged blood pressure and negative emotions was unexpected given the results of both the adolescent study (Southard et al., 1984) and Sokolow et al.'s (1970) finding of a positive association between negative moods and blood pressures using an average of intra-individual correlations.

Sokolow et al.'s analysis however, emphasized within-subject variation much as did the combined within and across analysis used in the current study. The combined within and across analysis in this study did find a relationship between SBP and negative moods. It appears therefore, that the relationship between negative emotions and blood pressure is highly sensitive to the amount of within subject variation included in the analysis. The one exception to this statement is the relationship noted between averaged ambulatory blood pressure and negative mood noted in the adolescent study. Again, the unique characteristics of that study population (i.e. inner-city, blacks) may suggest that such finding would not be representative.

Hypothesis C: Ambulatory blood pressure will be associated with adjectives characteristic of the Type A behavior pattern.

Results. Between subject correlational analysis found that the Type A mood cluster was negatively associated with SBP in females only. The combined within and across subject analysis found relationships between the Type A mood cluster and high versus low SBP (total, males and females), DBP (females), and HR (total, males, females).

Discussion. The negative relationship between the Type A mood cluster and average ambulatory SBP in females is an interesting finding. No relationship was noted amongst males. This conceptual relationship in females was supported by the negative relationship found between average ambulatory SBP and the JAS, a measure of the Type A construct. An analysis of this latter association finds that there was no relationship when examined by sex (males: $r=-.17$, $p \leq .37$; females: $r=-.15$, $p \leq .54$). These findings suggest that those

individuals reporting high levels of Type A mood ratings or who reported Type A behavior on the JAS have the lowest average blood pressure readings. In contrast, the Type A mood cluster strongly and consistently discriminated high from low readings for SBP, DBP (females only) and HR. In all cases, high blood pressure and heart rate readings were associated with higher Type A mood cluster ratings. These latter results are supported by Sokolow et al.'s findings that high versus low SBP and DBP could be discriminated by mood ratings of anxiety, time-pressure and (for SBP only) alertness.

One might speculate that the relationship between Type A moods and blood pressure is a complex rather than a simple association. Moods characteristic of the Type A construct clearly discriminate between high and low SBP and DBP. This finding compliments the research demonstrating Type A/B differences in cardiovascular reactivity to laboratory stressors (see Krantz & Manuck, 1984). The absence of an association, or in the case of this study a negative association, between Type A measures and resting or average daily blood pressures, suggests that the Type A construct may not exert its association with CHD via the development of hypertension (again, Krantz & Manuck, 1984 provide a nice review). Rather the link may be directly through transient yet repeated elevations of blood pressure and associated neuroendocrine changes. Such repeated cardiovascular insults may in-themselves be the primary causal pathway linking Type A with CHD. The findings of this study are consistent with such a perspective.

Hypotheses II

Hypothesis A: Questionnaire measures of psychological constructs

will not be associated with ambulatory blood pressures.

Results. In general, this hypothesis was supported by this study's findings. Correlational analysis between average ambulatory blood pressure and questionnaires measures did reveal a negative relationship between SBP and the JAS as well as the Beck. Also noted was a negative association between SBP variation and the STAIS. None of the other psychological questionnaires were associated with ambulatory blood pressure.

Discussion. The findings in regards to the JAS were described above and will not be repeated here. The negative association between the Beck and SBP might be a reasonable finding if depression were associated with inactivity. Such inactivity might be characterized by mood ratings of tired and passive. However, the Beck was not associated with these mood ratings. In contrast, the Beck was associated with anxious, assertive, high time-pressure, angry, worried, frustrated, concentrated thoughts and hard-driving mood ratings. This group of mood ratings appears to be combination of the Type A and negative mood clusters. Thus, the findings between the Beck and SBP may be a similar relationship to that noted between the JAS and SBP.

The association of the STAIS with decreased variability of SBP has little or no conceptual basis to support it. If state anxiety is truly related to decreased SBP variability, one would expect that it would also be associated with a high average SBP. Since this latter association did not occur, the former appears to be a chance finding.

Hypothesis B: Self-monitoring of mood states will be associated with the corresponding construct as assessed by questionnaire measures.

Results. Correlations coefficients suggest that many conceptually appropriate adjectives were significantly associated with the various questionnaire measures of psychological constructs (i.e. anger, depression, anxiety etc.). However, some of the most descriptive adjectives were not associated with the appropriate questionnaire measure. For example, the correlation coefficient between the mood rating of depression and the Beck did not reach statistical significance, although it was in the appropriate direction. Similar lack of relationships were noted for anger arousal and the SAI, anger expression and the SAII and SAIO, and competitiveness for the JAS.

Discussion. Although many expected associations were noted, the conspicuous absence of several conceptually appropriate correlations suggests that questionnaire measures and mood ratings do not necessarily overlap. Foremost among the obvious explanations for this discrepancy is that the sampling period over which the mood ratings were collected was not representative of their average mood state. Unfortunately, this perspective can also be applied to the day upon which the questionnaire was completed and hence does not necessarily point to the mood ratings as being unrepresentative.

A second, and perhaps more illustrative perspective, concerns problems with scaling and labeling emotional states. Individuals who utilize only part of the mood rating scale may be indicating a high level of depression yet in comparison to other individuals, have a relatively low score. The inconsistency provided by that data point would lower the correlation between the depression mood rating and the Beck Depression Inventory. That subject's score on the Beck may

however, be quite consistent with that individual's perception of what that average mood rating means.

Two further observations regarding the relative usefulness of mood ratings versus questionnaire measures should be noted. A large difference between them is the manner in which they are used in comparative analyses. Questionnaire measures are generally taken as trait measures rather than state. They are therefore correlated with summary physiological characteristics such as average blood pressure or average blood pressure reactivity. Comparisons are made across individuals in a nomothetic fashion. In contrast, mood ratings can be used as assessments of psychological state concurrent with specific physiological observations. Inherent in this approach is greater variability in the psychological variable which in turn increases study power to demonstrate a significant correlation with the physiological variable. This approach not only maximizes variability but provides the basis for an idiographic approach as well. Such an approach minimizes inter-individual differences on other variables influencing blood pressure and emphasizes the change in psychological status associated with blood pressure changes.

A second observation concerns the specificity of both the mood ratings as well as the questionnaires. An examination of Table 27 suggests that three mood ratings were consistent across a wide variety of questionnaires. Anxious, worried and hard-driving mood ratings were significantly correlated with the questionnaire measure of Type A (JAS), anxiety (STAIS, STAIT), anger (SAI), depression (Beck), social anxiety and distress (SAD) and fear of negative evaluation (FNE). Such

a consistent relationship suggests that these questionnaires may be assessing some unitary construct of distress as well as their specific construct. A similar finding occurs when one examines the relationships of mood ratings to blood pressure. There tends to be either very few findings (moods associated with averaged ambulatory SBP) or a large number (moods associated with high versus low SBP). The ability of a priori mood clusters (Type A, negative and positive) to associate with blood pressure measures as well as, or even better, than individual mood ratings supports the concept of one or more unitary factors. Given the difficulties with scaling and labeling of emotions noted above, such clusters may be as specific as one can get with between individual analyses.

Hypotheses III

Hypothesis. Blood pressure response to a laboratory relaxation procedure will be correlated with an individual's initial blood pressure response to that laboratory environment.

Results. This relationship was true for DBP only.

Discussion. Studies examining the relationship between casual, laboratory or clinic blood pressures and average daily pressures have suggested that the correlation, though high, results in a number of false positive diagnoses. Hence, a number of individuals are diagnosed as hypertensive based upon one or more clinic readings when in fact their average daily blood pressure is below the standard cut-off level of 140/90 mm Hg. This becomes of some concern when making the decision to place the individual on long-term antihypertensive medications. The current approach to resolving this dilemma is to suggest the use of

ambulatory monitoring as part of the assessment for hypertension. An alternative would be the use of a clinic assessment procedure capable of predicting whether the clinic blood pressure was representative of ambulatory blood pressure for that individual. More specifically, did that individual experience a rise in blood pressure as a function of entering the medical environment? To address this concern, this study attempted to assess whether a blood pressure response to a laboratory relaxation procedure would be capable of predicting the difference between baseline clinic blood pressure and average daily blood pressure (see Figure 8).

The finding of a relationship for DBP is intriguing, yet preliminary. Figure 9 presents a scattergram of reactivity to the laboratory versus reactivity to the relaxation procedure. It is clear that a number of individuals had blood pressure reactivity levels in the predicted directions. However, the scattergram also indicates that some of the individuals had a reduction in their DBP upon entering the laboratory and subsequently had an increase in DBP after the relaxation procedure. These cases also contributed to the overall positive correlation between reactivity levels. Hence, examination of the direction of the blood pressure reactivity measures is as important as the magnitude of their correlation.

Considerable refinement and standardization of the relaxation procedure is necessary before its usefulness as an assessment instrument can be suggested. Problems encountered during the administration of the relaxation protocol included:

a. reactivity to the sound and pressure of the Norelco 3500 during

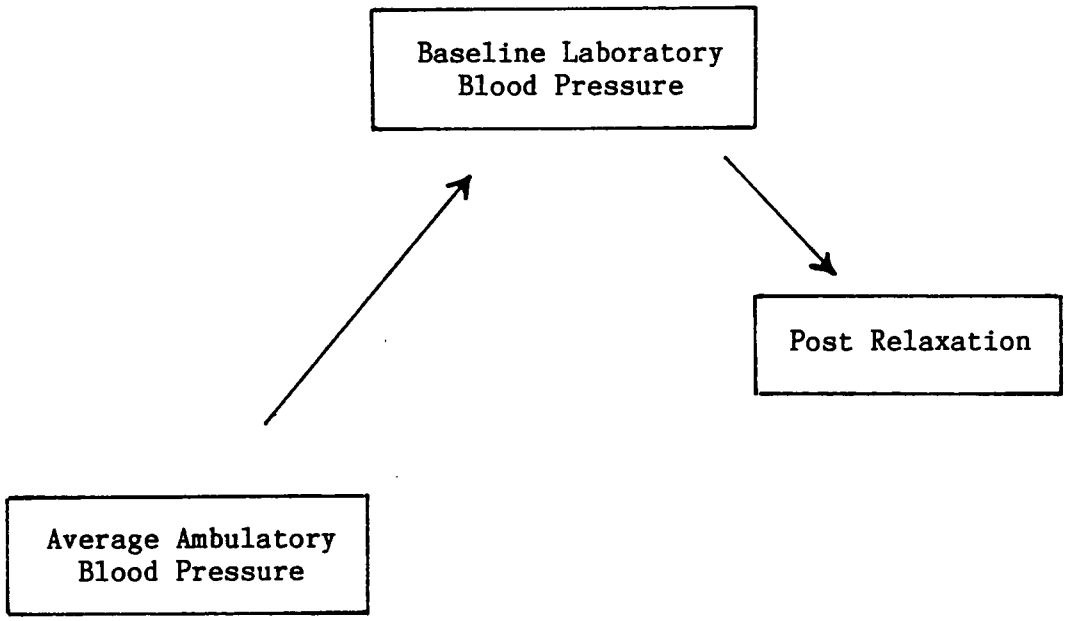

Figure 8. Blood Pressure Reactivity to the Laboratory.

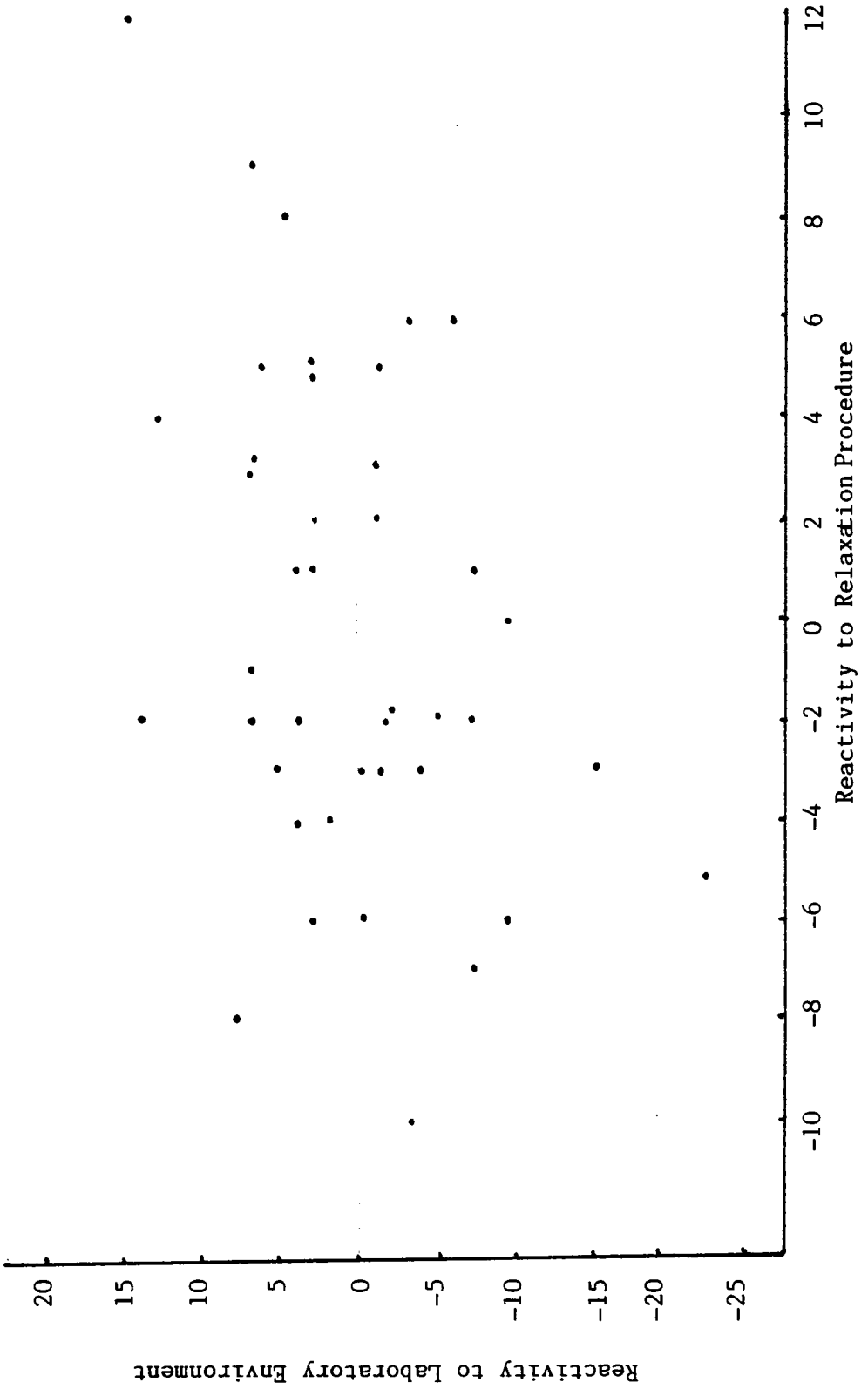

Figure 9. Scattergram of Diastolic Blood Pressure Reactivity

the post-relaxation measurement,

b. lack of sound proofing during the relaxation session,

c. lack of a standardized method of getting subjects to the clinic facilities, hence some uncertainty regarding the baseline,

d. failure of relaxation tape to induce self-reported relaxation in approximately 20% of subjects.

From a clinical standpoint, it may be suggested that the facilities used in this study are probably representative of the average health clinic environment. Hence, further refinement of the physical surroundings may increase the procedure's predictive ability for research purposes, yet not improve the procedure's usefulness in the average clinical setting. Clearly, one productive change would be a quieter blood pressure recorder.

Additional Findings

Accuracy in predicting blood pressure. The prediction of blood pressure appears to be based upon three factors:

a. knowledge of one's normal range of blood pressure.

b. feedback and comparison between a recent blood pressure measurement and the blood pressure level predicted at that time.

c. sensitivity to one's internal sensations and external stressors. The overall correlations between predicted and actual blood pressure in this study were quite high. One would suspect that this was probably due in large portion to the frequent feedback individuals received regarding the accuracy of the previous predictions as well as increased knowledge of their blood pressure range. However, further analysis of the relationship between predicted and actual blood pressure revealed a

lack of improvement in accuracy over time. This suggests that although they were able to predict a large percentage of the variance in their true blood pressure, this was not an active learning process. Rather, their initial accuracy was relatively high. This finding suggests an emphasis on internal sensations and external attributions supplemented by knowledge of normal range and feedback on previous readings.

Finally, at the first reading the average difference between predicted and actual readings was 8.0 ($\pm$ 6.5) mm Hg, 6.5 ($\pm$ 7.5) mm Hg, and 6.6 ($\pm$ 5.6) beats per minute for SBP, DBP and HR respectively. This level of accuracy was essentially the same throughout the remaining observations.

Lessons learned from blood pressure screening and compliance data. Based upon the experience noted in this study, one can expect a considerable challenge in recruiting hypertensive college students through a screening process similar to the one used here. Future efforts should be advised to project a longer recruiting period and possibly develop a long-term ongoing referral procedure for both clinical and research purposes. This is important both in terms of gaining clinical experience with this population as well as developing a more extensive rapport with the referring clinicians.

Of the subjects entering the study, the high level of compliance to the overall number of assigned readings suggests that the motivational factors operating in this study were sufficient to achieve this goal. Some difficulty was noted however with adherence to the assigned times for self-monitoring. Part of the low compliance to assigned times may have been due to instructions given by the investigator. In order to

avoid the influence of physical activity in this study, individuals were instructed to try to avoid physical activity for 15 minutes prior to each reading, and if unable to do so, to hold off taking their blood pressure for up to 15 minutes past their assigned time. This instructional set did reduce the influence of physical activity on blood pressure but in doing so reduced compliance to the assigned self-monitoring time. Thus one of the reasons for the low compliance to the assigned time was an effort to control for physical activity.

Subjects may also have avoided self-monitoring of their mood state and blood pressure level during stressful periods. This would have resulted in less variation in blood pressure and mood ratings, thereby lessening the power of the study. The use of automated ambulatory monitoring would have eliminated this sampling difficulty but would have introduced the problem with concurrent physical activity. A suggestion for future work in this area would be to use the self-monitoring procedure but require the individual to record reasons for any delay in completing an assigned reading. This would provide the information needed to discriminate delayed readings due to physical activity from delayed readings due to stressful moments and inconvenience.

Questions of external validity. Most of this discussion has centered on questions of internal validity. Of some import is the representativeness of these findings from a college-aged population. The primary finding from this study was chosen to examine this question. In the current study, the Type A cluster consisting of anxious, aggressive, assertive, hard-driving, active and self-confident mood ratings, was associated with high versus low SBP, DBP (females) and HR.

Similar findings were noted in Sokolow et al's (1970) hypertensive population where the average age was 41. In the study of 29 adult hypertensives by Whitehead et al. (1977) anxiety was found to be more highly correlated with blood pressure than anger. Finally, a preliminary report by Dembroski, MacDougall, Eliot, and Buell, (1983) found that ambulatory blood pressures assessed in 30 industrial managers were correlated with emotional indicators of stress. All four of these studies utilized a within and across analysis or an average of within subject analysis to generate their findings. The results of these three additional studies in the natural environment suggest that the co-variation between blood pressure and stressful emotional states within and across individuals is not merely a function of age or hypertensive status but rather appears to be a viable relationship regardless of subject characteristics. The relationship of mood states to average daily blood pressure is considerably less clear.

Methodological Issues. Throughout this paper, reference has been made to the variety of methodological approaches used in the study of mood and blood pressure relationships. Such diversity suggests that different analytical methods produce different relationships between the variables. As noted throughout this discussion section, this is indeed the case. Within subject analyses consistently demonstrate more frequent and stronger relationships than across subject analyses (Pennebaker, 1982).

Table 31 presents an outline of four methodological approaches to the study of blood pressure and mood co-variation. The first two levels are based primarily on a nomothetic comparison. Epidemiological surveys

Table 31

Levels of Analysis

Comparison	Blood Pressure	Psychological State	Statistic
Across Subjects	Screening Blood Pressure	Questionnaires	Correlational Coefficient
Across Subjects	Averaged Ambulatory Blood Pressure	Averaged Mood and Perceptions of the Environment Ratings	Correlational Coefficient
Within and Across Subjects	Dichotomized, High/ Low BP Over Sampling Period	Concurrent and Mood and Perception of the Environment Rating	Paired T-test
Within Subjects	Individual Blood Pressure Observations Within Subject	Concurrent Mood and Perception of the Environment Rating	Correlational Coefficient with Correction for Autocorrelations

and laboratory cardiovascular reactivity studies are generally analyzed in this fashion. The third level represents a combination of within and across subject analysis, a procedure found to be most useful in the current study as well as that of Sokolow et al. (1970). Finally, the fourth level consists of a within subject analysis. Several reports have presented a compilation of single case studies, usually averaging within subject correlation coefficients across subjects (Sokolow et al., 1970; Whitehead et al., 1977).

There are however substantial statistical problems inherent in within subject analysis. For the most part, problems result from a failure to demonstrate independence between repeated measures of the same variable within an individual over time. For example, a person's SBP at one moment may influence SBP at some point in the future. Hence, repeated measures of a variable within an individual may violate the assumption of independence between observations (Kazdin, 1984). In contrast, in across subject analysis, one can assume that SBP measured in one individual will be independent of SBP measured in another person. This is of some import since independence between observations on a given variable is the only assumption inherent in correlational analysis (the other two being normal distributions and equal variances) that will substantially alter bivariate analysis. Hence, an examination of the autocorrelation for each of the variables involved in a within subject bivariate analysis is required. To date, neither a discussion nor an illustrative example of this methodological concern has been uncovered in the literature in this field. This is the focus of Appendix 1 which presents several within subject case studies and an

exploration of methodological problems in their analysis.

An additional methodological concern arose during the course of data analysis in this study. Due to the multiple hypotheses submitted for testing as well as the variety of analytical approaches taken during analysis, a large number of correlational and t-test comparisons were made. This raises a concern regarding the level of Type 1 error used for each of these many comparisons. Keppel (1982) addresses this concern in his discussion of familywise error rates versus per comparison error rates. Based upon his review of the statistical literature regarding multiple comparisons, Keppel concludes that planned comparisons should probably be examined at the per comparison error rate while post-hoc analyses should be examined at the familywise error rate. The exception to this approach is if the total number of planned comparisons exceeds the number of degrees of freedom. Since the number of planned comparisons in this study clearly exceeds the number of degrees of freedom, a review of the proportion of significant findings at the per comparison error rate was performed. The purpose of this review was to assess whether the analyses providing the primary findings of this study exceeded the number of significant findings expected by chance alone. In addition, the proportion of significant findings could be compared across types of analyses.

The results of this review are presented in Table 32. The proportion of findings for the correlational analysis between average ambulatory blood pressure and average mood ratings as well as the regression analysis closely approximated that expected by chance alone (5%). This is consistent with the overall impression that no true

Table 32

Proportion of Significant Correlations Among Comparisons Bearing Upon Hypotheses

Type of Comparison	Number of Comparisons	Number Significant	Proportion Significant
Ambulatory Blood Pressure and Mood Ratings	126	6	4.8%
Regression Analysis	612	28	4.6%
Between Group T-tests	34	4	11.8%
Between Readings T-tests	63	18	28.6%
Ambulatory Blood Pressure and Psychological Questionnaires	72	3	4.2%
Moods and Psychological Questionnaires	207	65	31.4%
Reactivity Measures	3	1	33.3%
Predicted vs Actual Blood Pressure	27	15	55.6%
Total:	1144	140	Average: 12.2%

Note: Significance based on alpha of .05

relationships exist in these comparisons.

The analysis comparing individuals with high versus low average ambulatory blood pressure and psychological variables had a proportion of significant findings approximately twice that expected by chance. However, two out of the four significant findings concerned subscales on the Gambrill Richey Assertion Inventory. Review of all three Gambrill Richey subscales suggests that there is no clinical relationship between the Inventory and high versus low ambulatory blood pressure. If correction is made for this clinical interpretation, the proportion of significant findings (5.9%) is approximately that expected by chance alone (5%).

The analysis comparing high versus low blood pressure readings and mood ratings had a proportion of significant findings five to six times as large as that expected by chance alone. The conclusion that this within and across subject analysis provides insight into the relationship between blood pressure and mood states is supported by this evidence. In contrast, the proportion of significant findings in the comparison between average ambulatory blood pressures and psychological questionnaires was approximately that expected by chance.

The proportion of significant findings arising when mood and psychological questionnaires were compared was approximately six times that expected by chance. A similar finding occurred for the comparison of reactivity measures, although the absolute number of comparisons was very small. Finally, the proportion of significant findings arising when predicted blood pressures were compared with actual blood pressures is approximately eleven times that expected by chance.

In summary, review of the proportion of significant findings for each type of analysis as well as the average proportion significant across all comparison bearing upon the hypotheses, provides additional evidence in support of the conclusions drawn from this study. Findings between blood pressure and mood states tended to be confined to the within and across individual analysis. There was a considerable number of associations present between mood states and questionnaire measures of the psychological construct. Finally, there appears to be a consistent association between predicted and actual blood pressure.

Clinical significance of these findings. The clinical significance of this study is two fold. First, when working with groups or under conditions where individualized assessment is not possible, clients can be instructed that their blood pressure is probably elevated during periods of activity where they sense mood states characteristic of the Type A mood cluster described in this study. However, individualized assessment with ambulatory monitoring of blood pressure and self-monitoring of mood state is suggested as the preferred assessment approach. This provides more individualized "mood markers" of elevated blood pressure as well as demonstrates the magnitude of blood pressure increase associated with such mood states. Dembroski et al., (1983) point out the importance of identifying the "hot reactors" or those whose blood pressure increases dramatically under stress conditions.

In addition to ambulatory monitoring, the in-clinic relaxation procedure appears to have some potential as an assessment procedure for reactivity to the clinical environment. However, considerable refinement of the protocol is suggested before clinical application can

be suggested.

Future Directions. Two basic directions are suggested. First, the study of ambulatory blood pressure and mood states could be improved by including a distribution of subjects with a larger blood pressure range. The work should focus on getting individuals from similar demographic and health characteristics rather than compare normotensive teenagers with middle aged-hypertensives.

The second direction is toward refined within subject research designs. This includes both improvements in statistical methodology as well as adding additional physiological markers of the stress response to the monitoring procedure. Given the superiority of within subject approaches to the study of emotion and physiological activity, it is suggested that this direction be emphasized.

Appendix 1

SINGLE CASE DESIGNS

Methodological Issues

As noted earlier in this paper describing the group study results, within subject analyses consistently demonstrate more frequent and stronger relationships than across subject analyses (Pennebaker, 1982). The purpose of this appendix is to briefly present some of the methodological challenges to be met in performing within subject analyses and to provide several illustrative examples.

Several reports have presented a compilation of single case studies, usually averaging within subject correlation coefficients across subjects (Sokolow et al., 1970; Whitehead et al., 1977). Such analyses however, run the risk of violating one of the primary assumptions of correlational analysis: independence between repeated observations of a given variable. The problem confronting such studies is that there is a reasonable expectation that repeated measures of a variable within an individual will not be independent. It is the researchers task to demonstrate that they are. To date, neither a discussion nor an illustrative example of this methodological concern has been uncovered in the literature in this field.

The appropriate statistical procedure to assess for a lack of independence between observations is the autocorrelation. This should be performed for each of the variables involved in a within subject bivariate analysis. The autocorrelation assesses the correlation between repeated observations of the same variable. Autocorrelations can be generated for any number of lag periods. For example, a measure

of association can be generated for observations at time X, with observations at time X + 1 or X + 2 or X + 3, etc. For the purposes of demonstrating independence between observations in the within subject designs noted above, a lag of 1 is suitable.

The analysis of self-monitoring data from two case studies is presented below. A brief description of the subject will be followed by a presentation of the subject's self-monitoring data in raw form. The reader will then be guided through an analysis of that data using the autocorrelation procedures provided by the Statistical Analysis System (SAS; SAS Institute Inc., 1982).

Procedure

Recruitment of subjects for the single case designs was based on their ability to comply to an extended self-monitoring procedure as well as a past history of elevated blood pressure readings. Two subjects were selected who met these criteria. Both self-monitored mood and blood pressure using the Norelco 3500 but did not complete the questionnaire measures or the laboratory relaxation procedure. The self-monitoring procedure was similar to that used in the main study with the exception that monitoring was done once a day over a 30-day period. This provided equal intervals between all blood pressure measurements which is an assumption for the use of autocorrelational analysis. An alpha level of .05 was selected as the level at which to reject the null hypothesis. For the purposes of this demonstration, only the relationship between mood ratings and SBP and DBP will be analyzed. It should be understood that the same analysis can be performed for HR as well.

Missing Data

The autocorrelational procedure used below requires the absence of missing data. Some missing data occurred in both case studies. Case Study One had four missing observations out of 38 days. Case Study Two missed one day out of 31 days. It is argued that these missing values will have minimal impact on the autocorrelational analysis since they represent less than 11% and 4% of the total possible observations respectively. The autocorrelational procedures were therefore given data sets containing no missing values.

Case Study One

Case Study One (CS1) involved a 27 year-old, single, Caucasian female, who is an administrative director of a local daycare facility. She has a several year history of hypertension and is currently on Hygroton 50 mg daily. No history of cardiovascular disease is reported. She reports a past history of being overweight which she has resolved through diet and exercise. Her motivation to participate is primarily to see if she can control her blood pressure without the use of medications. She is therefore interested in the relationship between her blood pressure and stress level.

Blood pressure averages and standard deviations are presented in Table 33. Although both her average SBP and DBP are well within the normal range, one standard deviation takes her above the normal range for DBP. Since she continued to take her antihypertensive medication throughout the self-monitoring period, it is unclear whether her average ambulatory blood pressures would stay within the normal range without it.

Table 33

Ambulatory Blood Pressures: Means and Standard Deviations for Case Study One

Ambulatory Blood Blood Pressure	Mean	Standard Deviation
SBP	125.7	9.4
DBP	84.6	9.6
HR	67.5	6.4

Table 34

Correlations Between Ambulatory Blood Pressure and Mood, Mood Clusters, and Perceptions of Environment: CS1

	SBP	DBP	HR
Anxious	.38*	.29	.20
Happy	-.26	-.22	-.03
Interested	-.27	-.05	-.10
Quiet	-.10	-.22	-.17
Impatient	.35*	.22	.33
Cautious	-.11	-.35*	-.15
Assertive	-.27	.20	.10
Competitive	.00	.01	.29
Low Time Pressure	-.38*	-.41*	-.42*
Energetic	-.42**	-.22	.31
Unsure	.07	-.11	.03
Lonely	.15	.10	.08
Angry	.32	.24	.17
No Worries	-.10	.17	-.04
Easygoing	-.16	-.24	-.36*
Anger In	.51	.09	.45
Frustration	.31	.14	.20
Negative	.32	.27	.24
Positive	-.46**	-.24	-.05
Type A	.18	.42*	.30
E Demanding	.30	.35*	.31
E Hostile	-.15	-.18	-.10
E Comfort	-.33	-.21	-.06
E Noisy	.44**	.42**	.17
E Flex	-.20	-.14	-.21

* $p \leq .05$, ** $p \leq .01$

Standard Pearson correlation coefficients between her ambulatory blood pressure and mood states are presented in Table 34. At this point it was necessary to determine if the significant associations noted in Table 34 remained significant after correction for any serial dependency among the observations. To do this, one must be familiar with the formula for calculating the variance for the association between concurrent observations for two variables (formula 11.1.9, Box and Jenkins, 1976, p. 377). The formula can be stated as follows:

$$\text{Variance } (r_{xy}(0)) \simeq (1/n) \sum_{v=-\infty}^{\infty} \rho_{xx(v)} \rho_{yy(v)}$$

This can be restated and simplified to the following:

$$\text{Variance } (r_{xy}(0)) \simeq (1/n)\,[(\text{Autocorrelation X})(\text{Autocorrelation Y})]$$

If either the autocorrelation of variable X or the autocorrelation of variable Y is nonsignificant (i.e. one cannot reject the hypothesis that the observations are indeed independent), then the second part of the equation becomes one and the variance $(r_{xy}(0)) \simeq 1/n$. This is the factor utilized to determine the significance of the Pearson correlation coefficients. Hence, when serial dependence of either one of the two variables cannot be demonstrated, the significance of Pearson correlation coefficients can be calculated in the usual fashion.

Using the Autoregressive Integrated Moving-Average (ARIMA) procedure provided by SAS, autocorrelations were then generated for both SBP and DBP. It was found that SBP had a significant autocorrelation at

time lag 1 (r=.84, $p \leq .025$). Thus, for CS1, SBP on one day was not independent of SBP on the next day. When DBP was examined, a significant autocorrelation was not found (r=.17, $p > .025$). Thus, DBP did not demonstrate serial dependency. Since lack of serial dependency in one variable reduces the second part of the variance equation to 1, the significance levels provided by the SAS program can be taken at face value for DBP.

Since the autocorrelation for both variables must be significant for the second half of the variance equation to differ from 1, one might eliminate additional mood variables from further analysis by calculating their autocorrelations. This was done for the mood ratings found to be associated with SBP using the usual significance calculations associated with Pearson coefficients. The autocorrelation for anxious, impatient, and low time pressure were all found to be nonsignificant. Hence, their significance level is not influence by serial dependency. The autocorrelations at time lag 1 for the mood ratings energetic and positive as well as a perception of the environment as noisy were significant (r=.49, $p \leq .025$; r=.86, $p \leq .025$; and r=.39, $p \leq .025$ respectively). Significance levels for the relationship between SBP and energetic, positive and noisy environment therefore had to be recalculated.

Using equation 11.1.9 from Box and Jenkins (1976), the p-values presented in Table 35 were generated for the relationship between SBP and the mood ratings. The relationship between SBP and the mood rating energetic as well as the positive mood cluster rises above the accepted alpha level of.05. Perception of the environment as noisy

Table 35

Comparison of Significance Levels Before and After Correction for Serial Dependency

Mood	Correlational Coefficient	Original p-value Based on Assumption of Independence	P-value Based on Influence of Serial Dependency
Energetic	-.42	.0148	.0694
Positive	-.46	.0066	.1560
E Noisy	.44	.0090	.0078

maintains (and possibly improves) as an associate of SBP in CS1.

The following set of relationships can therefore be stated for CS1. SBP is associated with anxious, impatient, and high time pressure mood ratings as well as a perception of the environment as noisy. DBP is associated with aggressive, high time pressure and Type A moods as well as perceptions of the environment as demanding and noisy.

Case Study Two

Case Study Two (CS2) was a 25 year-old single, male Caucasian undergraduate student at Virginia Tech. Throughout the course of his self-monitoring he was a undergraduate research assistant. His duties included assisting in student dining hall blood pressure screenings, filling out Introductory Psychology experimental point forms, and performing the blood pressure self-monitoring procedure on himself. He reported a past history of occasional elevated blood pressure readings which were confirmed during the screening blood pressures taken at the student dining hall. Unfortunately, although several of these readings were above 140/90, they were not recorded. He reports no diagnosis of hypertension or cardiovascular disease and no current medications. His family history reveals heart disease in his father at 60 years of age. CS2 reports exercising 2-3 times per week and recently cutting back in his salt intake. Alcohol intake is approximately 1 drink/day and coffee intake is approximately 1/2 cup/day. His motivations for participating included receiving course credit for his self-monitoring as well as finding out whether his blood pressure was indeed elevated during the course of his daily activities.

Blood pressure averages and standard deviations are presented in

Table 36

Ambulatory Blood Pressures: Means and Standard Deviations for Case Study Two

Ambulatory Blood Blood Pressure	Mean	Standard Deviation
SBP	120.9	7.9
DBP	68.7	5.4
HR	69.7	8.5

Table 37

Correlations Between Ambulatory Blood Pressure and Mood, Mood Clusters, and Perceptions of Environment: CS2

	SBP	DBP	HR
Anxious	-.09	.16	.20
Happy	-.04	.22	-.16
Interested	.07	.25	-.17
Quiet	-.17	-.12	-.02
Impatient	-.02	.36*	.08
Cautious	.17	-.09	-.14
Assertive	-.16	.43*	.02
Competitive	-.21	.39*	.18
Low Time Pressure	.15	-.41*	-.15
Energetic	-.05	.14	.04
Unsure	-.06	.13	.17
Lonely	-.01	.48**	-.12
Angry	.18	.46**	-.13
No Worries	-.08	.04	-.23
Easygoing	.25	-.23	-.29
Anger In	.12	.33	.00
Frustration	.20	.00	-.02
Free Floating Thoughts	-.04	-.07	.08
Negative	-.01	.26	-.20
Positive	.02	-.03	-.12
Type A	-.11	.27	.16
E Demanding	-.40*	-.10	-.10
E Hostile	-.39*	-.02	-.08
E Comfort	.23	-.12	.10
E Noisy	-.37*	.04	-.02
E Flex	.13	-.03	.05

* $p \leq .05$, ** $p \leq .01$

Table 36. Both average ambulatory SBP and DBP are within normal limits as are readings within one standard deviation of the average. Standard Pearson correlation coefficients between his ambulatory blood pressure and mood states are presented in Table 37.

As in CS1, the next step was to generate autocorrelations for SBP and DBP. In contrast to CS1, the autocorrelation for SBP was nonsignificant ($r=.13$, $p > .025$) but that for DBP was significant ($r=.81$, $p \leq .025$). Thus, the significance level of the correlational coefficients between mood ratings and SBP can be taken as is. As in CS1, the autocorrelations of mood ratings significant under the assumption of independence were then tested. The autocorrelations for impatient, assertive, competitive, lonely and angry mood ratings were all found to be nonsignificant. Only high time pressure demonstrated a significant autocorrelation ($r=-.47$, $p \leq .025$).

The negative direction of this autocorrelation is interesting. It suggests that a perception of high time pressure on one day predicts a perception of low time pressure on the next day and the possibility of alternations on subsequent days. An examination of the extended series of autocorrelations at time $x + 1$, $x + 2$, $x + 3$, etc. finds that the autocorrelations do alternate between positive and negative although only the autocorrelation at $x + 1$ is significant. Thus, autocorrelations not only provide information useful in examining the relationship between two variables, but they also provide information regarding the nature of specific moods as they are perceived over time.

When the relationship between DBP and high time pressure was corrected for the influence of serial dependency, the significance level

associated with the Pearson correlational coefficient (r=.-.41) increased from $p \leq .0008$ to $p \leq .0285$. The relationship therefore remained a significant one at the alpha level of .05 even after correction for serial dependency.

The resulting associations between blood pressure and mood ratings for CS2 can therefore be stated as follows. SBP was not associated with any of the mood ratings. SBP was associated with perceptions of the environment as non-demanding, non-threatening, and quiet. DBP was associated with impatient, assertive, competitive, high time pressure, lonely, and angry mood ratings. The findings for DBP are generally consistent with that noted in the group data described in the main dissertation document. The findings for SBP are in marked contrast to that usually noted. As such they emphasize the individualistic nature of mood/blood pressure associations.

Clinical Implications of this Methodological Approach

The first, and perhaps most important implication of this methodology is the opportunity to apply traditional measures of association to repeated measures of two variables in a within subject design. This provides the clinician with an increased level of confidence regarding the level of association between blood pressure and other subject variables as the client ambulates in the natural environment. Such variables might include mood ratings, substance ingestion, and exercise etc.

The designing of interventions might utilize such information in several ways. Psychological variables associated with increases or decreases in blood pressure might be used as "mood markers" to identify

time periods when a subject should employ stress management or biofeedback procedures. Alternatively, relationships identified through self-monitoring of blood pressure, mood and coping styles might provide vital information toward diagnosing problems in the area of anger control, panic attacks and social skills in general. Therapeutic interventions specific to these problem areas could then be implemented with continued self-monitoring used to monitor therapeutic progress.

Appendix 2

QUESTIONNAIRE FOR BLOOD PRESSURE MONITORING PROJECT

NAME: _____ ID#_____

DATE OF BIRTH:_____

SEX:_____ OCCUPATION:_____

PLEASE CIRCLE HIGHEST LEVEL OF EDUCATION COMPLETED:

ELEMENTARY SCHOOL 1 2 3 4 5 6 7 8

HIGH SCHOOL 9 10 11 12

COLLEGE/BUSINESS SCHOOL 13 14 15 16

GRADUATE SCHOOL 17 18 19 20 21

MARITAL STATUS: SINGLE MARRIED

MEDICAL HISTORY

HAVE YOU EVER HAD:

	YES	NO
HEART DISEASE OR HEART PROBLEMS		
LUNG DISEASE OR DIFFICULTY BREATHING		
DIFFICULTY WITH COLD EXTREMITIES (HANDS,FEET)		
STROKE		
KIDNEY DISEASE		
HIGH CHOLESTEROL		
HIGH TRIGLYCERIDES		
DIABETES		
ANY OPERATIONS (TYPE:_____)		

HAVE YOU EVER HAD A BLOOD PRESSURE READING ABOVE NORMAL (140/90)? NO:__
YES:____HAVE YOU EVER BEEN DIAGNOSED AS HAVING HYPERTENSION? NO:___
YES:___

IF YES TO EITHER, PLEASE GIVE:
DATE OF DIAGNOSIS:_____

TYPE OF TREATMENT IF ANY:_____

_____

NAME AND ADDRESS OF HEALTH CARE PROVIDER AT THAT TIME:

_____

PLEASE LIST ANY MEDICATIONS YOU ARE TAKING AT THE CURRENT TIME:

_____

ARE YOU ALLERGIC TO ANY MEDICATIONS, DRUGS OR FOODS? YES_____ NO____

HAS ANYONE IN YOUR FAMILY BEEN DIAGNOSED AS HAVING:

	YES	NO	RELATIONSHIP TO YOU	AGE AT ONSET
HIGH BLOOD PRESSURE OR HYPERTENSION				
HEART ATTACK OR HEART DISEASE				
STROKE				
DIABETES				
KIDNEY DISEASE				

HEALTH HABITS:	NO	YES
DRINK CAFFEINATED COFFEE OR TEA	( )	_____ CUPS/DAY
DRINK ALCOHOL	( )	_____ DRINKS/WEEK
ADD SALT TO MEAL BEFORE TASTING IT	( )	( )
SMOKE CIGARETTES	( )	_____ CIGARETTES/DAY
SLEEP		_____ HOURS/NIGHT
EXERCISE	( )	_____ TIMES/WEEK
SPECIAL DIET (IF YES, PLEASE DESCRIBE)	( )	_____

_____

PLEASE GIVE NAME AND ADDRESS OF CURRENT HEALTH CARE PROVIDER:

_____

FEMALES ONLY:

DATE YOUR LAST MENSTRUAL PERIOD STARTED:_____

USUAL LENGTH OF YOUR MENSTRUAL CYCLE (28 DAYS, 30 DAYS, ETC.):_____

DO YOU USE BIRTH CONTROL PILLS? NO:___ YES:___ (TYPE:_____)

Coding System for Health Questionnaire

1. Past history of CHD, High Blood Pressure or Hypertension: 1 = No
   2 = Yes

2. Family history of CHD or Hypertension
   1 = No
   2 = One grandparent
   3 = Two grandparents
   4 = One parent
   5 = One parent, one grandparent
   6 = Two parents

3. Coffee
   1 = None
   2 = $\leq$ 1 per day
   3 = $>$ 1 + $\leq$ 2 per day
   4 = $>$ 2 per day

4. Salt
   1 = None
   2 = Small
   3 = Moderate
   4 = A lot

5. Alcohol
   1 = None
   2 = 0-1 per day
   3 = 1-2 per day
   4 = 3-4 per day
   5 = 5+ per day

6. Cigarettes
   1 = None
   2 = 1-5 per day
   3 = 5-10 per day
   4 = 10-20 per day
   5 = $>$ 20 per day

7. Sleep = Number of hours per night

8. Exercise = Frequency per week

Appendix 3

Blood Pressure Monitoring Form

Date:_____ Time:_____ ID# _____

Location: Home=1
Work or School=2
Shopping/Errands=3
Car/Bus=4
Someone else's home=5

Please record below the amounts you have used since your last self-monitoring.

Cigarettes: _____ Cigars: _____

Pipefuls of tobacco:_____

Caffeinated Coffee (cups):_____

Alcohol (beer, wine or liquor):_____

During the past 5 minutes, have you predominantly been:

Alone=1
With Spouse/Family=2
With Friends=3
With Co-workers=4
With Strangers=5

During the past 1/4 hour, have you:
Jogged or walked briskly? Yes/No
Climbed a flight of stairs? Yes/No
Otherwise exercised? Yes/No

Predicted blood pressure and heart rate:

SBP_____ DBP_____ HR_____

Perceptions of Environment

Non-demanding	1 2 3 4 5 6 7	Demanding
Non-threatening	1 2 3 4 5 6 7	Threatening/ Hostile
Uncomfortable	1 2 3 4 5 6 7	Comfortable
Quiet	1 2 3 4 5 6 7	Noisy
Structured	1 2 3 4 5 6 7	Flex-time

Moods and Thoughts

Anxious/Tense	1 2 3 4 5 6 7	Calm
Happy	1 2 3 4 5 6 7	Depressed
Interested	1 2 3 4 5 6 7	Bored
Quiet	1 2 3 4 5 6 7	Active
Impatient	1 2 3 4 5 6 7	Patient
Cautious	1 2 3 4 5 6 7	Aggressive
Assertive	1 2 3 4 5 6 7	Passive
Competitive	1 2 3 4 5 6 7	Cooperative
Low time - pressure	1 2 3 4 5 6 7	High time - pressure
Energetic	1 2 3 4 5 6 7	Tired
Unsure	1 2 3 4 5 6 7	Confident
Rejected/lonely	1 2 3 4 5 6 7	Accepted
Angry/Hostile	1 2 3 4 5 6 7	Friendly
No worries	1 2 3 4 5 6 7	Worried
Easy going	1 2 3 4 5 6 7	Hard-driving
Hold anger in	1 2 3 4 5 6 7	Express anger
Frustrated	1 2 3 4 5 6 7	Care-free
Free floating thoughts	1 2 3 4 5 6 7	Concentrated thoughts

Appendix 4

PHYSICAL EXAM

SUBJECT ID#:_____ DATE: _____

HEIGHT: _____ WEIGHT: _____

MID-ARM CIRCUMFERENCE:_____

BP (HG) POST 5 MINUTES REST: _____/_____/_____ _____

BP (HG) POST 7 MINUTES REST: _____/_____/_____ _____

BP #1 (N) AT 10 MINUTES: _____/_____ _____

BP #2 (N) AT 12 MINUTES: _____/_____ _____

BP #3 (N) POST RELAXATION: _____/_____ _____

BP (N) FIRST SELF-MONITORING _____/_____ _____

COMMENTS/OBSERVATIONS: _____

_____

_____

_____

_____

_____

Appendix 5

RELAXATION RESPONSE

The following exercise is called The Relaxation Response. It is designed to relieve tension and rebuild your body's resources. The Relaxation Response will bring your mind and body into a calm, deeply relaxed and healing state. To enjoy The Relaxation Response you will need to find a comfortable position in your chair. Try not to cross your legs. You may wish to loosen any tight clothing you have on. You will also need a place where you can focus your attention inside your body. We recommend that you close your eyes now and begin to focus on your breathing.

Take a deep breath. As you breathe out slowly - feel the tension leaving. Taken another deep breath. As you breathe out slowly - feel the calmness ... be at ease ... at peace. Breathe in ... and out. Feel the waves of deep calmness ... waves of deep peace and relaxation flowing through your body and mind. Lots of time ... so much time ... more and more time. Breathe in ... and out. In ... and out. Feeling so good ... floating ... at peace ... deep waves of calmness and tranquility ... deeply relaxed. Breathe in ... and out. Deep peace flowing calmly and gently through every muscle in your body. Absolutely calm ... waves of deep relaxation ... lots of time ... so much time. Feeling so good ... deep peace ... deeper and deeper relaxation. Breathe in ... and out. Let your thoughts drift away like bubbles in a glass of soda. As thoughts occur, disregard them and bring your attention back to your breathing. Breathe gently in ... and out. Just be aware of your breathing. Follow the flow of your breath as it comes

in and goes out. Let go of your thoughts as you breathe in and out. In ... and out. Let your body relax. Let all your muscles relax. Just allow your thoughts to drift away like bubbles ... and bring your attention back to your breathing.

In ... and out. Quietly watch your breath coming in ... and out. Your breath is slower, deeper and gentler now. Breathe in ... and out. In ... and out.

When a bird flies, it does not disturb the wind in the sky. When a fish swims in the ocean, it does not leave any track in the water. Let noise, thoughts and distractions come and go. Do not focus on them. Let your mind become like the sky or the ocean. Allow your thoughts and distractions to pass on by.

Breathe in ... and out. In ... and out. Let your whole body feel relaxed, calm and at peace. Your breath is slower, deeper and gentler now. Breathe in ... and out. In ... and out. Quietly watch your breath coming in ... and out.

If you notice yourself getting caught by a thought - don't get angry or frustrated. Your attention will be diverted many times. Each time, bring your attention back very gently to your breathing. Just be aware of your breathing. In ... and out. No thoughts ... no worries. Just breathe in and out.

Your breathing is like a river. Flowing in and out along its route. So calming. In ... and out. So peaceful. In ... and out. Let your breathing flow with the river. In ... and out. In and out.

In a few moments you will open your eyes and feel refreshed ... feeling good ... alert ... so alive. Do so gently and slowly as I

count from 1 to 5.

One: You are deeply relaxed and breathing gently.

Two: You are becoming aware of the room around you. You continue to be deeply relaxed.

Three: You can now hear sounds and feel the seat below you. Your breathing is gentle and relaxed.

Four: You can wiggle your toes and fingers and still be relaxed. In a moment you will hear the start of the blood pressure machine as it takes your blood pressure. Do not let the sound or the pressure on your arm bother you. You are calm, loose and relaxed.

Five: Slowly open your eyes. Let yourself slowly adjust to the room around you. You feel alert, alive, refreshed.

Appendix 6

INFORMED CONSENT FORM

The purpose of this study is to examine the relationship between blood pressure and your mood as you engage in your normal, daily activities. We are also interested in your ability to predict your blood pressure. Knowledge gained from this study will assist in the design of clinical assessment procedures for people who are suspected to have high blood pressure.

If you agree to participate, you will be asked to complete the following procedures.

1. Attend a 2 hour assessment session at the Behavioral Health Clinic which will involve:

   a. completing a health history form.
   b. completing a series of questionnaires regarding personality and lifestyle.
   c. learning to use an automated blood pressure meter. A series of insession blood pressures and heart rates will be taken.
   d. undergo a 15 minute relaxation procedure designed to lower your blood pressure.

2. Self-monitor moods and blood pressure over a three day period. This will include:

   a. completing a mood rating scale and predicting your blood pressure every two waking hours over a three day period (a total of 24 observations).
   b. self-monitoring blood pressure and heart rate at the same time as the mood ratings are taken. It is expected that each mood rating and blood pressure meausrement will take about 5 minutes.
   c. completing a brief End-of-Day questionnaire each night during the 3 day observation period.

The only discomfort to be expected during the course of this study is a moderate pressure sensation in the left arm during the 1-2 minutes when blood pressure measurements are being taken.

It is the subject's right to discontinue participation in the project at any time. Subjects will be responsible for the blood pressure recording equipment while it is in their possession during the 3-day self-monitoring period.

All information will be kept strictly confidential and will only be viewed by persons directly associated with this study. If the results of this study are to be published or presented publicly, the names and identifying information of all participants will be withheld.

This research project has been approved by the Human Subjects Research Committee and the Institutional Review Board. Any questions that you might have regarding the project should be directed to:

Richard M. Eisler, Ph.D. 961-6914 (Principle Investigator)
Douglas R. Southard, M.S., M.P.H. 961-6914 (Research Assistant)
William Schicht, Ph.D. 961-5346 (Chairperson, Human Subjects Committee)

I hereby agree to voluntarily participate in the research project described above and under the conditions described above.

_____ _____
Participant's Signature Date

Address Student ID #:_____

_____

_____

_____

Phone Number

Home:_____

Work:_____

Appendix 7

INSTRUCTIONS FOR USING BLOOD PRESSURE METER

GENERAL

1. Where a shirt with loose fiting or short sleeves. This will make it much easier to roll your shirt sleeve out of the way.

2. Take your blood pressure on the following schedule:

	Day One	Day Two
Reading #1:	_____	_____
Reading #2:	_____	_____
Reading #3:	_____	_____
Reading #4:	_____	_____
Reading #5:	_____	_____
Reading #6:	_____	_____
Reading #7:	_____	_____

You must take your measurements as close to these times as possible. Be prepared to take your blood pressure whereever you are and no matter what you are doing. THIS IS VERY IMPORTANT! We want to sample your blood pressure under a variety of situations and not just when you are alone and relaxing.

3. If you have exercised (jog, run or climbed stairs etc.) during the 15 minutes prior to your scheduled reading, please temporarily delay your reading to insure that your body is physically at rest. In no case however, should your reading be delayed more than 15 minutes beyond the scheduled time.

CUFF PLACEMENT:

1. Position arm cuff such that target circle on cuff is directly over mark on arm.

2. Cuff should be about 1 inch above the elbow.

3. Cuff should be tight enough that only 1-2 fingers will fit underneath it.

MEASUREMENT METHOD:

1. **Push ON/OFF button**. Wait for "0" to appear.

2. With arm supported by a table or other object at the same height as your heart, **push the start button**.

3. **Remain very still**. DO NOT MOVE DURING THE RECORDING.

4. The cuff will automatically inflate and slowly deflate. At the completion of the measurement sounds, the cuff will deflate rapidly and the printer will print out the blood pressure and heart rate readings.

5. If an error measage appears " Err " , push the ON/OFF button, wait 2 minutes and try again starting with #1 above.

6. If the insufficient pressure light comes on:

Call the Blood Pressure Project Manager

7. If at any point your arm becomes numb, has severe tingling or developes pain, **push the ON/OFF button to release the pressure immediately. Call the Blood Pressure Project Manager!**

IF YOU ARE HAVING PROBLEMS: PLEASE CALL ONE OF US AT THE FOLLOWING NUMBERS.

BLOOD PRESSURE PROJECT MANAGERS: * Doug Southard or Jay Skidmore *

Weekdays (9am - 5pm): 961-6914

Other times:
Doug Southard: 552-7288
Jay Skidmore: 953-1013

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