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Baisden, Barbara Steines

PSYCHOPHYSIOLOGICAL SUBTYPES OF MILD TO MODERATE ESSENTIAL HYPERTENSION

The Ohio State University

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Psychophysiologica subtypes
of Mild to Moderate Essential Hypertension

Dissertation

Presented in Partial Fulfillment of the Requirements of
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
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*****

The Ohio State University
1985

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PUBLICATIONS

People in disaster. Ohio Woodlands, 16(1), 1978.

Book Review of Human Adaptation Coping with Life Crises, Rudolph H.
An annotated bibliography on disaster mental health and crisis and intervention. Columbus, Ohio: The Disaster Research Center Miscellaneous Report Series #20, The Ohio State University, 1978.


Crisis intervention in smaller communities. Columbus, Ohio: The Disaster Research Center Preliminary Report Series #58, The Ohio State University, 1980.

Evacuation behavior and problems: Findings and implications from the research literature. With E. L. Quarantelli and T. Bourdess. Columbus, Ohio: The Disaster Research Center Miscellaneous Report Series #27, The Ohio State University, 1980.


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CHAPTER I
Introduction

Despite a vast research effort and undisputed treatment gains in the last several decades, essential hypertension remains a persistent public health problem. By most estimates, it occurs in 15 to 20% of the population, some 20 to 50 million Americans, depending on the level of blood pressure used to make the diagnosis (Swift and Black, 1984). High levels of arterial blood pressure can seriously damage the heart, kidneys and blood vessels, and even slight elevations beyond the normal range of pressure are associated with increased risk of premature death from coronaries, strokes, and kidney failure (Lew, 1964).

Hypertension is not only an extremely common disease, it is also largely uncontrolled. The Framingham study (Kannel, Schwartz & McNamara, 1969) a landmark in hypertension research, judged approximately 85% of its sufferers to be either undetected or inadequately treated. One major reason for this is the mystery that surrounds its pathogenesis. Approximately 5 to 10% of cases can be attributed to kidney, endocrine or other physiological disorders. For those remaining, there is no known etiology, merely a long and growing number of risk factors, hence the nonspecific yet all encompassing
diagnosis of "essential" hypertension (Epstein and Oster, 1984; Eyer, 1975).

Alexander (1950) considered essential hypertension to be one of the classic psychosomatic disorders, which are thought to begin with some degree of physiologic predisposition which is activated by psychic tension or conflict via the mechanization of somatization. Conflict triggers sympathetic or parasympathetic system responses which result in physical symptoms that may at first be primarily functional and which may then mature into organic disease (Henker, 1984). From a psychosomatic perspective, the physical disorder is no more important or interesting than the individual who evidences it (Weiner, 1977). Thus, it may be more appropriate and informative to study not hypertension per se, but hypertensives--persons suffering from the malady known as hypertension. Accordingly, much of the literature on the subject deals with various social and psychological factors that may play some role in the predisposition to, initiation of, and maintenance of the disease.

Several approaches or orientations have been employed. For example, from a cognitive perceptual viewpoint, hypertensives may view the world as dangerous, feel threatened, and respond with sympathetic arousal and elevated blood pressure (Sapira, Scheib, Moriarty & Shapiro, 1971). Behaviorists see the hypertensive as acting in a manner that may provoke ill treatment at the hands of others, with similar physiologic results (Graham, Lundy, Benjamin, Kabler, Lewis, Kunish, & Graham, 1962; Weiner, 1979). From a social psychological perspective, low socioeconomic status, cultural oppression, family
fragmentation and limited avenues of escape combine to drive blood pressure upwards (Harburg, Erfurt, Hauenstein, Chape, Schull & Schork, 1973).

The bulk of the psychological literature on hypertension, however, focuses on the role of personality factors in the development of the disease. As disease began to be seen partially as a physical response of an individual to intrapsychic conflict or psychosocial stress, the hypothesis was generated that certain types of people may develop certain kinds of illness. This idea became known as the specificity concept. The association of specific personality types with disease actually traces back to Hippocrates' typology based on the four bodily humours. Many years later, Pavlov (1957) utilized this classification in explaining maladaptive responses to stress in dogs. The melancholic/choleric dichotomy he formulated was further developed by Alexander (1950) who saw these two patterns in terms of attempts at mastery. The melancholic response is likened to a retreat from stressful stimuli, mediated through parasympathetic system functions, while the choleric response is seen as an exaggerated mobilization of resources to meet stress, mediated by sympathetic system activity.

The attempt to link personality with disease was furthered by Dunbar and Alexander, who each conducted longitudinal, in depth studies of chronic disorders with unknown etiologies. Dunbar (1943) correlated traits, habits and attitudes and found that particular illnesses were associated with rather consistent personality features, particularly in those with coronary artery disease. Hypertensives
were characterized as shy, perfectionistic, reserved and self-controlled, yet also given to sporadic outbreaks of anger, especially around authority issues.

Alexander (1939, 1950) hypothesized that specific unconscious conflicts were present in people with various diseases, conflicts that were not unique to the disorder, perhaps, but which did vary systematically in people with different diseases and were therefore specific to a given disease. In the case of hypertension, he believed it to be chronic suppression of hostile impulses out of fear of losing approval—a concept similar in many ways to that of Dunbar.

Alexander's work was the more ambitious of the two, since he sought a comprehensive theoretical framework capable of explaining etiology. His findings however were less conclusive. He denied in the end that conflict was a direct or sole cause of disease, but rather constituted a predisposing factor which was then activated in the presence of other genetic, biochemical and physiological factors. This work was very influential, providing a point of departure for much subsequent research in psychosomatics. As a corollary, Alexander's criticism of Dunbar's work as superficial and merely correlational appears to have done much to discourage research on personality profiles as they relate to illness.

Interest has been revived in recent years, sparked by, among other things, the discovery of Type A behavior and its association with coronary disease (Jenkins, 1971, Rosenman and Friedman, 1974). In a review of the current status of the specificity concept, Hawkins (1982) asserts that the evidence, while not conclusive, strongly
indicates that there are important identifiable personality differences connected with different disorders, and sees personality profile research as clinically and heuristically useful.

Numerous intrapsychic, interpersonal and environmental factors have been shown to be involved in hypertension. The research, however, when taken as a whole, is uneven and inconsistent. For every study showing a correlation with a given psychological variable, another can be found that apparently contradicts it (Baer, Collins, Bourianoff & Ketchel, 1979; Goldstein, 1981). There is general consensus that psychological factors play some role in the development of hypertension but less agreement on the identity of these factors and the nature and significance of the role they play.

The area of personality research has attracted a proportionately large share of attention, yet it is here that the findings have been most inconclusive. A review of the literature reveals several underlying themes that seem to have informed investigations on the subject. These include: a trait-based approach that assumes certain personality features to be unique to hypertensives, the implication that such traits play a causal role in the disease, a tendency to focus on psychological factors independently of physiological variables, and perhaps most significantly, a view of hypertension as a homogeneous disorder whose victims display a single characteristic personality profile.

Several recent reviews (Goldstein, 1981; Shapiro and Goldstein, 1982; Weiner, 1979) collectively suggest that such assumptions are erroneous and misleading. For example, Linden and Feuerstein (1983)
have noted a preoccupation with equating or at least reducing personality to the presence or absence of specific traits, especially those involving the expression of anger. Less has been said about how such traits, if they exist, might be manifested in the overall psychosocial functioning of the individual. Investigators now concur that there is no single personality trait specific to hypertension (Gutman and Benson, 1971; Weiner, 1979), calling this simplistic approach into question and suggesting that more complex personality dynamics are operative.

Regarding the issue of causality, it is frequently pointed out that studies of hypertensives are almost always conducted post onset of the illness, and are correlative rather than predictive in nature (Ostfeld and Shekelle, 1967; Weiner, 1979). The research does not, for this reason, justify the claim that there is a fundamental etiological link between psychological factors and hypertension (Davies, 1971; Goldstein, 1981). However, the question of whether or not personality features are directly linked to onset should not be confused with whether or not they might be important in the maintenance and progression of the disease. It may be helpful in both the identification of undetected cases and the treatment of uncontrolled cases to know something of the personality functioning of persons with established hypertension.

Another theme emerging in the literature is the supposed uniqueness of certain personality characteristics in hypertensives. This notion has not held up empirically (Goldstein, 1981). Many of the characteristics or traits that have been found to be associated
with this illness have also been found in normotensives (Innes, Miller, and Valentine, 1959; Lewinsohn, 1956; Ostfeld & Lebovits, 1959; Robinson, 1962). Moreover, there are hypertensives who do not show these features to any remarkable degree (Esler, Julius, Zweifler, Randall, Harburg, Gardiner, and Shapiro, 1977; Gentry, Harburg and Hauenstein, 1973). An explanation for this state of affairs may lie in the fact that psychological studies have tended not to take physiological factors sufficiently into account. Relatively little attention has been paid to psychophysiological interactions. It is possible that biological predisposition to hypertension is so marked in certain individuals that personality may be relatively unimportant as a contributing factor. On the other hand, some individuals may have minimal physiological vulnerability to the disease, so that hypertension only develops in the presence of a strong psychological component (Davies, 1971).

In addition to these limitations, probably the single greatest influence on the failure to produce consistent relationships between personality variables and hypertension has been the long held view that it is a homogeneous disease entity with a single, or at least circumscribed set of causes. In psychological terms, this has translated into a search for "the" hypertensive personality. There exists now a growing body of research to support the view that it is, in fact, far more heterogeneous and multifactorial than previously believed (Weiner, 1977, 1979, 1982).

Physiological studies provided the initial evidence for heterogeneity or multiple subtypes of hypertension. In attempting to
reduce the complexity of the data, investigators began to subdivide the disorder in various ways. One strategy is to classify hypertension according to different hemodynamic patterns—whether a given case is the result of increased cardiac output or increased peripheral resistance (Julius, 1977; Surwit, Williams, and Shapiro, 1982).

Another approach is to divide the disease, or diseases, according to whether blood pressures are stable (chronically elevated) or labile (fluctuating, with elevations frequently but not always in the hypertensive range). Still another approach is to distinguish early or "borderline" cases from those which show the chronic physiologic changes characteristic of later stage, well established hypertension (DeQuattro and Miura, 1973). Biochemical deviations, e.g., high versus low renin levels, also offer criteria for classification (Esler et al., 1977; Laragh, Sealey, Sommers, and Brunner, 1972).

Some of these groupings can be further subdivided. Borderlines in particular do not seem to constitute a uniform group. Although this condition is often considered a harbinger of established hypertension, some borderlines do not progress to more severe forms of the disease. Several subtypes of borderline hypertension have been identified. Approximately 30% are characterized by high cardiac output, inappropriately normal peripheral resistance, high catecholamine levels and increased pulse rates. In this group are also found high levels of plasma renin associated with elevated stress levels. The remaining 70% show increased peripheral resistance, decreased cardiac output, normal pulse rates, and do not react
strongly to stress (DeQuattro and Miura, 1973; Julius, Randall, Esler, Kashima, Ellis and Bennet, 1975; Kuchel, 1977; Lorimer, McFarlane, Provan, Duffy and Lawrie, 1971). Within this group, some 25 to 30% have low renin levels, the others have normal renin, while each subgroup demonstrates certain physiological and behavioral differences (Esler, Julius, Randall, Ellis and Kashima, 1975). These findings suggest as many as three different profiles with different pathogeneses. In light of this evidence, hypertension begins to look not as much like a single disease entity as it does a syndrome of related disorders.

Physiological heterogeneity, furthermore, appears to have psychological counterparts. A frequently cited study by Esler et al. (1977) showed that high renin hypertensives differed psychologically from normal renin hypertensives and normotensives in being more controlled, submissive, guilt ridden and having high levels of unexpressed or unexpressable anger. Normal renin hypertensives differed from normotensives in being more resentful, but just as capable of expressing anger.

In discussing the conflicting results found in the hypertension literature on psychological variables in general and personality features in particular, Goldstein (1981) suggests that the failure to demonstrate more consistent relationships may be at least partly due to the fact that hypertensives are usually treated as a homogeneous group. A possible consequence may be that unrecognized subgroup differences remain hidden and tend to cancel each other out.
Studies such as those discussed above, which identify and compare subgroups and examine psychophysiological interactions, are useful. Other investigators concerned with the interaction of psychological and physiological variables (Lebovits, Lichter and Moses, 1975; Richter-Heinrich and Lauter, 1969, 1970), have applied multivariate statistical techniques which are more powerful and appropriate than the predominantly univariate approaches favored in the past. The results have yielded further evidence for both the existence of subgroups and the significant involvement of personality factors in at least some of these groups.

Such findings have major implications for both the theory and treatment of hypertension. Traditional theory links suppressed anger to increased peripheral resistance but fails to account for the fact that only some hyperactives show this cardiovascular pattern and it is not they who seem to have problems with anger. Similarly, traditional behavioral treatment aims to reduce sympathetic arousal, but here again, only some hypertensives have overactive sympathetic nervous systems.

With regard to future investigations, Weiner (1982) recommends that "...research on the use of psychological techniques in the treatment of essential hypertension must be based on an awareness that subforms of the syndrome exist..." (p. 45). Goldstein (1981) further encourages the development of research designs and the use of statistical procedures that can more adequately address the multivariate nature of hypertension.
Need for the Study

Studies that apply multivariate procedures to statistically identify and describe hypertensive subgroups or types are relatively rare. Those that have been done tend to focus on either psychological or physiological aspects. There is a need for research that integrates both kinds of data, beginning with a closer examination of subgroups that have already been identified. The subset of mild to moderate, or borderline, hypertensives seems an especially likely area of study because this is a large, clinically important and relatively well researched group, and one that is sufficiently heterogeneous to merit further investigation. Given that within this group, various physiological patterns have been identified, as well as different psychological patterns and personality profiles, the question arises as to whether psychological differences are associated in any systematic way with physiological differences. If statistically and clinically significant psychophysiological subtypes can be identified, the road is opened for more effective treatment approaches, both behavioral and medical.

Purpose of the Study

This study investigates a sample of mild to moderate essential hypertensives to see if significantly different subgroups exist that vary systematically on the basis of psychophysiological patterns. Initially, personality variables will be subjected to cluster analysis to see if homogeneous types emerge from the larger sample. If they do, these types will then be explored for evidence of physiological patterns.
Profiles from the Minnesota Multiphasic Personality Inventory MMPI (Hathaway & McKinley, 1951), will be used as an indicator of personality functioning. This instrument yields objective measures of both distinct personality characteristics and of configurational patterns descriptive of dynamic relationships, in addition to being a well researched and widely used measure. The physiological phenomena to be explored include plasma renin activity (PRA), measured in terms of the Renin-Sodium Hyperbolic Index (RSHI), levels of catecholamines, triglycerides, high and low density lipoprotein cholesterols (HDL and LDL), pulse rate, and percentage of ideal weight (an indicator of obesity). Age and sex are also investigated. Strictly speaking, these are demographic variables, but since they are integrally related to physical functioning, they are here included under the general rubric of physiology, to simplify terminology. These measures are among those that have previously been found to show patterned variations in research already cited as well as in literature to be reviewed in CHAPTER II.

**Research Questions**

The following research questions will be addressed:

1. Given a sample of mild to moderate essential hypertensives, are there significantly different subtypes that can be identified using the MMPI?

2. Should subtypes be identified, can they be validated across several clustering procedures?
3. Are there linear combinations of MMPI scales that discriminate among subtypes, and what is the relative contribution of individual scales to those functions?

4. Are there patterns of physiological variables that discriminate among subtypes to predict group membership?
Summary

CHAPTER I has provided a brief overview of the evidence in support of the existence of different subtypes of essential hypertension. The need for further investigation on hypertensive subtypes was established, followed by the purpose of this particular study. Specific research questions were posed. A review of relevant literature is presented in CHAPTER II. CHAPTER III describes the methodology employed in addressing the research, the instrumentation, and procedures for analyzing the data. CHAPTER IV presents findings and CHAPTER V contains the summary, discussion and recommendations for further research.
CHAPTER II
Review of Literature

Introduction

Because of the nature of this study, both physiological and psychological aspects of hypertension must be addressed, both separately and with some degree of integration. This CHAPTER will first briefly outline the physiology of hypertensive disorders, then review personality research on the subject, with special attention given to studies using the MMPI. The fairly extensive physiological literature on multiple subtypes of hypertension will be discussed, as well as the somewhat scant psychological literature on this subject. Finally, investigations with an integrative, psychophysiological orientation, giving evidence for distinct subtypes of hypertension, will be described.

Physiology of Hypertension

Two focal points in hypertension research are the mystery surrounding its etiology and the variety of forms that become evident when it is closely observed. This section attempts to give some idea of the complexity of the disease by describing the action and interaction of three major regulatory systems: the renin-angiotensin system, the cardiovascular system and the central nervous system.
Other physiological factors that have been implicated are also outlined.

The wealth of research extant has failed, to date, to find the cause of hypertension. Each new finding contributes to the growing consensus that the disease may in fact be diseases. What seems to exist is a group of disorders that are multifactorial in nature—arising from multiple causes, and heterogeneous in effect—manifested in a range of physiological abnormalities. The evidence indicates that interactions among major regulatory systems play a significant role.

Figure 1 graphically depicts the factors thought to be involved in the development and maintenance of hypertensive disorders.

The Renin-Angiotensin System. Blood pressure is a function of cardiac output, or blood volume, relative to the degree of arterial vasoconstriction or peripheral resistance. Hypertension results from an imbalance between the two, and each is affected by multiple factors.

The renin-angiotensin-aldosterone axis is the basic control mechanism for simultaneously regulating volume and arterial pressure. Cardiac output is affected by changes in extracellular fluid volume induced by altered renal function and sodium balance influenced by aldosterone production. Influences on peripheral resistance include renin and angiotensin, which mediate vasoconstriction, and
Figure 1. Possible Participation of Various Factors in the Development of Hypertension. (From Pathological physiology of the cardiovascular system, by J. J. Friedman. In E. E. Selkurt (Ed.), Physiology (3rd ed.). Boston: Little, Brown, & Co. Reprinted by permission.)
prostaglandins and kinins which produce vasodilation (Laragh, 1960).

The Cardiovascular System. This system maintains organismic homeostasis by providing adequate cell nutrients to tissues in response to metabolic demands generated by the body's internal needs and interactions with the environment. This is done primarily by controlling cardiac output. Changes in heart rate and contractility directly affect cardiac output (Surwit, 1982). Autoregulation has a major effect on peripheral resistance, and also serves as a link between the two because it is the process by which changes in blood flow produce alterations in resistance.

An increase in output may stretch the arterioles and reset baroreceptors upwards, causing an initial decrease in peripheral resistance. Eventually the arterioles will attempt to compensate to prevent excessive volume by constricting. The resulting increase in peripheral resistance may return cardiac output to its original level, although the elevated blood pressure originally produced by cardiac output is now sustained by arteriolar vasoconstriction (Epstein and Oster, 1984).

The Central Nervous System. Peripheral resistance is modulated partly by the sympathetic nervous system with its vasoconstrictor (alpha) and vasodilator (beta) components. Normal cardiovascular and renal regulation are rather easily overridden by neural stimulation under conditions of stress (Brod, 1970). For these reasons, neurogenic factors have often been implicated in hypertension (DeQuattro and Miura, 1973; Esler, Julius, Zweifler, Randall, Harburg, Gardiner and DeQuattro, 1977).
The accepted early view was that increased blood pressure (BP) is caused by increased peripheral resistance caused by excessive autonomic nervous system activity. However, it now appears that the nervous system interacts with BP rather more complexly. Sympathetic activity can affect volume via direct effects on the kidney, by increasing sodium reabsorption and heightening plasma renin activity (Davis and Freeman, 1976; Gottschalk, 1979). Sympathetic activity itself is also known to be altered in some hypertensive persons. Although hypertensives have not consistently been found to have higher resting plasma catecholamine levels than do normotensives, these neurotransmitters do increase significantly more during exercise in hypertensives, suggesting a link between increased sympathetic reactivity and the disease (DeQuattro and Miura, 1973). Elevated catecholamines and sympathetic hyperreactivity seem particularly associated with subgroups within the larger hypertensive population: those having a labile form of the disorder and those with high renin levels (Esler et al., 1977).

Besides the regulatory systems just discussed, numerous other biochemical substances and physiological variables have been implicated, both as contributory factors and as indicators of pathology. Under conditions of stress, young hypertensives, with presumably milder forms of the disorder, showed in comparison with normal persons, protracted elevations in pulse rates, muscular tonus, free fatty acids (cholesterols and triglycerides), norepinephrine and cortisol in the plasma, and plasma renin activity, in addition to the
expected rises in systolic and diastolic BP (Bauman, Ziprian, Godicke, Hartrodt, and Naumann, 1973).

Age and overweight have also been shown to be risk factors, although not as systematically as was once supposed. While BP tends to increase with age, it does not do so in all hypertensives (Jenkins, Somervell, and Hames, 1983). Nor do changes in weight account significantly for changes in BP (Chiang, Perlman and Epstein, 1979).

The link between psychological factors and hypertension is generally accepted but the mechanism or sequence of steps leading from personality and behavioral characteristics, through physiological systems, to blood pressure pathology, is not known. Most plausibly, there is mediation by central and autonomic nervous system mechanisms that are involved in the regulation of cardiovascular, humoral and biochemical processes, in response to environmental demands (Surwit et al., 1982). However, much further research is needed. Clearly, any theory of single linear causation is inadequate. A systems viewpoint which acknowledges the contributions of several interacting influences, and multivariate research designs that can conceptually and statistically accommodate such complexity, would permit better understanding of the causes, characteristics and consequences of hypertension in different individuals.

Personality Research

This section reviews a representative sampling of studies on personality characteristics of hypertensives. The earliest research was heavily influenced by Alexander's formulations regarding suppressed hostility and shows the stamp of psychoanalytic theory in
its emphasis on interpersonal conflict and traits. More recent studies have attempted to refine the concept of anger as it relates to hypertension and have considered the effects of environmental factors. The nature of interpersonal relationships, particularly as shaped by family of origin, has also come under scrutiny, as well as cognitive perceptual processes that may have an effect on hypertension.

Foremost among the early psychoanalytic theories of hypertension was Alexander's (1939, 1950) formulation of the hypertensive as a person in conflict between passive dependent feelings and strong hostile aggressive impulses. Fearing to lose the affection or approval of others, the hypertensive seeks to control anger, overlearns inhibition, and becomes overly compliant and nonassertive. He or she tends to have problems with authority, is reluctant to delegate, is doggedly conscientious in approaching tasks, and becomes covertly resentful as self-imposed responsibilities pile up. Over time, the continued inhibition of hostile tendencies and mounting feelings of pressure are thought to lead to permanent cardiovascular and humoral changes and chronic elevation in blood pressure.

Much of the literature can be seen as attempts to substantiate or disprove Alexander's claims, with the concepts of submissiveness and inhibited or unacknowledged hostility frequently reiterated. Miller (1939) looked at 193 hospitalized psychotics and found much higher BP levels in those who had hostile paranoid delusions or who were agitatedly depressed, than in those with grandiose mentation or apathetic depression. Binger, Ackerman, and Cohn (1945) clinically described 24 hypertensives referred for outpatient psychological
treatment as anxious, dependent, and given to inhibited but not deeply repressed aggressive impulses. Anger was related to insecurity about handling internal conflict, external danger or fear of separation. College students were investigated by Hamilton (1942), who found elevations in BP to be associated with low assertiveness, low dominance and susceptibility to anger.

In a comparison study, Saslow, Gresel, Shobe, DuBoise and Schroeder (1950) behaviorally rated demographically matched groups of hypertensives, character disorders and medical patients. The presence of characteristic traits in hypertensives was confirmed: they were less impulsive, more compulsive, depressed, anxious, and more subnormally assertive than the medical patients, and less assertive and more compulsive than normotensives with character disorders. More recent studies comparing hypertensives with other psychosomatic illnesses have yielded similar or supportive findings (Lyketsos, Arapakis and Blackburn, 1982; Reiser, 1970; Weiner, 1979).

Wolf & Wolff (1951) and colleagues conducted a series of experiments comparing hypertensives with other psychosomatic, medical and normal individuals, finding that hypertensives were more squarely built and muscular and displayed two characteristic patterns of behavior. Many were outwardly easygoing but inwardly tense, vigilant and quick to take offensive action rather than to reflect thoughtfully. Others were restrained and tended to placate those they feared. It was suggested that the specific emotion elicited in situations may be important to the type of cardiovascular response elicited.
Grace and Graham (1952) related specific attitudes and emotions to different psychosomatic diseases and noted the characteristic attitude of hypertensives as consisting of an awareness of threat of bodily harm with no possibility of fight or flight, implying an inhibited desire to combat danger.

These and other studies have been criticized on methodological grounds (Davies, 1971; Goldstein, 1981). Numerous reports can be cited which offer only weak support for the theory of repressed hostility, or which even apparently contradict it. Several studies have found higher levels of expressed anger in hypertensives than in other groups (see for example: Cochrane, 1973; Ghosh and Bashey, 1966; Harburg, Blakelock and Roeper, 1979; Mann, 1977; Matarazzo, 1954; and Ostfeld and Shekelle, 1967). However, even critics acknowledge that while the role of inhibited hostility and related traits and behavior has not been conclusively proven, the consistency with which these traits appear in clinical descriptions and experimental reports bear witness to the need for further, better designed research.

In Detroit, Harburg and associates conducted several investigations aimed at refining the concept of anger as applied to hypertension, and at examining interactions among anger and various environmental and physiological factors. A special scale was developed to look for predicted BP differences between "Anger-in" versus "Anger-out" respondents within various demographic groups, considering especially race, socioeconomic status and neighborhood. These respondents were classified in terms of self reported coping
styles in specific anger provoking situations (Harburg, Erfurt, and Hauenstein, Chape, Schull, and Schork, 1973).

In the first of these studies, Harburg et al., (1973) observed that black and white males using an anger-in coping style had significantly higher diastolic pressure (DBP) and more documented hypertension than did their anger-out counterparts. Gentry, Harburg and Hauenstein (1973) compared DBP in white and black females. For black women in high stress locales and white women in low stress locales, anger-in was associated with elevated DBP. No differences were found among black/low stress and white/high stress females. A third study (Esler et al., 1977) found a much higher use of anger-in among high renin hypertensives than among low renin hypertensives or normotensives. Harburg, Blakelock and Roeper (1979) reported that coping styles characterized by "resentment" (holding anger in or expressing it via overt aggression) is associated with hypertension more than a "reflective" style which eschews anger and focuses on problem solving. Habitual coping styles rather than response to specific anger provoking situations were investigated by Gentry, Chesney, Gary, Hall, and Harburg (1982). A major finding was that chronically suppressed anger does in fact appear to be etiologically linked to both diastolic and systolic BP and hence to essential hypertension. Race and residing in a high stress neighborhood were found, not surprisingly, to be important determinants of the disease. Interestingly, gender appears to be equally important under certain circumstances; anger expression was related to systolic as well as diastolic BP but only for female subjects.
Alexander (1939) had observed that his criteria for predicting hypertension was less successful with women. Studies of female hypertensives (Harris, Sokolow, Carpenter, Friedman and Hunt, 1953; Harris and Singer, 1967; Kalis, Harris, Bennet and Sokolow, 1961) consistently find them to be somewhat different from the hypertensive described by Alexander. They are fighters rather than fleers, with interpersonal relationships marked by hostility and abrasiveness, and difficulties in dealing with culturally assigned feminine roles. Such personal characteristics interfere with adaptation to change and with asking for and accepting support from others.

What is particularly interesting is that in studies of Type A behavior and hypertension, no large correlations have been found. Indeed, the classic Type A person--driven, ambitious, restless and aggressive--is quite different from the stereotyped hypertensive, although some overlap in behavior can be seen. However, Type A behavior is quite similar to the description of the hypertensive woman given above. In studies that look specifically at gender, a three to seven fold higher incidence of hypertension is found in Type A woman (Rosenman and Friedman, 1961), and particularly in women over 40 (Shekelle, Schoenberger, and Stamler, 1976).

The nature of the hypertensives' interpersonal relationships--how others are perceived and how those perceptions alter relationships--has come under scrutiny. Family interactions seem especially important, both because this is where the bulk of social behavior is learned, and because of the fact that hypertension tends to run in families. Leaving aside the undoubted contribution of genetic
inheritance, family aggregation of the disease can also be understood in terms of how the perceptions and behavior of hypertensive parents may shape those of their children.

If, as some of the research indicates, hypertensives view the world as a hostile, dangerous place, their children may also be seen as threatening. The threat may be handled by intimidation or possibly through distancing; conceivably both methods could paradoxically provoke the anger and hostility that is feared (Weiner, Singer, and Reiser, 1962). Studies of children of hypertensives do tend to find somewhat higher levels of aggression, hostility, feelings of inadequacy and compulsive character traits than in children of normotensives (Thomas, 1958; Thomas, Ross and Higinbotham, 1964).

Baer, Reed, Bartlett, Vincent, Williams and Bourianoff (1983) conducted independent experiments on conflict management in families with hypertensive fathers. During role played conflicts, all family members tended to avoid eye contact, especially when making negative comments. Averted gaze was interpreted as an index of conflict avoidance, since it served to soften confrontational aspects and decreased the amount of information conveyed. Because it also diminished opportunities for communication and problem solving and hence reduction of hostility, it was thought that such coping by avoidance may generate the poor management of conflict thought to be a risk factor for hypertension.

That many children of hypertensives become adult hypertensives is well documented (Weiner, 1979). That many, if not all adult hypertensives have some type of problem in dealing with anger and
conflict has been demonstrated. What is not true is that all hypertensives either develop in childhood or demonstrate in adulthood similar personality characteristics with regard to anger and its expression. Nor do they all appear to share similar perceptions of parental attitudes and family relationships. Davies (1970) found that those with high levels of hypertension report that their fathers were quite tolerant, while those with relatively low BP levels (possibly younger cases or those with borderline and/or labile forms of the disease) were more critical of parents. Hypertensives with labile BP have reported disliking fathers for being domineering, stern and socially ambitious for their families (Harburg, McGinn, and Wigle, 1965).

The work of Baer et al. (1983) suggests that young potential hypertensives are not taught specifically to either repress, suppress or express negative emotion, but do learn a generic defensive style of avoidance and non-resolution that allows for individual differences to emerge at later dates. Hence, some of the different patterns that have been found in the literature: the overly inhibited person who may be aware of conflict but chooses to placate (Harburg et al., 1973; Wolf and Wolff, 1951); the vigilant person who outwardly seems easy-going but is quick to rush to judgment and takes ineffective action (Wolf and Wolff, 1951); the person who freely expresses "anger-out" but again usually inappropriately and ineffectually (Harburg et al., 1979); and the aggressive, ambitious, Type A woman with the chip on her shoulder (Harris, et al., 1953, 1967). In addition, another subgroup may exist: hypertensives who have so repressed and denied
and distanced themselves from any unpleasantness that they are no longer consciously aware of its existence in their lives.

Weiner et al., (1962) discovered that as long as hypertensives in an experimental situation could maintain cognitive distance, their BP stayed level. When the defense failed, critical elevations occurred. Sapira et al. (1971) showed a group of hyper and normotensives two films of a physician interviewing a patient. The same actor portrayed a warm and kindly doctor in one vignette, a cold, rude, aloof one in the other. Although the normals immediately spotted the contrast, hypertensives denied perceiving any differences, in spite of the fact that their BP and pulse rate soared, first while watching and again in later interviews that were conducted by the actor/physician. Sapira postulated that hypertensives screen out perceptions of good and bad in order to defend against cardiovascular hyperreactivity. To see one as "good" would be tantamount to admitting the other was "bad"; it is safer to eschew criticism altogether.

During interviews, hypertensives and especially older ones tend to insulate themselves, relating as little as possible to the interviewer and disclosing less personal information than do normotensives or ulcer patients (Berglund, Ander, Linstrom, and Tibblen, 1975; Reiser, Brust, and Ferris, 1951). Cumes (1983) compared degree of self disclosure in shopping mall patrons who were categorized as hypertensive and normotensive on the basis of readings taken at the time. Blood pressure was taken before and after completion of a checklist of personal concerns. Individuals
with elevations post checklist disclosed fewer concerns and were less likely to report feeling stressed even when BP had risen. The hypertensive group, whose average age was 59, rather improbably denied concern about such things as growing old, death of loved ones, or being lonely.

Blood pressure is generally thought to elevate with age but apparently to a significantly greater degree in those who report less stress. A willingness to acknowledge stress and distress seems characteristic of those whose BP does not increase with age (Jenkins et al., 1983). Linden and Feuerstein (1983) compared normotensives with treated and untreated hypertensives. Both groups of hypertensives were seen as more defensive and repressed than normals, but those in treatment were more like normals in their willingness to admit problems. Untreated hypertensives scored higher on measures of social desirability, lower on depression and reported fewer stressful social interactions than the other two groups.

Blandness and a preference for denying the vicissitudes of life, however, clearly do not typify all hypertensives. Apparently, important interactions among coping style, life experience, age, personality traits and physiological factors, and possibly other, as yet unknown, variables exist to create distinct subgroups of hypertension with different psychophysiological profiles.

**Hypertensive Studies Using the MMPI**

The MMPI has not been extensively used in studies of hypertension. When it has been, the results tend to show that hypertensives, when taken as a whole, do not consistently differ from
other groups in the directions predicted by classical psychosomatic formulations of the disease. However, when samples are broken down into subgroups on various bases, rather consistent differences do emerge.

Brower (1947) attempted to relate BP in college students with various personality features. All, regardless of whether initial BP was in the hypertensive range or not, reacted to stress with elevations in pressure. However, those with highest diastolic pressures and pulse rates (measures of lability) were found to have higher elevations on MMPI scales 1, 2 and 4 (hypochondriasis, depression, and psychopathic deviance which comprises elements of anger and acting out).

Lewinsohn (1956) used the MMPI to compare four groups of Veterans Administration's patients: controls, neurotics, ulcers and hypertensives. The neurotics scored higher on all MMPI scales but the two psychosomatic groups scored higher on scales 1, 2, 3 and 4 than normotensives controls, with hypertensives also elevating on 7 (anxiety, worrying). Studies using the MMPI conducted by Innes et al. (1959) and Robinson (1962) similarly showed few differences between hypertension and other psychosomatic illnesses, with all groups scoring high on scales 1, 2, 3 and 4.

Ostfeld and Lebovits (1959) compared 50 essential with 50 renal hypertensives. Both groups responded to stressful circumstances with equivalent elevations in BP. The conclusion was that there were no significant psychological differences between groups and therefore attitudes and personality features were not etiologically involved in
hypertension. Because the results did suggest an association of BP lability with emotionality and degree of BP elevation, a second study was conducted comparing labile subjects with those whose BP was stable. A significant correlation was found between lability and scales 1, 2 and 4, which suggested that the hypertensive population contains a separate subgroup with distinct personality and physiological features (Ostfeld and Lebovits, 1960).

In 1967, Ostfeld and Shekelle defined, a priori, three MMPI profiles thought to be related to psychological conflicts of hostility and passive-dependence. Analysis of a large sample of men in an industrial setting revealed no BP differences between groups fitting any of the profiles.

Wennerholm and Zarle (1976) used the MMPI as part of a battery of tests designed to investigate the role of locus of control, social desirability and defensive styles in hypertensives. Subjects scored higher on the Welsh R scale, suggesting greater use of denial and repression. Internals, who reported taking more personal responsibility for following treatment regimens demonstrated better adjustment and ego strength on the MMPI as well. High scores on the Welsh Anxiety and Repression scales were also reported by Jenkins et al. (1983).

In a recent study reminiscent of the Ostfeld and Shekelle work cited, Naliboff, Cohen, and Yellin (1983) developed four profiles, emphasizing scales 1, 2, 3 and 4, for analysis of three types of chronic illness, one of which was hypertension. Similar frequencies of all four profiles were found for all three groups. The argument
was made for the importance of utilizing configurational or profile analysis in MMPI research, rather than comparing single scales or multivariate linear compositions of scale elevations, in order to capture a fuller range of the psychological diversity found in any illness.

**Subtypes of Hypertension**

Reviews of the literature frequently comment on the multiplicity of often contradictory findings regarding the pathogenesis of hypertension. Goldstein (1981) among others, has conjectured that the confusion may arise because hypertension is usually investigated as if it were a single, homogeneous disease when it is actually multifactorial and heterogeneous. It is possible that the differences between subgroups within the larger hypertensive population, when pooled together, tend to cancel each other out. DeQuattro and Miura (1973) note a trend in the literature to classify hypertensives into subgroups, and believe this to be a reasonable approach to the study of a heterogeneous population, and one that might go far to explain apparent contradictions. The remainder of this CHAPTER will review attempts to identify subgroups from a physiological, a psychological, and most relevantly for the present study, a psychophysiological point of view.

**Physiological Types**

This section surveys the various ways in which, essential hypertensives have been subclassified. The criteria include stage and severity of the disease, levels and behavior of systolic and diastolic blood pressure (SBP and DBP), humoral indicators such as renin and...
catecholamine activity, and whether elevations in blood pressure are due to cardiac or vascular dysfunction.

Reisel (1969) claimed that essential hypertension is not a clear disease entity but a collective concept for a range of BP levels and pressure related maladies of various target organs (heart, kidneys, blood vessels, etc.). He formulated a stage model based on DBP and target organ damage, consistent with the notion that hypertensive disorders form a continuum from stable, non-pathological levels, through several phases of increasing severity. The implication is that there is a hypertension career path along which victims of the disease travel. Thus:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Indicators</th>
</tr>
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<tbody>
<tr>
<td>I. Pre-hypertensive</td>
<td>DBP 95 mm Hg.</td>
</tr>
<tr>
<td>II. Labile</td>
<td>DBP 95, intermittently</td>
</tr>
<tr>
<td>III. Persistent</td>
<td>DBP 95, consistently</td>
</tr>
<tr>
<td>IV. Established</td>
<td>DBP≥ 95, with atherosclerotic vascular disease</td>
</tr>
<tr>
<td>V. Malignant</td>
<td>DBP much≥ 95, with accelerating atherosclerotic vascular disease</td>
</tr>
</tbody>
</table>

The stage concept is apparently endorsed by Julius (1977), but in a more limited fashion. Persons with BP consistently below 140/90 mm Hg. (the most commonly accepted lower limit of hypertension) are clearly normotensive. Those with BP readings above 160/100 mm Hg. are definitely hypertensive. The range between these two points, however, is problematic because some show a labile pattern while others produce consistent elevations.
Labile hypertension is the term used by most investigators to characterize the condition of occasional, transient elevations above 140/90 mm Hg. This stage, or type as some prefer, is marked by large variability in BP, associated with hyperresponsiveness to various kinds of stimuli. Physiologically, it is manifested in increased cardiac output with or without corresponding abnormal increases in BP, and with peripheral resistance often remaining abnormally normal, that is, failing to respond with a compensatory decrease (Surwit et al., 1982).

Julius acknowledges that there are individual differences in SBP and DBP patterns, but chooses to classify all those who at any time show an elevation in this range as borderline hypertensives. He and others have observed behavioral differences between persons who have occasionally elevated readings and those who are consistently elevated, and have suggested that "labiles" form a separate type that should not be considered "true" hypertensives (Ostfeld and Lebovits, 1960; Richter-Heinrich and Lauter, 1969).

Borderline hypertension is frequently used as a classification category. Unfortunately, there is disagreement on how it should be defined and which patients can be so classified. It is generally accepted as a mild form of the disease, intermediate between normal BP levels and severe elevations. As just seen, the distinction between labile and stable pressures are sometimes disregarded (Julius, 1977). Some researchers consider it an early stage or transition phase to established hypertension while others note that only some borderlines go on to develop the higher elevations of established hypertension.
(Weiner, 1979). Several have observed differences other than lability versus stability and have concluded that borderline hypertensives do not constitute a uniform subgroup (Harburg et al., 1964; Surwit et al., 1982; Weiner, 1979).

A number of other important physiological concomitants of hypertension have been investigated: renin levels (Laragh, 1961; Esler et al., 1977); hemodynamics, or the relationship of cardiac output to peripheral resistance (Eich, Peters, Cuddy, Smulyan, and Lyon, 1962; Julius, 1977; Julius and Esler, 1975; Surwit et al., 1982); and catecholamine levels and the whole question of neurogenic influences (DeQuattro and Miura, 1973; Lorimer et al., 1971).

With the recognition that none of these factors operates in isolation, there has been recent emphasis on classifying hypertensives on the basis of interactions among cardiac output, plasma renin and catecholamine activity, SBP and DBP, cognitive mediation, and other pieces of the jigsaw puzzle that is hypertension.

Hypertensives can be classified according to two hemodynamic patterns, both of which are associated with certain types of renin, catecholamine, SBP/DBP behavior, and other physiological phenomena (DeQuattro and Miura, 1973; Julius, 1977; Weiner, 1979).

In one pattern, high blood pressure arises from increased cardiac output in conjunction with peripheral resistance that is either low or abnormally normal, given the degree of peripheral resistance. With this type of hypertension is found high levels of plasma renin activity, catecholamines, motor activity and SBP reactivity, all of which indicate a strong neurogenic component in the form of
sympathetic nervous system overactivity, possibly due to emotional
stress. DeQuattro and Miura (1973) estimate the incidence of this
pattern at 15-50% of all hypertensives.

The second pattern consists of normal cardiac output with
increased peripheral resistance, associated with low to normal renin
levels, low catecholamines and low DBP reactivity. These
hypertensives appear much less sensitive to neurogenic influences and
much more sensitive to sodium/water balance and mineralocorticoids in
the bloodstream. Estimates place anywhere from 25-60% of
hypertensives in this category, with approximately 20-30% having
very low renin levels and the strongest association with this pattern
(DeQuattro and Miura, 1973; Epstein and Oster, 1984).

Eich, et al. (1962), Julius (1977) and Weiner (1979) have looked
specifically at borderline hypertensives, noting that the same two
hemodynamic patterns are found in this subpopulation. Eich, et al.,
(1962) observed that two-thirds showed increased cardiac output and
one-third increased peripheral resistance.

The evidence seems to link the high cardiac output pattern with
more labile SBP and DBP elevations. Lorimer, MacFarlane, Provan,
Duffy and Lawrie (1971) observed that labile hypertensives behaved
physiologically much like normotensives, especially those whose blood
pressures responded most to stress. The difference seems to be one of
degree rather than of kind, at least initially. Similar elevations in
BP and catecholamines occur in both groups. Hypertensives, however,
responded with more severe and longer lasting elevations.
Hypertensives also show maladaptive changes in several other
physiological parameters including pulse rate, blood glucose levels, blood lipids, muscle tonus and oxygen consumption (Baumann et al., 1973). Over time, with the action of auto-regulation and other regulatory functions such as the resetting upwards of baroreceptors, these maladaptations may become established, with stable increases in peripheral resistance. Hence some labile hypertensives develop sustained high blood pressures (Weiner, 1979).

**Psychological Types**

In discussing the literature on psychological functioning in hypertensives, Tarlano (1978) points out that this population has been "pigeon-holed" with respect to personality variables. Descriptions of aggression, repression, etc. have typically been applied without any effort to distinguish subgroupings. He examined hypertensives for perception of threat, coping ability and life stress, and in addition to comparing hypertensives with normals, also subgrouped hypertensives along the dimensions of repression-sensitization, elevation of BP, duration of treatment, arteriole-venile nicking (an indicator of severity and longevity of the disease), and race. When differences were factored according to hypertension and normotension, results revealed subgroupings. Sensitizing hypertensives reported feeling more hostile than repressing hypertensives, a relationship that did not exist for normotensives. Those without AV nicking reported lower self-esteem than those with AV nicking. In regard to race, only whites demonstrated considerable variability in the areas of hostility, anxiety and assertion.
Baer et al., (1979) describe the development of a brief self-report instrument designed specifically to assess personality characteristics associated with essential hypertension. Factor analysis of the items yielded four orthogonal factors labeled resentment, attention seeking, anxiety and anger arousal. Responders were divided into two groups based on having extremely high or extremely low scores on the instrument.

Subjects also took Cattell's 16 PF, the idea being to determine whether responders in extreme groups were also distinctly different on an established personality inventory. They were shown to be so. High scoring hypertensives were characterized on the 16 PF by tension and anxiety, impaired emotional stability and control, and diminished problem solving ability. Low scores on the hypertensive instrument were characterized as less suspicious, more self controlled, with superior problem solving and social skills.

The authors note with interest that earlier studies using the 16 PF and other instruments to compare hypertensives with normotensives yielded inconsistent results. However, when standard personality instruments are used to identify subgroups within the hypertensive population, and these subgroups are used for comparison purposes, significant differences do emerge.

**Psychophysiological Types**

This section discusses efforts to integrate psychology with physiology. Personality and behavioral characteristics have been related to measures of BP lability, to hemodynamic patterns (SBP, DBP, pulse rate and peripheral resistance), to biochemical factors
and to cognitive processes. Attempts have been made to differentiate neurogenic from non-neurogenic hypertension. Finally, the particular appropriateness of using multivariate statistical analysis is shown.

As early as 1960, Ostfeld and Lebovits noted that labile BP elevations were associated with emotional instability, suggesting a distinct type of hypertension in which neurotic symptoms are likely to be found. Similarly, Harburg, Julius, McGinn, McLeod & Hoobler (1964) took a series of BP readings from a large population of college students. Those who had single marked elevations upon entry into the study, with lower readings after habituation to the experimental situation, were more submissive, sensitive and neurotic on the 16 PF, and were more likely to yield in arguments to partners whose initial systolic readings were low.

Kallinke, Kulick & Heim (1982) looked at BP variability and extent of chronic and situational life stress in clinic hypertensive patients. Three groups were discerned: one with no BP variability; one in which higher than usual elevations were associated with specific stressful life events, and one with multiple and/or chronic problems, who also reacted to many situations with elevated BP. The latter two "labile" groups were more likely to respond to stress management training with decreased BP than the group with no variability, again indicating that psychological factors were more involved in some groups of hypertensives than in others.

In a multifactorial study, Pilowsky, Spalding, Shaw & Korner (1973) related several psychological measures with systolic, diastolic pressures, pulse rate, and peripheral resistance. Correlations
between BP, in general, and scores on the EPPS, IPAT & CMI suggested that hypertensives are more guilt ridden, tense, emotionally immature, deferential to others and self abasive. Specific psychophysiological interrelations emerged. Self abasement correlated with higher overall BP, and deference to others with high overall BP and higher peripheral resistance. Peripheral resistance rose with anxiety and tension. Emotional stimulation produced fluctuations in diastolic and systolic readings and sexual stimulation produced higher pulse rates and diastolic pressure.

Surwit et al. (1982) investigated the interactions of hemodynamics, biochemical factors and cognitive processes, noting two distinctly different patterns. One can be characterized as the classic defense (fight or flight) pattern, which is associated with increased BP, cardiac output and motor activity, and with elevations in all catecholamines. The affect in such a response is a defensive fearfulness in which harm is expected but the individual is unsure of its ability to cope. Several catecholamines and related substances are involved. Cortisol is produced in the presence of emotional distress provoked by the environment--a general defense agent. Epinephrine is produced in situations of novelty and uncertainty in the face of aversive stimuli, where relevant behavioral responses are unavailable. Norepinephrine is linked to familiar situations where relevant responses are available. It is the biochemical substrate of anger and also of vigilance, where the individual engages in appraisal of the situation preparatory to going to meet threat rather than to
flee. In the defense pattern, all three substances are present in the bloodstream.

Surwit also discovered a second, qualitatively different response pattern, with BP rising in association with peripheral resistance and muscle vasoconstriction, and decreased pulse rate and motor activity, all in the service of paying close attention to environmental stimuli. He termed this the sensory intake response, noting the presence of only norepinephrine. Citing the work of other researchers who have looked at cardiovascular activity in connection with various cognitive styles, he notes that this pattern is more prevalent in sharpeners than in levelers (Israel, 1969), in those with internal rather than external locus of control (Williams, Poon and Burdette, 1977), field independent rather than field dependent persons (Dronsejko, 1972), and extroverts (Eysenck, 1967). Such people may be defensive, but are vigilant rather than fearful, and may feel relatively able to cope with threat by various means, as opposed to those who may wish to avoid threat by flight and who will fight if they believe themselves cornered.

In an attempt to differentiate neurogenic from non-neurogenic hypertension, Esler et al. (1977) divided 31 males with mild hypertension into high and normal plasma renin groups. All subjects were tested for anxiety and hostility on several instruments, including the 16 PF and Harburg's Anger-in/Anger-out Scale (Harburg et al., 1973). The high renin group was found to be controlled, guilt prone and submissive, had a high level of unexpressed anger, and appeared to sustain their BP via sympathetic overactivity. They had
higher heart rates and elevated norepinephrine, although not epinephrine, levels. Normal renin subjects did not differ from normotensive controls on any measures. The conclusion was that mild high renin hypertension constitutes a distinct type of the disease and that this group at least is clearly neurogenic with important psychosomatic mechanisms.

Richter-Heinrich and Lauter (1969) sought a way of screening for severity of hypertension using multivariate analyses with psychophysiological variables. Systolic and diastolic BP, pulse rate and galvanic skin response (GSR), in two stress conditions (arithmetic and sentence completion tasks), were used to assign 100 subjects into three diagnostic categories. These were normotensive, Hypertensive I (H-I) with relatively lower and labile BP, and Hypertensive II (H-II) with higher, stable BP. After discriminant analysis and stepwise reduction, two discriminant functions were found to accurately predict group membership. The first was mainly influenced by systolic BP; the second by GSR, pulse, and systolic BP. The inclusion of several variables improved prediction over that produced by any one variable. The fact that two functions were needed indicated that H-I cannot be regarded merely as a transition to H-II but that each has special qualities. H-I also appeared to be more heterogeneous than the other two groups, suggesting the possibility of even finer breakdowns.

Subjects had been asked to subjectively report their feelings of relaxation, tension or excitement during the tasks. These measures were not included in the discriminant analysis, but it was clear that certain individuals, primarily in H-I group reported more anxiety and
tension in a manner significantly different than the adaptive reactivity of normals.

A second study (Richter-Heinrich, 1970) included several psychological variables including the MMPI K and L Scales, and measures of extroversion, neuroticism and rigidity. The same statistical procedures were used. Again, two discriminant functions separated better than one. The H-I group was found to be less extroverted, more reactive and somewhat more anxious. The major finding, however, was that the inclusion of psychological variables improves the discrimination of groups and indicates psycho-physiological correlates only evident by means of multivariate analysis.
CHAPTER III
Methodology

Introduction
This CHAPTER describes the research setting, the sample, the rationale for selection of variables, definitions of unfamiliar terms, and the instrumentation and procedures used in obtaining the data. The research design is discussed and the statistical procedures employed to identify and analyze subtypes are explained.

Research Setting and Sample Characteristics
The Family Practice Center, an outpatient clinic attached to Riverside Methodist Hospital in Columbus, Ohio, provided the setting for this study. Clientele of the Family Practice Center are drawn from throughout the standard metropolitan area of Columbus, with the majority residing in the relatively affluent northern and western sections of the city.

During the course of routine treatment, patients with the diagnosis of uncomplicated mild to moderate essential hypertension were screened and questioned as to their willingness to participate in a study of the effects of cognitive-behavioral treatment on hypertension (Tosi, Rudy and Lewis, 1985). Those who volunteered were considered for inclusion in the study. The resulting sample
consisted of 73 adult, basically middle class caucasians, between the ages of 25 and 64. Males numbered 44 and females 29. Systolic blood pressure ranged from 111 to 177 mm Hg and diastolic from 72 to 112 mm Hg, with mean pressures of 141 over 93 mm Hg.

**Selection of Variables**

The psychological variables consisted of the ten clinical scales of the Minnesota Multiphasic Personality Inventory (MMPI). The selection of this instrument has been discussed in CHAPTER I and will be addressed further under Instrumentation.

The physiological variables consist of plasma renin activity (PRA), measured in terms of the Renin-Sodium Hyperbolic Index (RSHI), levels of catecholamines, triglycerides, high density lipoprotein (HDL) and low density lipoprotein (LDL) cholesterols, pulse rate, and percentage of ideal weight (as an indicator of obesity). Age and sex are included under the rubric of physiology, as explained in CHAPTER I.

The importance of renin in essential hypertension has been increasingly appreciated in the last decade, especially since the discovery of angiotensin (Skeggs, Kahn, and Shumway, 1956; Gifford, 1974). Laragh (1976) has subdivided all hypertensives into three subgroups based on renin level.

The relationship of catecholamine activity and renin levels has been studied by DeQuattro, Campese and Miura (1976) and by Esler et al. (1977). Rather strong relationships have been found between both of these indicators and sympathetic hyperreactivity and the handling
of hostility, suggesting that both substances contribute importantly to the psychophysiology of hypertension.

Lipoprotein levels, as indicated by triglycerides and the relative proportion of HDL to LDL cholesterol have also been implicated in subforms of hypertensive disorders (Bauman, et al., 1973).

The remaining variables are generally included in hypertension research, pulse rate as a further indicator of sympathetic arousal, and age, sex and overweight as important sources of variation in hypertensives (Taylor and Fortmann, 1983; Henry and Cassel, 1969). Definitions

The following definitions are taken from Dorland (1974):

**aldosterone**: A mineralocorticoid that acts as the principal electrolyte-regulating steroid secreted by the adrenal cortex.

**angiotensin**: A substance present in the blood and formed by the action of renin and angiotensinogen in blood plasma. The inactive form, angiotensin I, is further catalyzed into angiotensin II, a powerful vasopressor and stimulator of aldosterone secretion.

**catecholamines**: A group of similar compounds having a sympathomimetic action. They include epinephrine, norepinephrine and dopamine.

**cholesterol**: A fatlike alcohol, crystallizing in the form of leaflets or plates, and found in animal fats and oils, in bile, blood and brain tissue, milk and egg yolk, the myelin sheaths of nerve fibers, and the liver, kidneys and adrenal glands. It is the major constituent of common gallstones and occurs in the degenerative plaque obstructing arteries, in cysts and in carcinomatous tissue.
hypertension: Persistently high arterial blood pressure, having either no known cause (essential or idiopathic) or associated with other primary diseases (secondary). Suggested criteria for its threshold range from 140 mm. Hg systolic and 90 mm. Hg diastolic to 200 mm. Hg systolic and 110 mm. Hg diastolic.

lipids: Fatty acids, neutral fats, waxes, steroids and phosphatides. They are stored in body tissue, serve as an important source of fuel and are an important part of cell structure.

lipoprotein: A combination of lipids and protein that act as transporters of plasma cholesterol.

  high density lipoprotein (HDL) contains relatively more protein and less cholesterol and triglycerides. 
  low density lipoprotein (LDL) contains relatively more cholesterol and triglycerides and less protein.

mm. Hg: Millimeters of mercury. The unit of measurement for arterial blood pressure.

renin: An enzyme liberated by diminished pulse pressure or by a deficiency of blood in the kidneys due to functional constriction or actual obstruction of blood vessels, which changes ansiotensinogen into angiotensin. Because PRA varies widely as a response to sodium/water balance, it is an uncertain indicator.

Renin–Sodium Hyperbolic Index (RSHI): The actual measure of PRA used in this study. It is obtained by means of an indexing method derived by Rudy, Lewis and Eshbaugh, (1984) which takes the mathematical product of PRA and urinary sodium, thereby yielding a roughly constant measure for a given individual.
triglycerides: A compound consisting of three molecules of fatty acid. It is a neutral fat synthesized from carbohydrates for storage in adipose cells.

**Instrumentation**

Data on personality characteristics and functioning was obtained via the MMPI. This instrument was selected because of its widespread use in both counseling and research. Its counseling utility is related primarily to the quantity and quality of information reported, its ease of administration, scoring and interpretation facilitate its use as a research tool.

Studies using the MMPI with hypertensives are cited in CHAPTER II. The test has also proven itself as an effective typological tool in many areas of psychological research. Clustering procedures performed on MMPI data have been used in the study of several populations, including alcoholism (Goldstein and Linden, 1969; Eshbaugh, Tosi and Hoyt, 1978, 1980); drug abusers (Eshbaugh, Dick and Tosi, 1982; Johnson, 1981; Tosi, Eshbaugh, Raines and Murphy, 1985); and felons (Goeke, 1983). The selection of the MMPI for this study adds to this body of typological research.

**Scale Development and Test Construction.** Most of the MMPI scales were developed empirically from experiences with various hospitalized psychiatric patients with known diagnoses. Responses of these groups were compared to those of a sample of normal adults, and items which discriminated between patients and normals were included in appropriate scales as each was developed. The empirical method is thought to avoid the problem of item transparency inasmuch as the
irrelevancy of content makes conscious alteration of responses futile. Further, this approach established criterion validity simultaneously with construction (Goldstein and Neuringer, 1976).

**Reliability.** The MMPI has held up in test-retest situations covering three days to over one year (Cottle, 1950; Hathaway & McKinley, 1942; Holzberg and Alessi, 1949; McKinley & Hathaway, 1942, 1944). Reliability coefficients range from .52 (Scale 4) to .93 (Scale 0), with the majority falling in the .70's and .80's.

**Validity** The goal of the MMPI's creators was the objective assessment of major personality characteristics. By measuring the presence and the degree of certain of those traits, singly and in combination, they expected to be able to identify and predict psychopathology. Scale elevations were found to predict subsequent clinical diagnoses in 60 percent of new admissions. In cases where elevated scores did not predict actual diagnosis, the trait indicated was found to be abnormally present in the individual (McKinley and Hathaway, 1943).

There is a certain problem here in that while the scales were expected to measure pure traits, the original developers provided little information that defined those constructs, other than the names of the scales themselves, and actuarial interpretations of individual scales and profile configurations. More recently Comrey (1957, 1958); Harris and Lingoes (1968); and others have applied factor analytic techniques to the problem of construct validity, or at least construct
definition. The contents of each scale have become increasingly identified, clarified and understood.

There is considerable debate about the validity of the MMPI (Anastasi, 1976), however it continues to be a major instrument of choice for researchers and practitioners alike. Because of its wide currency in research, there is a wealth of data against which to compare newer studies, thus contributing to the expansion of knowledge. Moreover, because of its familiarity to clinicians, MMPI findings offer information that is easily interpreted and meaningful in practice. Hathaway (in Dahlstrom, Welsh and Dahlstrom, 1972) acknowledges the criticisms leveled against the instrument, but contends that it is the best method extant to assess personality dynamics.

Data Collection

Patients previously diagnosed and treated for hypertension were given a physical exam and had their medical histories taken. Those with a history of heart disease and those for whom secondary causes for high blood pressure could be determined were excluded. The sample was to consist of adults, aged 18 to 65, of either sex, with uncomplicated mild to moderate essential hypertension, operationally defined as having a diastolic pressure under 112 mm Hg. on three separate occasions.

Patients who met the criteria for inclusion were taken off anti-hypertensive medication. In the third week following discontinuation, they underwent a protocol which included:
1. blood pressure readings taken on three consecutive days.
2. laboratory blood workup for triglyceride and cholesterol levels.
3. 24 hour urine and creatinine readings.
4. plasma renin activity, using the commercial method developed by the New England Nuclear Corporation.
5. plasma catecholamine levels, measured with the Enzymatic Method.
6. administration of the MMPI.

In the event that three consecutive blood pressures showed systolic pressure greater than 200 or diastolic pressures greater than 112 after one-half hour's rest, participation in the study was discontinued. The same was done for patients who began to show hypertensive complications such as retinopathy or congestive heart failure. Conventional treatment was resumed for these persons, with psychological testing and treatment offered electively at a later date.

A graduate student trained in the use of the MMPI administered the instrument, following standard procedures described in the manual. Answer sheets were scored using templates from the Psychological Corporation. K-corrected scores were plotted on the appropriate male or female profile, thereby converting them to standardized T scores. These T scores provided the data for statistical analysis. Profiles that were judged valid using Lachar's (1974) rules were retained in the sample.
It has been recommended that studies using the MMPI employ non-K-corrected scores, treating K as a separate indicator so as not to assume its validity as a suppressor variable that corrects for a tendency to distort answers to create a more favorable impression (Butcher and Tellegen, 1978). The decision to use K-corrections in this study was made for the following reasons. Cluster analysis, one of the principal procedures used in the analysis of the data, was originally developed on much larger samples than the present N of 73. In order to better ensure statistical power with this size sample, it was necessary to reduce the number of variables. The decision was therefore made to include only the ten clinical scales in the analysis. The use of the K-correction avoids the loss of the information yielded by the K scale by incorporating it into the analysis. In addition, scoring and interpretation of the MMPI by practitioners typically makes use of the K-correction. The K-corrected profiles reported in this study should therefore be more meaningful and pragmatically useful to the clinically oriented reader.

**Research Design and Statistical Analysis**

The basic areas of investigation in this study were the identification of discrete subgroups or types in a population of mild to moderate essential hypertensives, and the possibility of relationships between physiological and psychological factors.

Statistical analysis of the data involved the use of multivariate techniques, specifically cluster analysis, descriptive discriminant analysis and discriminate classification. These procedures permitted investigation of several variables, singly and in combination. A
multivariate approach most adequately addressed the complex, heterogeneous nature of the phenomena under investigation and better explained interactional effects. It was hoped that from these analyses, discrete, identifiable psychophysiological subtypes of hypertension would emerge. It was further hoped that the identification and description of the psychological and physiological characteristics of each type would lead to more effective guidelines for differential treatment.

Cluster Analysis

This is a type of statistical procedure widely used for taxonomic/classification purposes to search for relatively homogeneous subgroups within a larger body of superficially similar but internally heterogeneous units (Everitt, 1980). MMPI scores were subjected to cluster analysis to see if homogeneous subgroups or types existed within the larger sample.

Cluster analysis involves the use of any one of a growing number of mathematical algorithms that place objects or observations into groups or clusters that are suggested by the data rather than defined a priori. Members of a larger group are distributed in such a way that smaller groups are formed, whose members tend to be similar to each other in some ways, and dissimilar to members of other groups (SAS Manual: Statistics, 1982). It is an extremely useful taxonomical tool and one that has been increasingly employed in a wide variety of research areas (Everitt, 1980; Sneath and Sokal, 1973). However, it involves subjective elements that leave it open to question and criticism.
One of the thornier problems is the meaning of a cluster, that is, how is the essential similarity of a subgroup determined? Each of the rapidly proliferating methods employs a different algorithm for computing similarity and distance; each tends to find clusters of a particular shape. If there is no a priori reason for assuming a particular shape, then the use of a given method may impose a structure rather than find one that inherently exists. Choice of method, then, becomes a major decision.

In using data which lends itself to profiling, such as MMPI scores, the best measure of similarity would appear to be one that takes profile shape, elevation and scatter into account. Several of the algebraic indices of similarity currently used are more or less successful at capturing these three elements. None captures all three equally well. Eshbaugh's (1976) review of similarity indices demonstrates that selection of an index for use in the clustering algorithm is at best an exercise in optimization.

Of the many methods so far developed, hierarchical procedures have been well researched and have proved to yield useful typologies with psychological data (Everitt, 1980; Fisher and Van Ness, 1971; Sneath and Sokal, 1973). These are stepwise operations that successively agglomerate or fuse smaller groups, or alternatively, successively subdivide larger groups, until no further fusions or subdivisions are possible. A basic assumption is that a cluster may be entirely contained within another, but no other overlap is possible.
A major problem in using hierarchical methods is the determination of the optimal number of clusters present in the data, or in other words, which of the successive generations of clusters best represents the "true" structure of the data. There is no set method for solving the number of clusters problem. Solutions so far developed involve inspection of the various graphic and statistical outputs provided by the programs. Printouts offer cluster maps (sometimes called trees or dendrograms) and plots, as well as various similarity/distance ratios, which are helpful in determining the number of clusters. A sudden marked flattening of the curve, or sharp jump in frequency of a cluster, or increase in the ratios are intuitively thought to occur at the point where the number of groups best corresponds to the optimal within/between group distance (Gower, 1975; Thorndyke, 1953; SAS, 1982). Unfortunately, these indices are often far from clear cut, with the result that subjectivity inevitably enters into the decision.

One solution to the number of clusters problem is to randomly halve the data set to see if clusters from each half match. In cases where the sample is too small to subdivide without sacrificing statistical power, the recommended approach is to use a variety of procedures and retain only those clusters which are produced by all or most of the methods (Everitt, 1980; Everitt, Gourlay and Kendall, 1971).

A number of clustering methods are currently available in the 1982 edition of Statistical Analysis Systems (SAS), mainly of the agglomerative hierarchical type just described.
The three options available on the CLUSTER procedure are the Centroid, the Average Linkage, and Ward's methods, each of which uses a different algorithm to compute distance between clusters.

The Centroid method employs the distance between group means or centroids. It is more robust to outliers but is less sensitive to variances between clusters with a small number of objects or members.

In Average Linkage, the average distance is computed between pairs of objects, one in each cluster of a generation, thus forming the next generation. This method tends to join clusters with small variances and is biased toward producing clusters of approximately similar variance.

In Ward's method, the distance between two clusters is the sum of squares between the two, added up over all variables. At each new generation, the within cluster sum of squares is minimized over all partitions obtainable by merging two clusters from the previous generation. This tends to join clusters with a small number of objects and is biased toward producing clusters of approximately equal sizes.

Each of these methods has its advantages, although many studies have indicated that Ward's and Average Linkage are among the best hierarchical algorithms available (Everitt, 1980; Milligan, 1980).

SAS procedures cluster objects or cases that have been arranged on a multivariate data matrix (rows being objects and columns being variables). A history of the clustering process is provided, showing each successive iteration or generation of clusters, and an output data set is created from which the TREE procedure can produce a
cluster map. The statistics provided for estimating the optimal number of clusters include the root mean squared standard deviation (RMS STD) and the cubic clustering criterion (CCC).

According to Ward (1963), at any stage of the analysis, the loss of information resulting from the grouping of individuals into clusters can be measured by the sum of squared deviations of every point from the mean of the cluster to which it belongs. SAS (1982) printouts show the RMS STD for the total sample and for each new set of clusters up to the tenth iteration. The point at which the RMS STD of a set deviates most from the RMS STD of the total is an indicator of the best set or number of clusters.

The CCC is a computed statistic that is plotted against number of groups up to ten. A sharp step in this plot indicates the correct number of groups (Gower, 1975). CCC plots are also provided on SAS printouts. Both the RMS STD and the CCC approaches tend to be less clear cut in practice than in theory. In consequence, decisions about the optimal number of clusters remain highly subjective.

In addition to the three methods described, the 1979 edition of SAS offered Johnson's method which is based on an algorithm that attempts to incorporate to the maximum degree of information about profile shape, scatter and elevation. It is particularly sensitive to small clusters. The printout provided by the Johnson's program does not offer RMS STD statistics nor does it employ the CCC. Statistical determination of the optimal number of clusters is ideally found where the distances within clusters are minimum and the distances between are maximum. The printout lists a table of distance ratios showing
minimum and maximum differences. The ratio begins at 1.00 where each observation forms a separate cluster (the 73rd iteration) and decreases gradually throughout the iteration process until it becomes relatively stable. When the ratio shows a significant value increase, the point of optimal clustering should theoretically be the iteration just above this rise.

The data for this study was subjected to each of these four techniques and the cluster solutions were compared. Ratios were examined to determine optimal number of clusters; cluster maps were inspected for general structure of the clusters, i.e., size, point of formation, etc. When similar cluster solutions were produced, that is when different methods yielded a similar optimal number of clusters with roughly similar structures, those clusters were considered stable and worthy of further investigation.

In any cluster analysis, the best number or composition of clusters from a statistical perspective is not necessarily ideal for clinical application. For this reason, a further approach to analysis was utilized, namely the visual interpretation of mean MMPI profiles.

Critics of cluster analysis have noted a certain circularity in these techniques in that the choice of method would be simplified if one had prior knowledge of the structure of the data. However, this structure is precisely what cluster analysis attempts to discover. Thus, the ultimate criterion in choosing a method or choosing a solution when several methods are tried, may well be a value judgment. It may be permissible, advisable, or simply necessary to choose the
method that produces the solution most meaningful and useful to the researcher (Bonner, 1964).

In terms of the present study, the search for the "most meaningful" solution is made easier by the fact that it is possible to translate clustered data into a form of graphic presentation that is more familiar and interpretable than cluster maps in and of themselves. Because the map identifies each member within a given cluster, one can obtain cluster means for the MMPI clinical scales and so plot mean profiles for each group. Visual comparison of the mean profiles produced by the different methods gives immediate information on the similarity or difference of the cluster solutions, aiding in the determination of which clusters hold up over different methods, and are therefore likely to represent actual differences between groups, rather than being artifacts of a particular algorithm. The use of mean profiles permits clinical judgment and experience to enter into the decision making since profiles provide the most direct way of describing the personality characteristics of subgroups of hypertensives, which is one of the chief aims of the study.

The use of mean profiles has been recommended as a way of ameliorating the problems inherent in the single case or the small sample (Goldberg, 1972). However, it is also true that taking the mean of several profiles and using it to represent the many may be dangerous in that one may come up with an "average" profile that does not look particularly like any one person in the group. Since the goal of this study is in part to obtain hypertensive
subtypes which are clinically useful, the analysis excluded clusters that were too small to be considered stable.

Following Goldstein and Linden (1969) and Lorr, Klett, and McNair (1963), only clusters with four or more members were retained for consideration. At the same time, the upper limit was kept as low as possible, given the limits of the actual cluster solution, on the assumption that the mean of a relatively small group would be more likely to accurately represent that group in a clinical as well as a statistical sense.

While similarity among the four clustering solutions was expected, and could be validated by comparing profile shape, elevation and scatter, it was not expected that the solutions would be identical. Based on profile comparison and comparison of the graphic and statistical information given by the four methods, the solution that appeared to yield the most representative and clinically meaningful set of clusters was selected and used as the basis of further analysis.

**Discriminant Analysis**

The resulting validated clusters were subjected to discriminant analysis to assure that distances between groups were statistically significant (Tatsuoka, 1971). Additionally, the discriminant functions provided information on the relative contribution of each of the MMPI scales to group differences.

Finally, the validated MMPI clusters were used as the classification variable in a discriminant analysis of the entire data set, to determine if linear combinations of the physiological
variables could discriminate among the psychological subgroups, and correctly assign members to the predicted group (Huberty, 1984). As with the MMPI clusters, the discriminant functions also provided information on the relative contribution of various physiological variables to those functions.

With these analyses, it should theoretically be possible to make statements about the effects of psychological subgroup membership relative to differing physiological phenomena. The discovery of significant between group differences will be taken as evidence for the existence of discrete subgroups or types of essential hypertension, each with an observable pattern of psychological and physiological characteristics.
CHAPTER IV

Results

This CHAPTER presents the results of the data analysis and will be organized into the following sections: (a) sample characteristics; (b) hierarchical cluster analysis of the MMPI profiles using Ward's, Average Linkage, Centroid and Johnson's clustering procedures; (c) comparison of the clustering solutions yielded by these four procedures and selection of the most representative solution for further analysis; (d) discussion of the empirically derived MMPI profile subtypes, including configurational interpretations and descriptive data; (e) discriminant analysis of the MMPI profile subtypes; and (f) discriminant analysis of the physiological variables using the MMPI subtypes as the grouping variable.

Sample

The sample consisted of 73 middle class caucasians diagnosed as being mildly to moderately hypertensive. There were 44 males (60% of the sample) and 29 females (40%). Mean blood pressure was 141/93 mm Hg., with systolic pressures ranging from 111 to 177 mm Hg. and diastolic pressures from 72 to 112 mm Hg. There were no significant differences between males and females on these measures.
Figure 2 depicts the mean MMPI profile for the total sample. Table 1 provides descriptive statistics on the physiological variables.

Table 1
Sample Means, Standard Deviations and Probabilities for Physiological Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>SD</th>
<th>Prob&gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSHI</td>
<td>174.37</td>
<td>106.92</td>
<td>147.58</td>
<td>141.93</td>
<td>0.015</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>418.47</td>
<td>410.48</td>
<td>415.36</td>
<td>147.27</td>
<td>0.815</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>174.75</td>
<td>136.38</td>
<td>159.51</td>
<td>97.50</td>
<td>0.260</td>
</tr>
<tr>
<td>HDL</td>
<td>46.95</td>
<td>55.17</td>
<td>50.22</td>
<td>12.62</td>
<td>0.770</td>
</tr>
<tr>
<td>LDL</td>
<td>147.14</td>
<td>145.35</td>
<td>146.42</td>
<td>32.94</td>
<td>0.392</td>
</tr>
<tr>
<td>Pulse</td>
<td>81</td>
<td>79</td>
<td>80</td>
<td>10</td>
<td>0.022</td>
</tr>
<tr>
<td>Age</td>
<td>44</td>
<td>48</td>
<td>46</td>
<td>10</td>
<td>0.308</td>
</tr>
<tr>
<td>Percentage of Ideal Weight</td>
<td>123</td>
<td>140</td>
<td>130</td>
<td>28</td>
<td>0.007</td>
</tr>
</tbody>
</table>
Figure 2. Mean MMPI Profile for the Sample
Hierarchical Cluster Analysis

The K-corrected T-scores of the 73 MMPI profiles in the sample were subjected to Ward's, Average Linkage, Centroid and Johnson's hierarchical clustering procedures. The following cluster solutions were obtained.

Ward's method Three distinct MMPI subtypes were derived with all 73 observations being clustered. The third iteration appeared to be optimal since above this point profiles merged into very large groups that were likely to be insensitive to individual differences, while below this point the groups that were formed tended to form a continuum with relatively little distinction from one group to the next. Figure 3 shows the mean MMPI profiles for the three subtypes. For purposes of comparison, the mean profiles from the second iteration, containing two subtypes, is shown in Figure 4. Appendix A contains the RMS STD statistics and the CCC plot for Ward's method.
Figure 3. Ward's Method, Third Iteration
Figure 4. Ward's Method, Second Iteration
**Average Linkage Method.** Two separate subtypes were derived, with 71 observations clustered. The fourth iteration was selected as optimal since earlier iterations merely dropped one observation each, leaving one extremely large cluster. Below the fourth iteration new clusters were too small to be considered stable, following the criteria that any cluster accepted must have more than four observations. Figure 5 shows the mean MMPI profiles for the resulting two subtypes. RMS STD statistics and the CCC plot are found in Appendix B.

**Centroid method.** Because of its sensitivity to extreme cases, use of the Centroid method produced a pattern of successive iterations consisting of one very large cluster, with remaining clusters containing one observation each. The third iteration appeared statistically optimal, but as can be seen from Figure 6, it provided a single mean profile very similar to that of the mean for the entire sample, before clustering (see Figure 2). Appendix C contains RMS STD statistics and the CCC plot.
Figure 5. Average Linkage Method
Figure 6. Centroid Method
Johnson's method. Two separate subtypes were derived, with 72 observations being clustered. The third iteration appeared to be the best cut off point. The first iteration, as always, yielded one large cluster, consisting of all the observations. The second iteration produced clusters with N's of 72 and 1. Below the third iteration, cluster profiles split into groups that were less distinctive and useful for practical application. Figure 7 shows the mean MMPI profiles for the two subtypes that emerged. The distance ratios can be found in Appendix D.

Comparison and Validation of Clustering Solutions.

In comparing the mean profiles in Figures 3 through 7, the cluster solutions obtained showed considerable similarity, increasing the likelihood that these clusters represent actual subtypes within the larger population. Although the Centroid method yielded only one large, rather uninformative cluster, the two or three clusters derived from each of Ward's, Average Linkage and Johnson's methods produce mean MMPI profiles that are consistent with respect to shape, elevation and scatter.

All three methods yield one relatively small cluster characterized by profile elevations on scales 8-7 and 2-1-3. The Average Linkage, Johnson's and one of Ward's solutions also each yielded a second, larger cluster, the profile of which is essentially within normal limits and quite similar on scales 1 through 8. Differences emerged on scale 9, where Average Linkage shows a marked elevation, suggestive of much higher energy or activity levels.
Figure 7. Johnson's Method, Third Iteration
Because of this difference, which is clinically important from a psychological perspective, and also theoretically significant in light of connections between motor activity and levels of catecholamine and renin, and also because the second cluster is so large, the Ward's three-cluster solution appears to be most heuristically interesting. In this solution, the large second group is differentiated into two smaller ones with differences in the relative elevations of scales 4, 8, 9 and 0. One profile is indicative of high energy and some degree of impulsiveness, imagination or capacity for abstract thought and sociability, while the other profile suggests opposite tendencies.

Ward's three-cluster solution thus appears to be most useful for clinical purposes as well as most representative of the underlying structure of the data. As additional support for choosing this solution for further analysis, the literature recommends it as the best of the hierarchical clustering procedures. It is, in fact, the default option for SAS cluster analysis programs, a further indicator of its power and reliability.

Profile Subtypes: Configural Interpretations and Physiological Characteristics

In this section, the three empirically derived MMPI subtypes are described. Interpretations for each profile are drawn from Webb, McNamara and Rodgers (1981) and Greene (1980), and represent an integration of descriptive statements for various high-point codes and for specific elevations of individual scales, as well as the researcher's own experience with the MMPI. Profile interpretations
are accompanied by descriptive statistics on the size, sexual composition, and physiological variables for each group.

Subtype I. This group consisted of 46 individuals, 31 of whom were male (66%) and 15 female (34%). Figure 8 shows the mean MMPI profile. Means and standard deviations for each of the physiological variables are given in Table 2. The profile is seen as a mild peak 9.

The profile for Subtype I is within normal limits, which usually indicates an absence of severe psychopathology. Mild elevations on certain scales, as well as the overall configuration, suggests characteristic personality features and behavioral tendencies which are likely to be rather well established and consistent over time. Individuals with similar profiles are usually seen as energetic, socially versatile and generally able to mobilize their resources in the service of their aims. They frequently have a good opinion of themselves and strive for independence and status, often quite competitively. Such individuals dislike delays, restrictions and external authorities and may be quick to perceive conflict in situations. Although basically open and friendly, they also tend to be somewhat self centered, with an impulsivity that can cause problems in interpersonal relationships. When things go as they wish, they are likely to be outgoing and enthusiastic, in the face of frustration however, they can become irritable, resentful, and given to mild acting out, with rationalization employed as a defense mechanism.
Figure 8. Mean MMPI Profile for Subtype 1
Table 2
Means and Standard Deviations of Physiological Variables
for MMPI Subtype I

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSHI</td>
<td>139.93</td>
<td>119.98</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>445.52</td>
<td>153.95</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>163.37</td>
<td>97.13</td>
</tr>
<tr>
<td>HDL</td>
<td>49.35</td>
<td>13.97</td>
</tr>
<tr>
<td>LDL</td>
<td>148.35</td>
<td>33.58</td>
</tr>
<tr>
<td>Pulse</td>
<td>80</td>
<td>11</td>
</tr>
<tr>
<td>Age</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>% Ideal Weight</td>
<td>126</td>
<td>21</td>
</tr>
</tbody>
</table>

Subtype II. This group numbered 16. With nine females (56%) and seven males (44%), it was the only group with a preponderance of women. The mean MMPI profile is shown in Figure 9. Means and standard deviations for the physiological variables appear in Table 3.

The profile for Subtype II, like the previous one, is within normal limits. The personality characteristics and expected behavioral tendencies here, however, run in rather opposite directions. Individuals with profiles similar to this are likely to be quiet, steady, conforming and even overly compliant in their dealings with others. They tolerate sameness and boredom well and
manifest few conflicts with authority. Conscientious about the performance of responsibilities, they often take on very realistic, practical stance. Although their judgment is good and they may actually desire recognition, they lack the energy, self-confidence and assertiveness to put forth their views effectively. Such persons tend to be hesitant to become involved in interpersonal relationships, especially in new and unfamiliar situations. They appear to be withdrawn and aloof, which is frequently the result of shyness, self-deprecation and social inadequacies. With some, it is a matter of low energy levels and an adjustment to the status quo, with low motivation to change and a preference for being alone or dealing with a small circle of known friends. This profile may be characterized as a mild 0/2 code type.
Figure 9. Mean MMPI Profile for Subtype II
Table 3
Means and Standard Deviations of Physiological Variables for MMPI Subtype II

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSHI</td>
<td>167.94</td>
<td>202.97</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>358.38</td>
<td>130.27</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>140.56</td>
<td>98.82</td>
</tr>
<tr>
<td>HDL</td>
<td>51.19</td>
<td>10.53</td>
</tr>
<tr>
<td>LDL</td>
<td>145.13</td>
<td>28.46</td>
</tr>
<tr>
<td>Pulse</td>
<td>79</td>
<td>10</td>
</tr>
<tr>
<td>Age</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>% Ideal Weight</td>
<td>134</td>
<td>42</td>
</tr>
</tbody>
</table>

Subtype III. This group consisted of 11 individuals, six of whom were male (55%) and five female (45%). The mean MMPI profile appears in Figure 10, means and standard deviations for the physiological variables in Table 4. The high point code is 8-7/2-1-3.

In contrast to the other two groups, the profile of subtype III suggests considerable psychic distress with physical involvement. Individuals with similar profiles are characterized by anxiety, tension, depression, easy fatigability, and difficulties in concentration. They worry a great deal and tend to be fearful and
irritable, in a complaining, whiny fashion. In interpersonal relations, they are likely to be shy, socially uncomfortable and lacking in confidence. Although they feel a need for social support, they are not good at securing it. It is usually difficult for such people to form close personal attachments and when they do, their relationships are beset with problems centering around the inappropriate expression of hostile feelings and dependency needs, with demandingness, ego-centricity and expectations of rejection apparent. With such limited resources, they often withdraw into fantasy, which exasperates obsessive rumination. Although conscientious, they tend to be highly self critical; inefficiency of thinking and behavior are seen in life histories marked by underachievement and inability to cope with everyday stress and responsibility.

These individuals often report that it is difficult to relax and frequently develop a variety of tension symptoms, including hypertension. There is an overconcern with bodily function, an overreaction to illness and injury, and often the development of a wide variety of psychophysiological ailments.

The basic personality functioning of such persons tends to be deeply engrained and resistant to change. Physical complaints and identification with the sick role may persist because they offer a means of maintaining a defense against emotional problems with which they feel unable to cope.
Figure 10. Mean MMPI Profile for Subtype III
Table 4
Means and Standard Deviations of Physiological Variables
for MMPI Subtype III

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSHI</td>
<td>149.95</td>
<td>132.40</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>372.09</td>
<td>112.33</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>170.91</td>
<td>102.75</td>
</tr>
<tr>
<td>HDL</td>
<td>52.45</td>
<td>9.66</td>
</tr>
<tr>
<td>LDL</td>
<td>140.27</td>
<td>38.27</td>
</tr>
<tr>
<td>Pulse</td>
<td>79</td>
<td>7</td>
</tr>
<tr>
<td>Age</td>
<td>46</td>
<td>11</td>
</tr>
<tr>
<td>% Ideal Weight</td>
<td>136</td>
<td>28</td>
</tr>
</tbody>
</table>

**Discriminant Analysis of MMPI Profiles**

Using the three subtypes, represented by the mean MMPI profile for each subtype, as the classification variable, a discriminant analysis was performed on the profiles. The purpose was to discover if there were linear combinations of MMPI scales that discriminated among subtypes, and the relative contribution of individual scales to those functions, as well as the functions' classificatory power.
Two discriminant functions were obtained that accurately classified all 73 cases into the predicted group (See Table 5).

**Table 5**

Classification Results for Discriminant Analysis of MMPI Profiles

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Cases</th>
<th>Predicted 1</th>
<th>Group 2</th>
<th>Membership 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>46</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0%</td>
<td>100%</td>
<td>0.0%</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 6 gives the statistics for the discriminant analysis, showing the percentage of total variance accounted for by the Eigenvalue value associated with each function.

**Table 6**

Statistics for Discriminant Analysis of MMPI Profiles

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>Percent of Variance</th>
<th>Wilks' Lambda</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0424</td>
<td>57.60</td>
<td>0.131304</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>1.5033</td>
<td>42.40</td>
<td>0.399476</td>
<td>0.000</td>
</tr>
</tbody>
</table>
The standardized discriminant function coefficients, showing the relative contribution of each scale to each of the functions are presented in Table 7. The most heavily weighted scales or discriminant functions are 0 (negatively), and 9 (positively), with moderate positive weightings on scales 4 and 5.

Table 7
Standardized Canonical Discriminant Function Coefficients

<table>
<thead>
<tr>
<th>Scale</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.2575</td>
<td>0.2696</td>
</tr>
<tr>
<td>2</td>
<td>-0.0252</td>
<td>0.3902</td>
</tr>
<tr>
<td>3</td>
<td>-0.2323</td>
<td>-0.1808</td>
</tr>
<tr>
<td>4</td>
<td>0.5646</td>
<td>0.2585</td>
</tr>
<tr>
<td>5</td>
<td>0.4966</td>
<td>0.0092</td>
</tr>
<tr>
<td>6</td>
<td>0.2675</td>
<td>0.0865</td>
</tr>
<tr>
<td>7</td>
<td>-0.2072</td>
<td>0.3647</td>
</tr>
<tr>
<td>8</td>
<td>0.0328</td>
<td>0.5764</td>
</tr>
<tr>
<td>9</td>
<td>0.7033</td>
<td>-0.0703</td>
</tr>
<tr>
<td>0</td>
<td>-0.7313</td>
<td>-0.3498</td>
</tr>
</tbody>
</table>

This function may be viewed as a continuum with one pole representing characteristics indicated by an elevated 9 scale, a lowered scale 0, and slight elevations on scales 4 and 5. The other
pole is characterized by a lowered 9 scale, relatively lowered 4 and 5 scales, and an elevated scale 0. For purposes of identification in the context of this study, the continuum has been labeled Social Orientation, although such a label does not comprehend the totality of qualities implied in the continuum, nor necessarily the most important.

The first pole, to which Subtype I is closest, suggests greater energy, self confidence, sociability and impulsivity, with some mild conflict between dependency needs and rebelliousness. The opposite pole, to which Subtype II is closest, suggests a quiet, somewhat withdrawn personality, low in energy and self confidence, likely to be compliant and overly controlled. Subtype III falls between Subtypes I and II, but closer to II, indicating that members of this group share some characteristics with members of Subtype II. It would appear, however, that discriminant function 1, by itself, is less efficient at discriminating Subtype III from the other two subtypes.

The most heavily weighted scales on discriminant function 2 are scales 8, 2 and 7, all positively. On the continuum formed by this function, labeled distress, the characteristics represented by one pole would be those attributed to an elevated score on scale 8 with somewhat lower elevations on scales 2 and 7. The other poles would be characterized by low scores on the same three scales.

The first pole, to which Subtype III is closest, suggests alienation, anxiety and depression, with features of self dissatisfaction, pessimism, obsessive rumination and confusion. The
opposite pole indicates relative freedom from anxiety and worry, with a practical, realistic outlook conducive to good social/vocational functioning, and no strong subjective feelings of unhappiness or dissatisfaction. Subtype II is closest to this pole, with Subtype I occupying a position roughly midway but closer to II. Members of Subtypes I and II, then, would appear to demonstrate a higher degree of competence on social/vocational functioning, with lower levels of psychic distress.

Figure 11 visually illustrates the relative location of group centroids, the central point about which each subtype would cluster. The placement of centroids relative to the two axes of the graph suggests that the functions capture independent constructs, with function 1 better at discriminating Subtypes I and II, and function 2 useful primarily at discriminating Subtype III.

**Discriminant Analysis of Physiological Variables**

A second discriminant analysis was performed to discover if linear combinations of the physiological variables could be found which would accurately predict subtype membership.

The two discriminant functions obtained accurately classified 46 or 63% of the 73 cases. As seen in Table 8, a large percentage of the members of Subtype I were correctly assigned. Classification accuracy dropped sharply for Subtypes II and III, with most of the members of those two subtypes incorrectly assigned to Subtype I.
Figure 11. Location of Subtype Centroids with Relative Placement on Functions 1 and 2
### Table 8
Classification Results
for Discriminant Analysis of Physiological Variables

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Cases</th>
<th>Predicted Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>42 3 1</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>91.3% 6.5% 2.2%</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>11 4 1</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>68.8% 25.0% 6.3%</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>8 3 0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>72.7% 27.3% 0.0%</td>
</tr>
</tbody>
</table>

The statistics for the discriminant analysis, showing percentage of total variance accounted for by the Eigenvalues associated with each function are shown in Table 9. The significance levels indicate that linear combinations of the physiological variables investigated in this study do not discriminate subtypes well.

### Table 9
Statistics for Discriminant Analysis of Physiological Variables

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>Percent of Variance</th>
<th>Wilk's Lambda</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2068</td>
<td>89.42</td>
<td>0.808859</td>
<td>0.7291</td>
</tr>
<tr>
<td>2</td>
<td>0.0245</td>
<td>10.58</td>
<td>0.976128</td>
<td>0.9910</td>
</tr>
</tbody>
</table>
The standard discriminant function coefficients are presented in Table 10. Given the very weak discriminatory power of these functions, the following interpretation is made, and should be viewed, with caution.

The most heavily weighted variables on discriminant function 1 are catecholamines (negatively) and RSHI and sex (positively). Viewing this function, which accounts for nearly 90% of the variance obtained, as a continuum, one pole represents a physiological state in which catecholamine levels are low relative to RSHI levels, and the individual is more likely to be female. The opposite pole represents catecholamine levels that are high relative to RSHI levels, and an expected preponderance of males. This continuum has been labeled arousal. Although all three subtypes are clumped rather closely around the mid point, (see Figure 12), Subtype II appears to be almost to the first pole, which is suggestive of low excitability and activity and a possible tendency to be controlled, submissive, somewhat guilt prone and reluctant to express aggression. Subtype II was in fact the only group with a majority of females. Subtype I which was 66% male, is closest to the second pole, which suggests higher excitability and arousal levels and probably a greater willingness to express aggression.
Table 10
Standardized Canonical Discriminant Function Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSHI</td>
<td>0.6219</td>
<td>-0.2581</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>-0.7731</td>
<td>-0.0302</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>-0.0761</td>
<td>0.5672</td>
</tr>
<tr>
<td>HDL</td>
<td>0.2137</td>
<td>0.7051</td>
</tr>
<tr>
<td>LDL</td>
<td>-0.1426</td>
<td>-0.3005</td>
</tr>
<tr>
<td>Pulse</td>
<td>-0.0941</td>
<td>-0.2040</td>
</tr>
<tr>
<td>Age</td>
<td>0.2363</td>
<td>-0.1880</td>
</tr>
<tr>
<td>Sex</td>
<td>0.4568</td>
<td>-0.5511</td>
</tr>
<tr>
<td>% Ideal Weight</td>
<td>0.1600</td>
<td>0.6336</td>
</tr>
</tbody>
</table>

Discriminant function 2 accounts for a very small percentage of the Variance. The most heavily weighted variables are HDL, percentage of ideal weight and triglycerides(all positively). At one pole of the continuum labeled overweight, one would expect to find individuals who are well over their ideal weight, with high blood cholesterol and triglyceride levels. The other pole would represent persons who weigh in closer to the ideal range for their height.

As seen in Figure 12, all three subtypes are located closely together around the mid-point. It would appear that variables associated with obesity discriminate in some small way, with members
of Subtypes II and III most likely to be obese and/or to have high cholesterol levels.

Figure 12. Location of Subtype Centroids With Relative Placement on Functions 1 and 2
CHAPTER V
Summary and Discussion

The purpose of this study was to investigate a sample of mild to moderate essential hypertensives to see if significantly different subtypes existed that varied systematically on the basis of characteristic psychophysiological patterns.

The study was performed on a sample of 73 adult caucasian patients served by the Family Practice Center of Riverside Methodist Hospital. Subjects were between the ages of 25 and 64, with a mean age of 46. There were 44 males and 29 females. Blood pressures were between 111/72 to 177/112 mm. Hg, with mean pressures of 141/93 mm. Hg.

Three weeks after discontinuation of anti-hypertensive medication, and barring adverse health effects, subjects underwent a protocol that included measurement of plasma renin activity, urine creatinine, plasma catecholamines, triglycerides and cholesterol levels, and an administration of the MMPI. Lachar's (1974) rules were applied to the three validity scales with profiles judged valid retained in the sample. The ten K-corrected clinical scales were used in the analysis.

Statistical analysis consisted of several steps. The MMPI scores for the 73 subjects were subjected to cluster analysis using four
different hierarchical procedures: Ward's, Average Linkage, Centroid
and Johnson's. The resulting clustering solutions were compared on
the basis of cluster maps, CCC plots and statistical output.
Additionally, mean MMPI profiles for the obtained clusters were
graphed and compared visually. The emergence of similar clustering
solutions and mean MMPI profiles was accepted as a validation of the
clusters, or psychological subtypes, obtained, and of the method
itself. Based on these comparisons, the solution that appeared to
yield the most representative and clinically meaningful set of
subtypes was selected and used as the basis of further analysis.

The three MMPI subtypes selected were described in terms of
actuarial interpretive statements. They were then subjected to
discriminant analysis, both as a test of statistical significance and
to provide information on the relative contribution of individual MMPI
scales to subtype differences. Finally, a second discriminant
analysis was performed to determine if linear combinations of the
physiological variables could discriminate among the three
psychological subtypes and correctly assign subjects to the predicted
group.

The findings indicate that cluster analysis can be used to
identify three distinct psychological subtypes represented by
characteristic MMPI profiles. The profiles of two of the subtypes
were essentially within normal limits, with no severe psychopathology
evident. The configurations did suggest, however, the presence of
fairly stable personality features and behavioral tendencies.
Subtype I (N=46), with a slight overrepresentation of males, consisted of extroverted, energetic, self-confident and somewhat competitive individuals who dislike restrictions and may become easily frustrated. Subtype II (N=16) was predominantly female and was characterized by quiet, steady compliance, some deficiency of confidence and assertiveness, with self-effacement and discomfort in social situations.

In contrast, Subtype III (N=11) was suggestive of significant psychopathology. With an equal representation of males and females, this group consisted of individuals who are highly stressed and suffer from depression, anxiety and tension, with a proneness to develop psychophysiological illnesses. They are inefficient and ineffective in social/vocational activities and find it difficult to form or maintain satisfying interpersonal relationships.

Discriminant analysis of the MMPI subtypes yielded two discriminant functions that correctly classified 100% of the cases, indicating that differences among the three subtypes were statistically significant. On the first function, scales 9, 0, 4 and 5, respectively, contributed most heavily to a linear combination forming an axis labeled Social Orientation, that seemed most useful for discriminating between Subtypes I and II. A second function utilized scales 8, 2 and 7 primarily, to produce a linear combination labeled Distress that differentiated Subtype III from I and II.

The discriminant analysis of physiological variables failed to achieve significance and had poor classification accuracy. Of the two
functions obtained, one labeled Arousal accounted for almost 90% of the variance and indicated that a combination of high catecholamines and low RSHI levels may have some limited power to discriminate Subtype I, while low catecholamines and high RSHI were more closely associated with Subtype II. The second function suggested that variables having to do with being overweight are very slightly associated with Subtype III.

This study was done in the hope of discovering psychophysiological subtypes of essential hypertension. In this respect, the findings are weak, although supportive in some ways of past research, and suggestive of future research directions. Nevertheless, the results do offer some interesting contributions to the literature, chief of which are: (a) the illustration and validation of cluster analytic techniques in typological research; (b) the discovery within a fairly homogeneous population of three subtypes with distinct psychological characteristics, that in many ways may account for conflicting findings in past personality research on hypertensives; and (c) suggestions for the development of differential treatment approaches, based on subtype differences and aimed at modifications in behavior that may be beneficial in themselves and very possibly result in decreases in blood pressure.

The application of clustering procedures to psychological data will in all likelihood yield subgroups, merely because of the heterogeneous nature of such data. In this study, the fact that several different clustering procedures yielded mean cluster profiles
with a high degree of similarity in profile shape, elevation and scatter indicates that the subgroups derived do represent stable underlying differences. It is also true that these techniques have their limitations. They are a useful first step in exploring data; however, the better the knowledge and understanding of the population under study, the more accurate subsequent interpretations are likely to be. When cluster analysis is used with psychometric instruments that yield profiles, experience in the interpretation of those profiles is essential. Cluster analysis is more a descriptive than a purely analytical technique, that can, with the help of informed judgment, be used to initially identify subgroups; other statistical procedures are needed to determine the significance of the differences found.

Results of the discriminant analysis indicate that differences between subtypes are statistically significant. Visual inspection of the mean MMPI profiles of these three groups shows clinical significance as well. The three profiles differ markedly in elevation and configuration. A continuum of basically similar psychological characteristics that vary only quantitatively is not suggested. Instead, members of these subtypes would be expected to demonstrate widely divergent coping styles, interpersonal relating, social and vocational efficacy and general personality functioning.

I and II, which comprise the large majority of the sample, produced subclinical profiles, indicating that whether or not personality features play a role in the development and
maintenance of hypertension, neither the features nor the illness were creating a major mental health problem. The issue of just what role personality does play in their illness is open to question and research. The third small group, Subtype III, demonstrated significant psychopathology, at least psychometrically. It is unlikely that hypertension per se would generate such dysfunction. It is possible that the dysfunction plays some etiological role, and probable that both dysfunction and illness are interrelated responses in a broader clinical picture and both influenced by intervening variables.

Past personality research in hypertension has been notable for its lack of consistency. The classic description of "the hypertensive personality" (Alexander, 1939; Dunbar, 1939) stressed features of inhibition, overcontrol, and conscientiousness in a fairly high functioning person, who nevertheless had authority problems and occasional outbursts of anger. Behavior was supposedly shaped by an underlying conflict between dependency needs and aggressiveness. The hypertensive was uncomfortable in expressing anger out of fear of rejection.

Within each of the three subtypes, one can see some of these features, but no one profile captures the entire definition. Subtype II comes closest, with a general picture of overcontrol, compliance and low energy which may bespeak inhibition. The only evidence of suppressed anger lies in a slight relative elevation of scale 2, which may indicate inwardly directed anger or dissatisfaction. Non-assertiveness is commonly thought to produce built up resentment which
eventually erupts (the turning worm phenomenon), but this behavior in Subtype II can only be conjectural in light of actual profile data.

Subtype III offers more evidence for strong dependency/hostility conflicts, and it is easy to imagine persons with this profile displaying an erratic pattern of overcontrol and acting out. However, the overall picture does not evoke images of the steady, doggedly conscientious and basically effective person hypothesized by Alexander.

Research with the MMPI in this area does not report great differences between hypertensives and normotensives, but it should be remembered that these studies were conducted on hypertensives as a single group, with little attention paid to the possibility of subtypes. There are repeated findings of elevations, usually in the low clinical range, on scales 1, 2, 3, 4, and 7, suggestive of general distress in the form of anxiety, neuroticism and acting out (Brower, 1947; Innes et al., 1959; Lewinsohn, 1956; Nalibogg et al., 1983; Ostfeld and Lebovits, 1960).

A similar pattern was found in Subtype III. The fact that this was a very small group explains why this pattern might be easily overlooked or why findings might be nonsignificant in studies that lump all hypertensives indiscriminantly. The relative size of Subtype III versus Subtypes I and II is consistent with conclusions drawn by Sainsbury (1960) and Robinson (1962) that hypertensives as a whole are not an especially neurotic or anxious group.

More recent research has paid closer attention to anger in hypertension, both in terms of refining the concept and in questioning
whether it is an important feature in the personalities of all hypertensives. In a series of studies conducted by Harburg and associates (Esler et al., 1977; Gentry et al., 1973, 1982; Harburg et al., 1973), "anger-in", or hostile feelings that were recognized but suppressed, was clearly associated with rises in SBP, DBP and with overall incidence of hypertension. However, other hypertensives were found to score high on a measure of "anger-out", meaning that they were not all unwilling, and in fact overready, to express hostility overtly (Harburg et al., 1979).

The profile for Subtype I, with characteristics of rebelliousness, impulsiveness, quickness to perceive conflict, irritability when frustrated, coupled with extroversion and higher available energy is easily reconciled with an "anger-out" style. Subtype II is more suggestive of "anger-in", although, as has been commented on earlier, while members of this group tend to hold things in, there is some question as to whether the thing being held in is anger.

Wolf and Wolff (1951) also noted two characteristic patterns of behavior in hypertensives that seem consistent with Subtypes I and II. The majority were outwardly easgoing and sociable but inwardly tense, vigilant and quick to take offensive action rather than to reflect. Others were restrained, placating and more reflective.

While discussion of anger in hypertension has focused on suppression and expression, a further way of dealing psychologically with aversive states is repression. That is, to deny them to the point of unawareness. Subtype II in some ways presents a picture of
bland, nonreactive detachment, a form of defense that may be very effective in controlling blood pressure, but one that also implies repression.

Weiner et al. (1962) discovered that as long as hypertensives could maintain cognitive distance their BP stayed level, but when this defense failed critical elevations occurred. Sapira et al. (1971) similarly demonstrated a facility in hypertensives for screening out threatening perceptions. Older hypertensives, especially, tend to insulate themselves by limiting social interaction (Berglund et al., 1975). A tendency to deny life stress and problems has also been found to characterize older hypertensives (Cumes, 1983; Linden and Feuerstein, 1983). The possibility exists that members of Subtype II—the oldest of the three groups—are not struggling with suppressed anger, but have habitually repressed hostile feelings and other aversive stimuli for so long they have become unaware of the presence of such threats to their composure. This condition could make it easier for them to maintain their typically nonassertive stance. In light of Weiner et al.'s (1962) statement regarding the failure of defenses resulting in higher blood pressures, and considering that weakened defenses also result in distress and psychological symptoms, it is interesting to speculate that some members of Subtype III represent "failed" Subtype II's.

Turning to the interaction of psychology with physiology, the second discriminant analysis was intended to investigate the possibility of patterns of association between physiological factors and the three psychological subtypes. As reported, the two functions
failed to reach significance and were very poor predictors of subtype membership. The analysis did indicate that a combination of catecholamines, RSHI and possibly gender could account for nearly all of the variance obtained. Although this finding cannot, with any degree of rigor, be offered as evidence for a distinct psychophysiological subtype as hoped, it does offer some support for earlier findings.

Esler et al. (1977) reported a link between high plasma renin activity, high plasma catecholamines, specifically norepinephrine, and a tendency to be controlled, guilt prone, submissive and unwilling to express anger. Heightened norepinephrine was thought to be an indicator of sympathetic nervous system activity as a potential causal factor in a particularly "neurogenic" type of essential hypertension. In the present study high RSHI, in females, was associated with Subtype II, whose members could be expected to show the psychological characteristics found by Esler. However, in this group catecholamines were not elevated. High catecholamines and low RSHI were most likely to be found in Subtype I, whose members would probably not be seen as controlled, submissive or especially guilt prone.

The high renin-high norepinephrine findings (Esler et al., 1977) were based on a male only sample, however Engelman, Portnoy and Sjoerdsm (1970) found that approximately 25 - 30% of all hypertensives showed increased norepinephrine levels and that these were predominantly women. Generally speaking, the connection between renin activity and catecholamines has not been found to be very
strong, possibly because of the complexity of any research involving neurotransmitters (DeQuattro & Miura, 1973). Elsewhere, studies of catecholamines have been conducted with regard to hemodynamic patterns.

High epinephrine concentrations and other indicators of sympathetic activity were found by Nestel (1969) in younger persons with labile hypertension. Eich et al. (1962) similarly found epinephrine in young, labile hypertensives with a high cardiac output/low peripheral resistance pattern. High cardiac output was also associated with elevations in all catecholamines and also with increased motor activity and a readiness to react to stress with the classic fight or flight response (Surwit et al., 1982). The MMPI profile of Subtype I, and in some ways that of Subtype III are indicative of increased motor activity, impulsiveness and sensitivity to threat. Subtype I, moreover, had the highest catecholamines and youngest mean age, and Subtype III the next highest catecholamine elevations. It is possible that some of the members of these two groups might also have shown high cardiac output and/or labile forms of hypertension if these variables had been included in the investigation.

Subtype II, on the other hand, appears to at least partially fit a pattern of findings that links high peripheral resistance/low cardiac output, older persons with established rather than labile hypertension, norepinephrine (but not epinephrine) concentrations,
decreased motor activity, a tendency to hesitate before taking action and a preference for a detached, appraising stance.

In order to test these hypotheses, it would have been necessary to measure catecholamines separately, to distinguish labiles from non-labiles and those with differing hemodynamic patterns, and to control for age and sex. Looking at what did and did not emerge from this study, a major conclusion drawn is that, if psychophysiological associations and interactions are sought, more careful attention must be given to physiology. A larger number of physiological variables should be included, and they should be more precisely measured and controlled.

Implications for Treatment

The standard therapy for hypertension relies almost exclusively on pharmacology and consists of a program of "stepped care" in which a series of medications are prescribed, additively, beginning with a diuretic, progressing through one or two beta-blockers, and finally alpha adrenergic blockade. At each stage the patient is monitored to see if control has been achieved. This approach is estimated to be effective for only about 50 percent of mild to moderate cases (Rudy, Lewis and Tosi, 1984).

Lack of success is usually attributed to noncompliance with the regimen, either because of a failure of education or because of unpleasant side effects of the drugs. Even where compliance is good, however, approximately one-fourth of cases remain uncontrolled. Behavioral and environmental factors may be significant in drug resistant hypertension. Behavioral treatment has largely focused on
relaxation, biofeedback, and other techniques designed to lower autonomic arousal, and by themselves have also proven inadequate for controlling blood pressure (Luborsky, 1982).

An approach combining behavioral intervention with pharmacology seems logical. A number of group and individual strategies could be designed to improve compliance, to reinforce beneficial lifestyle changes having to do with diet, exercise, etc., and to alter individual traits, perceptions and behaviors that are thought to contribute to hypertension.

A basic model would be one that emphasizes self management. The role of the therapist is to motivate change and to provide the basic skills for achieving it, but places the responsibility on the person. An important component would be education on the role of stress in exacerbating hypertension. Whether stress is generated by environmental forces or by intrapsychic/interpersonal conflict, the hypertensive responds with marked elevations in BP that return to resting levels more slowly than in normotensives. Stress management would thus be therapeutic, if not curative.

Stress is a response to perceived threat; perceptions and subsequent emotional, physiological and behavioral responses vary with individuals. Coping strategies and defensive styles, which vary in different subtypes of hypertension, are a major intervening variable between perceptions and psychophysiological response. The greater the range and effectiveness in coping, ie., altering perceptions, assessing resources, problem solving, etc., the less likely that life events will result in stress and elevated BP.
If, as Baer et al. (1983) suggests, hypertensives learn in childhood to avoid conflict, which diminishes communication and does not permit the development of skills for conflict resolution, they may demonstrate in adulthood deficiencies in stress management.

Behavioral intervention with hypertensives, then, would involve several components. Relaxation techniques could aid in lowering autonomic arousal and in obtaining self control. Cognitive restructuring would help in reinterpreting threatening stimuli, and specific coping skills tailored to the personality makeup of the individual should facilitate desired behavioral change.

Persons with Subtype I characteristics might, for example, be taught to slow down and reflect before rushing to judgment and action, and to soften their aggressiveness into appropriate assertiveness. Subtype II individuals, who are too deferential and controlled, could be taught assertiveness, general communication and social skills, and confidence building exercises. Group approaches would probably work well for these kinds of psychoeducational strategies.

Persons with Subtype III characteristics suffer stronger fears of rejection and threats to security, with much less cognitive and emotional control, and more maladaptive functioning. Resistance to behavioral change would probably be high, initially. Individual psychotherapy, to develop a relationship of trust, in which dependency needs could be acknowledged, accepted and expressed appropriately, might be necessary before or in conjunction with psychoeducational, skill building techniques.
Limitations and Recommendations for Future Research

The hypertensive subjects under study were medical patients in treatment with physicians affiliated with an outpatient clinic of a large midwestern general hospital, located in an affluent quarter of a large midwestern city. In sociocultural terms, they were rather homogeneous, consisting of white, middle to upper middle class individuals diagnosed and treated for mild to moderate essential hypertension, who agreed to participate in the study. It was not possible, therefore, to make statements about hypertensive populations of other racial and socioeconomic backgrounds. The variables of age and sex were not controlled for, and given that the aim of the study was to investigate psychophysiological interactions, it now appears that the physiological variables included were too few, and perhaps, inadequately measured on their purpose.

Future studies should differentiate and control for lability versus stability of blood pressure, and duration of disease, and whether the hypertensives studied are characterized by high cardiac output or high peripheral resistance. Since changes in cardiovascular functioning occur against a backdrop of differing and individual blood pressure resting levels, baselines and fluctuation rates should be obtained for heart rate, SBP and DBP, peripheral resistance and cardiac output.

Such studies would require a large N, to enable proper control of these variables as well as of age and sex. Investigators should be
expect themselves, or have available to them specific expertise in the physiology of hypertension, in order to adequately interpret data and findings.

A further limitation of this study was that psychological data was limited to measurements provided by the instrument chosen: the MMPI. This instrument was designed to measure psychopathology, which it does well. Most hypertensives, however, produce subclinical profiles and do not manifest severe pathology. What they do manifest is a variety of traits that are expressed in a multiplicity of ways. Several other techniques exist for assessing behavioral and psychological characteristics and it may well be that a more appropriate instrument would be one that provides descriptive, behaviorally based information on traits and patterns shown by essentially healthy persons. The California Psychological Inventory and the Personality Research Form are two that might be considered.

Finally, future research should be aimed at validation, both by direct replication on other populations and by controlling for subtypes found in preliminary studies. Experiments should be conducted to evaluate the outcomes of different treatments approaches applied to different subtypes, whether they be the ones found in this study or other subtypes yet to be discovered.
APPENDIX A

Ward's Cluster Analysis:

Statistics and Cubic Clustering Criteria Plot
Table 11
Ward's Minimum Variance Hierarchical Cluster Analysis

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<th>Number of Clusters</th>
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Figure 13. Cubic Clustering Criteria Plot for Ward's Method
APPENDIX B

Average Linkage Cluster Analysis:

Statistics and Cubic Clustering Criteria Plot
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Figure 14. Cubic Clustering Criteria Plot for Average Linkage Method
APPENDIX C

Centroid Cluster Analysis:

Statistics and Cubic Clustering Criteria Plot
Table 13  
Centroid Hierarchical Cluster Analysis  

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Figure 15. Cubic Clustering Criteria Plot for Centroid Method
APPENDIX D

Johnson's Cluster Analysis:

Table of Distance Ratios
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Johnson's Hierarchical Cluster Analysis

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References

Alexander, F. (1939). Emotional factors in essential hypertension. *Psychosomatic Medicine, 1*, 139-152.


Esler, M., Julius, S., Zweifler, A., Randall, O., Harburg, E.,
Gardiner, H., & DeQuattro, V. (1977). Mild high renin essential
hypertension: Neurogenic human hypertension. The New
England Journal of Medicine, 296, 405-411.

Halsted Press.

at validation of traditional psychiatric syndromes by cluster

International Journal of Health Services, 5, 539-558.

Springfield, Ill.: Thomas.

procedures. Biometrika, 58, 91-104.

Gentry, W. D., Chesney, A. P., Gary, H. E., Hall, R. P., & Harburg, E.
(1982). Habitual anger-coping styles: Effect on mean blood
pressure and risk for essential hypertension. Psychosomatic
Medicine, 44, 195-201.

Gentry, W. D., Harburg, E., & Hauenstein, L. (1973). Effects of
anger expression/inhibition and guilt on elevated diastolic blood
pressure in high/low stress and black/white females. Proceedings
of the American Psychological Association, 115-116.


