Cardiovascular and Emotional Reactivity to Stress in Offspring of Hypertensives

Perry S. J. Adler

Department of Psychology

McGill University, Montreal

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Abstract

Psychological stress may be a risk factor for essential hypertension. While several variables have been implicated as mediators or moderators of the relationship between stress and high blood pressure, their exact roles and level of importance remain to be elucidated. A key moderating variable may be family history of hypertension. A series of five studies examined the cardiovascular and emotional reactions to stress of normotensive individuals with and without a parental history of hypertension. In an attempt to facilitate the generalizability of the results, the studies used stressors with greater ecological validity than those used in most previous studies of this topic. This aspect of the research aided the examination of a possible mediator of group differences in cardiovascular reactivity, i.e., emotionality. Several studies observed significant group differences in cardiovascular reactivity to stress, suggesting that stress may be more likely to contribute to the development of hypertension in those with a genetic predisposition for the disorder. However, the exaggerated cardiovascular responsivity of individuals with a parental history of hypertension did not appear to be mediated by greater trait or state emotionality.

Résumé

Le stress psychologique peut être un facteur de risque pour l'hypertension essentielle. Bien que plusieurs variables soient impliquées comme éléments de médiation ou de modération entre la relation du stress et l'hypertension artérielle, leur rôle précis et leur degré d'importance restent à être déterminés. Une généalogie familiale d'hypertension artérielle est possiblement une variable modératrice clé. Une série de cinq études évaluent les réactions cardio-vasculaires et émotionnelles au stress d'individus avec une tension artérielle normale, avec ou sans une généalogie d'hypertension artérielle. Afin de faciliter la généralisation des résultats, ces études utilisent certains stresseurs avec une plus grande validité écologique que ceux employés dans la majorité d'études précédantes, à ce sujet. Cet aspect de la recherche facilite l'étude d'un élément de médiation possible pour les différences de groupe au niveau d'une réactivité cardio-vasculaire, par exemple, l'émotivité. Plusieurs études révèlent des différences significatives pour les groupes concernant une réactivité cardio-vasculaire au stress. Ceci suggère que le stress est plus apte à contribuer au développement d'une hypertension artérielle pour ceux qui ont une prédisposition génétique du désordre. Parmi les gens avec une généalogie d'hypertension artérielle, une émotivité caratérielle ou situationnelle importante ne semble pas être un facteur de médiation au niveau d'une réaction cardio-vasculaire excessive.

Acknowledgements

It is important to note that completing a doctorate, while at times a very solitary process, can be made easier and more enjoyable through the assistance and support of others. While many people added to the positive aspects of my graduate studies I would like to acknowledge those people who were especially important to me.

Dr. Blaine Ditto, my research supervisor, had the greatest influence on my formation as a researcher. With his clarity of thought, scientific acumen, and genuine curiosity, he always served as a model to emulate. His confidence in my abilities and the allowances he made for my need for independence will always be greatly appreciated. He provided me support when and if I needed it and gave me latitude when I desired it. My respect for him was always reciprocated. He is a gentleman. I would like to thank the members of my graduate thesis committee, in particular Dr. Richard Koestner who always showed a keen interest in my research and clinical endeavors and treated me as a friend.

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I deeply appreciate the support, encouragement, and understanding my family and friends gave me throughout my graduate education. I know they were growing tired of my repeated refrain "I can't, I have to work on my thesis", but they never showed it. I thank them for their patience.

Patience should be one of my wife's middle names, along with every other virtue known. Anna was, is, and always will be my life. I unabashedly say that she has the most beautiful soul I know and that one of my two main goals in life is to try to make her as happy as I can. Thank you Anna, my love, for loving me and always being at my side. At the time of writing these acknowledgements my daughter Olivia is two years old. She is the universe to me. The second of my life's

goals is to succeed in demonstrating to Olivia on a daily basis the deepest love I feel for her and to help guide her in developing a strong sense of self-worth and a great capacity to love.

Manuscript-Based Thesis[1]

Candidates have the option of including, as part of the thesis, the text of one or more papers submitted or to be submitted for publication, or the clearly-duplicated text of one or more published papers. These texts must be bound as an integral part of the thesis.

If this option is chosen, **connecting texts that provide logical bridges between the different papers are mandatory.** The thesis must be written in such a way that it is more than a mere collection of manuscripts; in other words, results of a series of papers must be integrated.

The thesis must still conform to all other requirements of the "Guidelines for Thesis Preparation". **The thesis must include:** A Table of Contents, an abstract in English and French, introduction which clearly states the rationale and objectives of the study, a review of the literature, a final conclusion and summary, and a thorough bibliography or reference list.

Additional material must be provided where appropriate (e.g., in appendices) and in sufficient detail to allow a clear and precise judgement to be made of the importance and originality of the research reported in the thesis.

In the case of manuscripts co-authored by the candidate and others, **the**

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candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. Supervisors must attest to the accuracy of such claims at the doctoral oral defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of all the authors of the co-authored papers.

Statement of Authorship

This thesis describes five separate studies. At the time of submission of this dissertation the results of the fourth study to be discussed are being reviewed for publication while those of the fifth study have been published. The following is a statement regarding the contributions of my co-authors to this work.

As my thesis supervisor, Dr. Ditto served in an advisory capacity on each study, helping me to clarify and translate my ideas into feasible and meaningful research projects. He also suggested statistical procedures to use in the analyses of the data and provided editorial suggestions to improve the final reports.

Dr. Christopher France of Ohio University contributed to studies two and five by consulting on the design and allowing me to pool the data from his U.S. subjects with mine. Dr. Janis France contributed to the fifth study by testing subjects at the American site.

Statement of Original Contributions

The research in this thesis provides original contributions to the study of the relationship between psychological stress and the development of hypertension. While a good deal of evidence suggests that stress is associated with risk for hypertension, this association is inconsistently, and not always robustly, observed. This inconsistency may be better understood when one considers the possibility that stress affects hypertension risk for only certain groups of individuals. One such group may be offspring of hypertensives, who have often been found to manifest cardiovascular hyperreactivity to acute stress. The present research used several new and unusual stressors to examine parental history group differences in cardiovascular reactivity and their possible mediation by psychological factors.

Past research in this domain also often suffered from a number of limitations which the present research attempted to address. The majority of studies were laboratory-based, using protocols with questionable ecological validity. In order to increase the external validity and generalizability of the results obtained, the present research used more emotionally relevant stressors, thus more akin to real-life, than typically used. Further, one of the studies to be described is a field study conducted to obtain information in a naturalistic setting. Not only did this latter study provide a distinct contribution by it being one of the few naturalistic comparisons of cardiovascular reactions of individuals with and without a parental history of hypertension, it also employed one of the largest samples to date of individuals with confirmed parental history of hypertension. Moreover, this study examined the responses to stress of both men and women with a parental history of hypertension - something far too few studies have done in the past. Finally, while other investigators have examined the influence of negative affect on differences in cardiovascular reactivity between offspring of hypertensives and normotensives, this thesis also provides, to my knowledge, the first report of a study which sought to compare reactions of these two groups to the inducement of both negative and positive affect.

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GENERAL INTRODUCTION

Hypertension, or chronically increased arterial blood pressure, is one of the major causes of illness and death in the industrialized world (Kaplan, 1984). Hypertension can lead to a variety of problems such as heart failure, stroke, and kidney damage. As such, research to identify potential risk factors or causes of hypertension is of great importance.

Although there is some debate concerning the most appropriate cut-off point, blood pressure below 140/90 mmHg is commonly regarded as placing one in the normotensive range while pressure above 160/100 mmHg is unambiguous hypertension (Pickering, 1968; Vander, Sherman, & Luciano, 1975). Borderline hypertension is the term often used to describe the condition when the individual's blood pressure either falls between these ranges or fluctuates between the two. On the other hand, despite the less serious sound of the term "borderline hypertension", the relationship between blood pressure and risk for cardiovascular disease is a continuous function. Each 10 mmHg rise in blood pressure has been found to be associated with a 30% increase in risk for cardiovascular disease, regardless of gender (Page, 1983).

Hypertension affects approximately 16% of the North American population (Anderson, Williams, Lane, Houseworth, & Muranaka, 1987), although this varies significantly with variables such as age, sex, race, and the definition of hypertension. As many as 30% of middle-aged Canadian and European men have been estimated to be hypertensive (Canadian Blood Pressure Survey, 1989; Richard, 1976), and a recent American survey estimated that 27% of adult women have blood pressure levels in the hypertensive range (Hypertension prevalence, 1985).

There are two general categories of hypertension. When hypertension results from a known physiological disorder, such as an adrenal tumour or diabetes, it is classified as secondary hypertension. Hypertension secondary to known pathologies accounts for approximately 15% of all diagnosed cases of hypertension. Eighty-five percent of cases of established high blood pressure are classified as primary or essential hypertension. For this majority, the specific etiological factors remain to be elucidated. The present dissertation concerns itself with primary hypertension and for simplicity all further uses of the term hypertension will refer to primary hypertension unless otherwise specified.

The lack of a clear understanding of the etiology of hypertension is easy to comprehend in light of the complex interplay of factors associated with the control of an individual's blood pressure (Figure 1). At the broadest level, blood pressure is determined by cardiac output and blood vessel resistance. The former itself is determined by a number of factors, such as contractility of the heart muscle and blood volume, both of which are in turn influenced by a number of factors. As can be seen in the simplified schematic of Figure 1 there are numerous interacting factors which serve to determine blood pressure. Alterations of any one factor without sufficient compensatory responses could, in principle, lead to hypertension. It seems likely that hypertension is a multifactorial condition, in which genetic and environmental factors

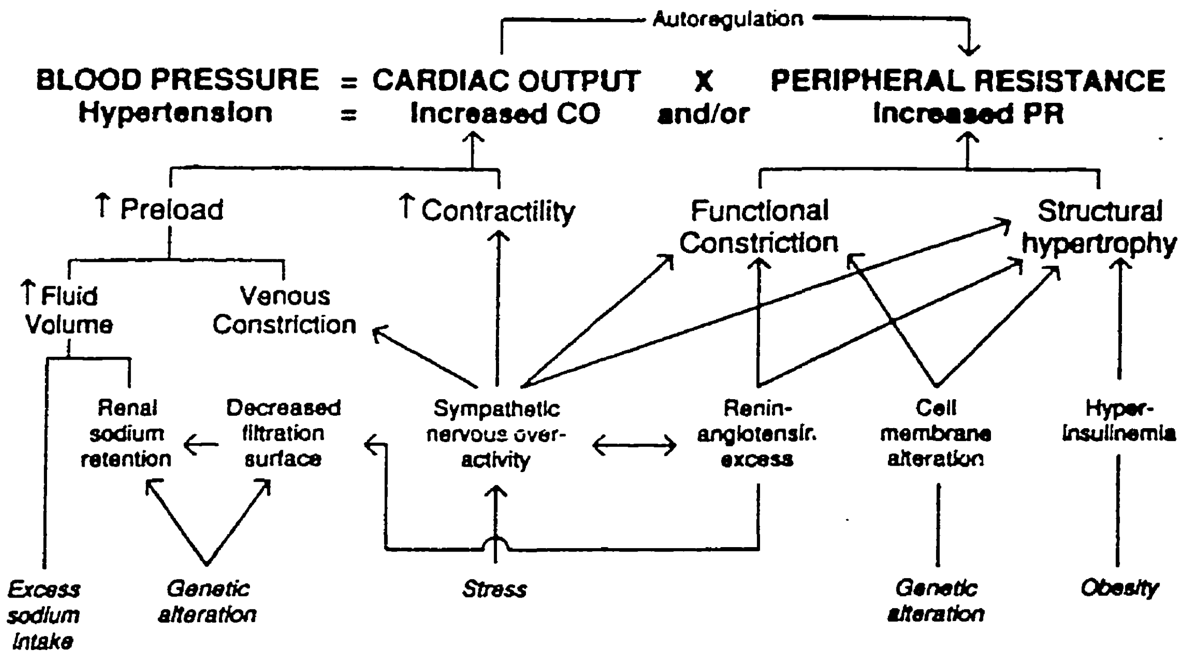

Figure 1. Some factors involved in the control of blood pressure. From Clinical hypertension (p. 57), by N.M. Kaplan, 1990, Baltimore: Williams & Wilkins. Copyright 1990 by Williams & Wilkins. Reprinted with permission.

influence neurological, physiological, and psychological processes at several levels to produce sustained high blood pressure (Williams, 1991).

Despite the complexity of the problem, research has clearly implicated a number of risk factors for the development of primary hypertension. Among the most commonly cited potential risk factors are hereditary influences, obesity, dietary sodium, and psychological factors such as the experience of life stress.

There is substantial evidence for the notion of a genetically transmitted predisposition for hypertension. For example, offspring of hypertensives have twice the risk of developing the disorder than those without a parental history of hypertension (Stamler, Stamler, Riedlinger, Algera, & Roberts, 1971; Williams, 1991). In addition, studies of families with both natural and adoptive children have found significant correlations in blood pressure between parents and their biological offspring but not with their adopted children (Biron, Mongeau, & Bertrand, 1976) and between natural sibling pairs but not between adopted sibling pairs (Biron & Mongeau, 1978). Further, the correlations for resting blood pressure among monozygotic twins are nearly twice as great than among dizygotic twins (Feinleib, 1979). However, even among monozygotic twins the correlations tend to be in the 0.40 to 0.60 range (Havlik, Garrison, Katz, Ellison, Feinlieb, & Myrianthopoulos, 1979; Feinlieb, Garrison, Fabsitz, et al., 1977; Kaplan, 1986) reflecting the fact that blood pressure is also strongly influenced by idiosyncratic, non-genetic environmental factors. It is important to note that not all familial aggregation is due to shared genes. Shared environmental factors can also cause significant associations between blood pressure and associated traits. For example, salt intake, amount of physical exercise and work satisfaction have all been found to correlate significantly between spouses and some related individuals much better than between people selected randomly from the general population (Williams, 1991).

Life Stress and High Blood Pressure

In attempt to explore the influence stress has on blood pressure a number of studies have looked at the blood pressures of migrants who moved from pre-industrialized societies to "westernized" urban centres. This was assumed to be a stressful experience for a variety of reasons: the need to adapt to a new environment, the faster pace of westernized life, separation from traditional support systems, etc. Several of these epidemiological studies found higher blood pressure among those who moved to the city than those who remained behind in the rural setting (Cassel, 1975; Cruz-Coke, 1960; Scotch, 1963). However, a number of other changes occur when people move from rural third-world settings to more westernized urban ones. For example, it has been argued that blood pressure elevations are largely due to changes in weight (Florey & Cuadrado, 1968; Ostfeld & D'Atri, 1977; Prior, Stanhope, Evans, & Salmond, 1974). Beaglehold, Salmond, Hooper, and Prior (1977) attempted to address these criticisms by dividing migrants into those who interacted frequently and rarely with their new urban neighbours. The migrants who integrated into their new environment to a greater degree had the highest blood pressures, even after controlling for body weight and diet, although changes in body mass, carbohydrate and salt intake accounted for even more of the variance in blood pressure levels than social interaction.

Other social factors have been examined for possible influences on blood pressure. High socio-ecological stress, as defined by low socioeconomic status and living in a densely populated neighbourhood with high levels of crime, residential mobility, and marital break-up, has been found to be associated with higher levels of blood pressure (Harburg, Erfurt, Hauenstein, Chape, Schull, & Schork, 1973). This association remained even after adjusting for age and weight. Social crowding, which leads to interpersonal conflict, has also been linked to elevated blood pressure. Both animal analogue studies and studies of human prisoners have found that individuals housed in single cells have lower blood pressure levels than those kept in more crowded conditions (D'Atri, 1975; Henry & Stephens, 1977; Paulus, McCain, & Cox, 1978).

In an attempt to avoid the complexities associated with trying to disentangle the influences of psychosocial factors from the contributions of factors such as diet and exercise some researchers have studied more discrete stress situations. Early investigations of responses to extremely stressful acute situations such as desert warfare (Graham, 1945) and a chemical explosion (Ruskin, Beard, & Schaffer, 1948) revealed transient increases in blood pressure lasting several days. In 1987 an accident occurred at the Three Mile Island nuclear power station in Pennsylvania, USA. This accident threatened nearby residents with harmful radiation. Although the "emergency period" which involved a general evacuation of the surrounding area lasted only two weeks, the post-accident period brought many new stressors such as the uncertainty associated with the removal of trapped radioactive gas which lasted months, if not years (Baum, Cohen, & Hall, 1993). Studies of the reactions of people to the chronic stress associated with living near the accident site during this period showed that ruminative intrusive memories and worries are positively correlated with systolic blood pressure (Davidson & Baum, 1986).

Subsequent studies of responses to more common stressors revealed psychological stress to be associated with blood pressure elevation. For example, although there are some conflicting findings, there is a fair amount of research which indicates that noise leads to increased blood pressure (Fogari, Zoppi, Vanasia, Marasi, & Villa, 1994). Some interesting findings include those of Regecova and Kellerova (1995) who observed that children who attended preschool in a high noise area exhibited higher blood pressures than comparable children who attended preschool in quieter neighbourhoods, independent of a number of variables such as socioeconomic status. There also appear to be significant individual differences in susceptibility to the effects of chronic noise on blood pressure. For example, Melamed, Harari, and Green (1993) found that Type A behaviour was significantly related to blood pressure in workers exposed to high noise workplaces but not among workers in low noise workplaces. Finally, there is also a good deal of cross-cultural data linking noise, blood pressure, and the prevalence of hypertension from such diverse places as Italy (Fogari et al., 1994), the Slovak Republic (Regecova & Kellerova), Israel (Melamed et al., 1993), Iran (Parvizpoor, 1976), and China (Zhao, Zhang, Selvin, & Spear, 1991). It is interesting to consider such findings in light of the recent emphasis on the association between responsivity to acoustic startle stimuli and emotionality (Lang, Bradley, & Cuthbert, 1992).

A number of other studies of various occupational stressors support an association with high blood pressure. Cobb and Rose (1973) conducted a study of over 400 air traffic controllers to examine the role that occupational stress may play in the development of high blood pressure. The prevalence of hypertension was four times greater in the air traffic controllers than in a control group of second class airmen, controlling for fitness level and several other potential confounding variables. In addition, controllers working at more stressful airports, as defined by airplane traffic density, manifested earlier onset of hypertension. The results of a study by Melamed, Ben-Avi, Luz, and Green (1995) also point to the importance of vigilance in stress related high blood pressure. Factory workers who were asked to perform repetitive, short cycle tasks were significantly more likely to exhibit higher blood pressures than comparable workers assigned other tasks. Others have focused explicitly on the negative effects of high job demands and low decision latitude (Schnall et al., 1990; Matthews, Cottington, Talbott, Kuller, & Siegel, J., 1987). In contrast, some data links the stress of job loss with increased blood pressure (Kasl & Cobb, 1970).

In summary, the results from these and many other epidemiological studies are consistent with the view that psychosocial stress is associated with the development of hypertension. However, many remain cautious as it is difficult to conclusively exclude alternative hypotheses, many studies have obtained negative results and even in studies with positive associations the effects of stress on blood pressure are often small (James, 1987). However, the lack of robust findings may be due in part to the failure of past research to address the possibility that stress is a factor in hypertension development for only a subgroup of individuals who are particularly susceptible to stress-related high blood pressure in some biological or psychological manner (Brody et al., 1987; Ditto & Miller, 1989). Although there is some risk of circularity in such reasoning, this acknowledges the fact that the stress response is the product of complex, multi-stage process (Lazarus & Folkman, 1984). There is also precedent for this idea in the animal literature. For example, data from comparative studies indicates that stress can significantly alter the course of hypertension in rats bred to be genetically predisposed to the disorder, i.e., spontaneously hypertensive rats (SHR; Yamori, Matsumoto, Yamabe, & Okamoto, 1969; Hallback, 1975). Using rats with somewhat less predisposition for hypertension, i.e., male offspring of SHR X WKY matings, Lawler, Barker, Hubbard, and Schaub (1981) found that many who were exposed to two hours daily of a conflict paradigm for 15 weeks developed hypertension whereas most non-stressed control rats remained normotensive. In the human literature one factor often discussed as potentially moderating the influence of life stress on the development of hypertension is cardiovascular reactivity.

Cardiovascular Reactivity to Stress

The stress-reactivity hypothesis of hypertension proposes that exaggerated cardiovascular responses to acute stressful stimuli may both predict and be involved in the development of hypertension. Support for this proposal comes from a variety of sources such as findings of elevated cardiovascular responses to stress in young and borderline hypertensives (Fredrikson & Matthews, 1990; Santangelo, Falkner, & Kushner, 1989). However, the exaggerated responses of hypertensives may be secondary to their disorder. Thus, stronger support for the proposal has been obtained through longitudinal studies in which the development of hypertension was predicted from exaggerated cardiovascular responses to stressors such as physical exercise (Dlin, Hanne, Silverberg, & Bar-Or, 1983; Jackson, Squires, Grimes, & Beard, 1983), the anticipation of physical exercise (Everson, Kaplan, Goldberg, & Salonen, 1996), mental arithmetic (Borghi, Costa, Boschi, Mussi, & Ambrosini, 1986; Falkner, Kushner, Onesti, Angelakos, 1981; Matthews, Woodall, & Allen, 1993), reaction time tasks (Light, Dolan, Davis, & Sherwood, 1992), video games (Murphy, Alpert, & Walker, 1992), and the cold pressor test (Menkes et al., 1989; Wood, Sheps, Elveback, & Schirger, 1984). Although several studies using the cold pressor test have failed to predict the development of hypertension (Armstrong & Rafferty, 1950; Eich & Jacobsen, 1967; Harlan, Osborne, & Graybiel, 1964; Thomas & Duszynski, 1982), the lack of sufficient follow-up has been noted as a serious criticism of these studies (Manuck & Krantz, 1986). In addition, stressors involving physical effort or pain may not be as relevant to the stress-reactivity hypothesis as those involving mental effort and/or the elicitation of emotions (Light et al., 1992). These latter stressors are likely to be more ecologically valid in terms of the production of psychological or emotional states similar to those elicited by stressors involved in daily life. That is, the hypothesis that individual differences in acute cardiovascular reactivity to stress may predict and/or contribute to the eventual development of sustained high blood pressure in people exposed to repeated stress is better tested using stressors similar to those encountered in daily life.

Further, due to the minimal level of environmental control available to the subject, the cold pressor test tends to elicit passive coping. This form of coping has been linked to a somewhat different pattern of sympathetic nervous system activity than active coping, that is, it accentuates alpha-adrenergic activity to a greater degree than beta-adrenergic activity (Buhler, Bulli, Hulthen, Amann, & Kiowski, 1983; Sherwood, Allen, Obrist, & Langer, 1986). This is an important distinction because exaggerated cardiac output in excess of metabolic need has been hypothesized to elicit physiological adjustments leading to permanently elevated blood pressure (Obrist, 1981). It is also interesting to reflect on the previously discussed epidemiological findings relating stress to high blood pressure, which seem to support the view that stress-related high blood pressure is the result of an environment which requires chronic struggle and adaptation.

Although a detailed discussion of possible mechanisms linking life stress, exaggerated cardiovascular reactivity, and the development of sustained high blood pressure is beyond the scope of the present thesis, it is useful to note that there are already several models of this process. One involves a process called autoregulation, an intrinsic property of the vascular bed to regulate the flow of blood depending upon the metabolic needs of the tissues (Borst & Borst-de Geus, 1963; Guyton & Coleman, 1969; Obrist, 1981). The autoregulation model relies on the fact that local tissue mechanisms maintain local blood perfusion by regulating vascular constriction or dilation. For example, with increased cardiac output, without a corresponding elevation in physical activity, more blood flows through the tissues than is required, delivering extra nutrients and oxygen or removing additional metabolic end products (Carrier, Walker, & Guyton, 1964). In response, the vessels constrict reestablishing the appropriate levels. As previously noted in discussion of active coping stressors, some psychological stressors lead to increases in cardiac output without a corresponding increase in metabolic demand. It is proposed that this leads to an overperfusion of body tissues with oxygenated blood during psychological stress, and to the autoregulation of blood flow. With constricted arterioles, cardiac output is reduced to normal levels but the blood pressure remains elevated due to increased vascular resistance (Obrist, 1976).

Another possible explanation for the development of sustained high blood pressure in reactive individuals is Folkow's structural adaptation model (Folkow, 1990; Folkow, Grimby, & Thulesius, 1958; Folkow, Hallback, Lundgren, Sivertsson, & Weiss, 1973). According to this theory, repeated increases in cardiac output and blood pressure cause hypertrophy to occur in the smooth muscle in the blood vessels. The enlargement of muscle leads to a narrowing of vessel diameter and increased peripheral resistance. In addition, the strengthened muscle wall makes the vessel more responsive to the constrictive factors that cause blood flow autoregulation.

Thus, a more persuasive case for the importance of psychological factors in the development of hypertension may be made if individuals with high cardiovascular reactivity to stress are studied, although it is important to note that the ideal study in this area, that is, studying the joint effects of cardiovascular reactivity and chronic life stress over a long period of time, has not been done. There have been a few studies which approached this idea, but not many. For example, Elbert, Dworkin, Rau, Pauli, Birbaumer, Droste, and Brunia (1994) recently examined the effects of daily life stress on blood pressure over a 20 month period. There was no general association between life stress and change in blood pressure. However, the results of regression analyses indicated greater elevations in "high risk" subjects (defined as someone who exhibits a decrease in pain following mechanical stimulation of the carotid baroreceptors - a characteristic some have observed in borderline hypertensives) exposed to repeated life stress.

In sum, individuals who manifest elevated cardiovascular responses to stress may form an at-risk group. This leads, inevitably, to the question "What determines one's cardiovascular reactivity?". As already discussed, there is substantial genetic influence on risk for high blood pressure. Considerable evidence suggests that this influence may be partially mediated by, or at least related to, cardiovascular reactivity. For example, although the twin literature regarding cardiovascular reactivity to stress is relatively small, the results of these studies typically indicate moderate heritability of the degree of one's cardiovascular reactivity to stress (Hewitt & Turner, 1995). For example, studies focusing on the heart rate and blood pressure responses of twins to stressors such as mental arithmetic, video games, interviews, and concept formation tasks have resulted in heritability estimates in the range of 30-

90% (Ditto, 1993; Shapiro, Nicotero, & Scheib, 1968; Theorell, deFaire, Schalling, Adamson, & Askevold, 1979; Turner, Carroll, Sims, Hewitt, & Kelly, 1986). There is also a good-sized literature documenting differences in cardiovascular reactivity to stress between SHR rats and various other strains. SHR rats have been found to exhibit greater stress-related increases in heart rate, blood pressure, and cardiac output (Folkow, 1982; Hallbach & Folkow, 1974; LeDoux, Sakaguchi, & Reis, 1982).

Parental Hypertension: Cardiovascular and Emotional Reactivity?

The largest literature relevant to this issue concerns the cardiovascular reactivity to stress of human offspring of hypertensives (Fredrikson & Matthews, 1990). Evidence that offspring of individuals with hypertension manifest exaggerated cardiovascular responses to stress has been obtained from examination of their reactions to a number of different stressors. In comparison with offspring of normotensives, healthy offspring of hypertensives have been found to demonstrate greater cardiovascular reactions to stressors involving isometric exercise (Borghi, Costa, Boschi, & Ambrosini, 1988; Manuck & Proietti, 1982; Stoney & Matthews, 1988), dynamic exercise (Molineux & Steptoe, 1988; Wilson, Sung, Pincomb, & Lovallo, 1990), mental arithmetic (Ditto, 1986; Falkner, Onesti, Angelakos, Fernandes, & Langman, 1979; Jorgensen & Houston, 1981; Manuck & Proietti, 1982; Manuck, Proietti, Rader, & Polefrone, 1985), video games (Ditto & Miller, 1989; Ewart, Harris, Zeger, & Russel, 1986; Miller & Sita, 1994), the Stroop word-colour interference test (Ditto, 1986; Jorgensen & Houston, 1981; Shapiro, 1961), reaction time tasks (Allen, Lawler, Mitchell, Matthews, Rakaczky, & Wesley, 1987; Hastrup, Kraemer, Hotchkiss, & Johnson, 1986; Hastrup, Light, & Obrist, 1982), shock avoidance tasks (Ditto & Miller, 1989; Jorgensen & Houston, 1986), and, less frequently, the cold pressor test (Shapiro, 1961; Johnson, Nazzaro, & Gilbert, 1991).

Although there is an impressive amount of evidence linking cardiovascular hyperresponsivity with a positive parental history of hypertension it is important to note that, as in most scientific areas, there are also many negative findings and important qualifications (Hohn et al., 1983; Lawler & Allen, 1981; Ohlsson & Henningsen, 1982; Matthews, Manuck, & Saab, 1986; Matthews & Rakaczky, 1986; McCann & Matthews, 1988; Morell, Myers, S;hapiro, Goldstein, & Armstrong, 1988). For example, greater attention has recently been given to the fact that although individuals with one hypertensive parent possess a greater risk of developing high blood pressure than those with no hypertensive parents, most such offspring of hypertensives never develop the disorder (Julius, Schneider, & Egan, 1985). Studies using subjects with only one hypertensive parent have been criticized for their use of an occasionally weak design, contributing to the likelihood of observing inconsistent results (Muldoon, Terrell, Bunker, & Manuck, 1993). As a result, the use of designs comparing the offspring of two hypertensive parents or offspring of hypertensives with modestly elevated resting blood pressure to various control groups are becoming more common in the literature (e.g., Everson, Lovallo, Sausan, & Wilson, 1992; Waldstein, Ryan, Polefrone, & Manuck, 1994). There may also be systematic differences in the types of stressors which elicit group differences in cardiovascular reactivity. For example, Hastrup, Light, and Obrist (1982) failed to find significant differences between offspring of hypertensives and normotensives in heart rate or blood pressure reactions to the cold pressor test although parental history positive individuals demonstrated greater reactions to a reaction time task. Similarly, Ditto (1986) found parental history positive subjects exhibited greater systolic blood pressure responses to two active coping stressors, mental arithmetic and the Stroop Word-Color Interference Test, but not to the non-active isometric hand-grip stressor. Such findings are consistent with Obrist's (1981) theory that risk for hypertension is associated with cardiac hyperreponsivity in reaction to stressors which elicit active coping.

In a recent review, Schneiderman and McCabe (1989) also suggested that offspring of hypertensives may be predisposed to exhibit exaggerated cardiovascular reactivity to stressors producing active coping. The reasons for this trend are unclear, but there are a number of possibilities. For example, it is possible that offspring of hypertensives may be primarily predisposed to exhibit large increases in cardiac sympathetic activity during stress, a tendency which is accentuated by the presentation of active coping stressors. As noted before, stressors such as mental arithmetic tend to elicit greater beta-adrenergic activation (leading to greater increases in heart rate, forearm blood flow, and other measures) while stressors such as the cold pressor test tend to elicit greater alpha-adrenergic activation (leading to greater vasoconstriction). Miller and Ditto (1991) found that administration of the beta-1 blocker metroprolol completely eliminated the group difference in heart rate response to a stressful video game between offspring of hypertensives and normotensives. Other researchers have speculated that offspring of hypertensives display reduced baroreflex sensitivity (Parmer, Cervenka, & Stone, 1992), which might make them particularly susceptible to the predominant effects of active coping stressors on the heart.

However, while the differences between offspring of hypertensives and normotensives in cardiovascular reactivity may ultimately be explained by such physiological processes, other explanations are possible. In an early study, Jorgensen and Houston (1981) found that family history positive individuals reported more anxiety during a shock avoidance procedure while at the same time showing greater heart rate and diastolic blood pressure elevations compared to offspring of normotensives. Soon after, Holroyd and Gorkin (1983) found that men with a family history of hypertension reported more anxiety during emotional role-play scenes than family history negative men. These results suggest that genetic risk for hypertension may be accompanied by an increase in emotionality which, perhaps, explains the greater cardiovascular reactivity to stress in offspring of hypertensives. This hypothesis is not necessarily inconsistent with the observation that offspring of hypertensives tend to display greater cardiovascular reactivity primarily to active coping stressors, as it is possible that tasks such as mental arithmetic and shock avoidance are more emotionally engaging than more passive stressors such as the cold pressor test. Further, although the literature has emphasized differences between offspring of hypertensives and normotensives in cardiovascular reactivity, some investigators have noted group differences in electrodermal (Collins, Baer, &

Bourianoff, 1981) and adrenal reactivity (Fredrikson, Tuomisto, & Bergman-Losman, 1991). These latter findings are easier to reconcile with an effect of family history on emotionality as opposed to a specific effect on, for example, cardiac reactivity to stress.

Although not widely studied, the results of a number of other studies of offspring of hypertensives suggest that these individuals may experience greater emotional reactions in response to stress than parental history negative individuals. Healthy sons of hypertensives reported greater distress, tension, and fatigue in response to the challenge of serial subtraction and digits backwards tasks than comparable offspring of normotensives (Sausen, Lovallo, & Wilson, 1991). In addition, normotensive offspring of hypertensives achieved greater scores on the state version of the State Trait Anxiety Inventory in anticipation of engaging in mental and physical stressors than healthy offspring of normotensives (Perini, Muller, Rauchfleisch, Battegay, Hobi, & Buhler, 1990). Melamed (1987) developed a scale measuring a construct he labelled "Emotional Reactivity", defined as "a tendency to more easily enter and maintain a state of emotional arousal". Comparisons of 121 offspring of hypertensives to 560 subjects without such a history found the former group to have significantly higher scores on the Emotional Reactivity scale.

There are also studies of behavioural differences between normotensive offspring of normotensives and hypertensives which have found the latter group to manifest more conflict avoidance as assessed by eye gaze aversion during simulated conflict (Baer, Reed, Bartlett, Vincent, Williams, & Bourianoff, 1983) or interpersonal challenge (Semenchuk & Larkin, 1993) - behaviours which can be interpreted as attempts to avoid emotional arousal and the ensuing elevated cardiovascular activity. In sum, these results point to the possibility that differences in cardiovascular reactivity are, at least partially, determined by differences in affective response and coping styles.

In fact, there are some interesting data from animal studies suggesting that SHR rats, who exhibit many physiological similarities to human offspring of hypertensives, display behaviours which can be interpreted as reflecting elevated emotionality (Knardahl & Sagvolden, 1979; Tucker & Johnson, 1981). Casto and Prince (1990) found that SHR rats exhibited greater motor and cardiovascular response to tactile (air puff) startle stimuli than rats not known to be at genetic risk for hypertension (WKY rats). As noted before, there is a clear association between degree of startle and emotionality (Lang et al., 1990). However, some have interpreted the SHR's behaviour in response to stress as indicative of hypoemotionality (Ledoux et al., 1982; Svensson, Harton, & Linder, 1991). For instance, Soderpalm (1989) found that SHR rats were more likely to venture into open maze arms than WKY rats.

Despite the previously discussed findings of differences in affective response to stress between those differing in parental history of hypertension, a key assumption typically made in research on cardiovascular reactions of individuals with and without a parental history of hypertension is that the stressors employed have an equal psychological impact on the two groups. Thus, mood ratings or other measures of emotional response to stress are often not obtained. To some degree, this assumption can be justified. Subjects are typically drawn from young, non-clinical populations. Nevertheless, the scarcity of research designed to compare family history positive and negative individuals in emotional reactivity is somewhat surprising as the cardiovascular phenomena under study are peripheral manifestations of a complex, centrally-mediated defense response (e.g., Gray, 1991). As noted above, the elevated cardiovascular reactivity could be mediated by other processes and does not necessarily require elevated emotional reactivity. For example, classic findings in the psychophysiological literature indicate that the autonomic, behavioral, and self-report emotional responses to stress may be poorly correlated at times (Lacey, 1967; Lang, 1968). In fact, several studies have not noted a greater emotional reactivity in normotensives with a positive parental history, even when exhibiting greater cardiovascular reactivity (Lamensdorf & Linden, 1992; Manuck et al., 1985). However, there seems to be enough evidence to warrant further investigation of this potentially key issue in the field. Investigation is further warranted given the fact that there appear to be some other behavioral differences between offspring of hypertensives and normotensives, as well as the large literature linking affect, particularly anger, with hypertension.

Other Possible Behavioral Effects of Family History of Hypertension

For a number of years, investigators have been aware of differences between hypertensive patients and controls in several neuropsychological measures, independent of potential confounds such as education, age, and medication use

(Waldstein, Manuck, Ryan, & Muldoon, 1991). In an early study, Shapiro and colleagues found that young, mildly hypertensive individuals displayed significant impairments compared to matched controls in tasks assessing sensory-perception, cognitive, psychomotor, and non-verbal communication abilities (Shapiro, Miller, King, Ginchereau, & Fitzgibbon, 1982). A more recent study compared men with untreated hypertension to normotensives matched for education, age, and average alcohol consumption, and found hypertensives had poorer performance on tests of memory and visual recall (Waldstein, Ryan, Manuck, Parkinson, & Bromet, 1991). Various hypotheses have been proposed to account for these effects, such as an impairment in cerebral blood flow, mild brain damage, and metabolic change (Mentis et al., 1994; Thyrum, Blumenthal, Madden, & Siegel, 1995). However, the picture has recently changed as it has recently become apparent that neuropsychological deficits may also be observed in normotensive, asymptomatic individuals at risk for hypertension (Pierce & Elias, 1993; Thyrum, et al., 1995; Waldstein et al., 1994). Thus, for example, the idea that these problems are the result of minimal brain damage seems less tenable. While their link to emotionality is not clear, these findings suggesting diminished neuropsychological functioning in certain offspring of hypertensives reinforce the idea of behavioral differences between offspring of hypertensives and normotensives.

Similarly, there is also a literature associating pain sensitivity with risk for high blood pressure. Recently, the established reduction in pain sensitivity observed in hypertensive rats (Maixner, Touw, Brody, Gebhart, & Long, 1982; Sitsen & de

Jong, 1984; Sitsen, Nijkamp, & de Jong, 1987; Zamir & Maixner, 1986) and humans (Ghione, Rosa, Panattoni, Nuti, Mezzasalma, & Giuliano, 1985; Guasti et al., 1995; Rosa, Vignocchi, Panattoni, Rossi, & Ghione, 1994; Zamir & Shuber, 1980) has been noted in both individuals with marginally elevated blood pressures (Rau et al., 1994) and offspring of hypertensives (France, Ditto, & Adler, 1991). Ditto, France, and France (1997) have speculated that this might be, at least partially, a variant of the phenomenon of stress-induced analgesia. Although there may be other physiological mechanisms, this could stem from greater emotionality.

The Relationship Between Anger and Hypertension

There is a large literature addressing possible differences between hypertensive and normotensive individuals in emotional or personality styles. Since the earliest proposals of the existence of reliable personality differences between hypertensives and normotensives, the nature of how one typically experiences and expresses anger has usually been part of the description. Moschowitz (1919) proposed that hypertensives are "quick-to-anger" as compared to normotensives. Alexander (1939) believed that hypertensives differed from normotensives particularly in their style of anger expression. He theorized that hypertensives suppressed the expression of their angry feelings because of anxiety about the consequences of expressing anger and that frequent experience of anger and inhibition of its expression were major determinants of hypertension. In a study utilizing home monitoring of blood pressure, borderline hypertensives who maintained elevated blood pressure at home reported a greater tendency to suppress the expression of their anger than a comparable group of borderline hypertensives whose blood pressure returned to normal levels at home (Schneider, Egan, Johnson, Drobny, & Julius, 1986). Most traditional viewpoints see differences between hypertensives and normotensives in anger experience and expression as pre-dating and contributing to the development of this disorder (Ayman, 1933; Diamond, 1982; Esler, Julius, Zweifler, Randall, Harburg, Gardiner, & DeQuattro, 1977; Harburg et al., 1973), although they are not always viewed as the product of genetic predisposition. In understanding how anger can be associated with hypertension it is important to understand the physiological consequences of anger. Experimental manipulations designed to elicit anger typically result in increased sympathetic nervous system activity, plasma renin activity, plasma norepinephrine, and decreased parasympathetic drive to the heart (Diamond, 1982; Schneider et al., 1986) - reactions theoretically linked to the development of hypertension in both the autoregulation theory (Borst & Borst-de Geus, 1963; Guyton & Coleman, 1969; Obrist, 1981) and Folkow's structural adaptation model (Folkow, 1990; Folkow et al., 1958; Folkow et al., 1973).

A limitation of much of the earlier research which investigated the relationship between anger and hypertension is that many studies used diagnosed hypertensives, allowing for the possibility that characteristics attributed to the hypertensives are secondary to established hypertension. For example, as previously noted, the disorder may cause neurological changes which could possibly influence anger (Blumenthal, Madden, Pierce, Siegel, & Appelbaum, 1993; Miller, Shapiro, King, Ginchereau, & Hosutt, 1984; Shapiro et al., 1982). In addition, the proposed hypertensive personality characteristics may be related more to psychological reactions to the diagnosis of a serious illness or the selection of more "neurotic" samples of hypertensives whose high blood pressure was diagnosed after they sought medical care (Suls, Wan, & Costa, 1995). A recent review argues that merely knowing one has hypertension may have a negative effect on mood and behaviour, and could possibly influence one's anger experience and expression styles (MacDonald, Sackett, Haynes, & Taylor, 1984). In fact, several studies of hypertensives who were unaware of their hypertensive status failed to find group differences in personality between them and healthy normotensive controls (Irvine, Garner, Olmsted, & Logan, 1989; Steptoe, Melville, & Ross, 1982; Theorell, Hjindahl, Eriesson, Kallner, Knox, Perski, Svensson, Tidgren, & Waller, 1985). Collectively, these results raise the possibility that the personality differences often noted between aware hypertensives and normotensives may not be fundamental characteristics of hypertensives but are related to knowledge of hypertensive status. In order to investigate the existence of a relationship between hypertension and personality characteristics, particularly anger, uninfluenced by the individual's knowledge of the diagnosis or by the disease process itself, attention has turned to the study of normotensive individuals.

Siegel (1984) found that high scores on a composite measure of the tendency to frequently experience anger were associated with greater systolic and diastolic blood pressure in a sample of 213 healthy adolescents. In a study which used ambulatory measurement of blood pressure, Linden, Chambers, Maurice, and Lenz (1993) observed a significant association between hostility as measured by the Cook

Medley Hostility Inventory and diastolic blood pressure in healthy male, but not female, university students. In a widely cited study, McClelland (1979) found that themes of dominance and aggression in response to the Thematic Apperception Test were predictive of elevated blood pressure 20 years after initial testing of college men. The results of a recent meta-analysis of the relationship between anger and blood pressure revealed a significant, albeit modest, association (Suls et al., 1995).

Anger expression as well as anger experience has been found to be related to blood pressure in healthy individuals. Goldstein, Edelberg, Meier, and Davis (1988) found that scales assessing the tendency to express anger were inversely associated with resting diastolic, but not systolic blood pressure or heart rate. Johnson and colleagues had 489 male high school students complete the Anger Expression scale, a measure of anger expression style, and obtained resting blood pressure values for all subjects (Johnson, Spielberger, Worden, & Jacobs, 1987). Those who reported frequently suppressing their anger had higher systolic and diastolic blood pressures, even when controlling for traditional risk factors (e.g., weight, salt intake). Similar findings were obtained with a sample of 450 normotensive adolescent females (Johnson, Schork, & Spielberger, 1987). In a sample of 1006 individuals, Gentry and colleagues found anger suppression to be associated with greater systolic blood pressure among women and with greater diastolic blood pressure among both men and women (Gentry, Chesney, Gary, Hall, & Harburg, 1982). However, the previously discussed study of ambulatory blood pressure in university students' by Linden and colleagues did not observe an association with the tendency to withhold anger as assessed by the Anger Expression Scale's Anger-In subscale (Linden et al., 1993).

Along with evidence associating anger with increased resting blood pressure, there is also evidence of the effects of anger on cardiovascular reactivity. A number of studies have found that normotensive individuals who score highly on measures of hostility manifest greater physiological reactions to stress as compared to less hostile control subjects (Houston, Smith, & Cates, 1989; Smith & Allred, 1989; Suarez, Harlan, Peoples, & Williams, 1993; Suarez & Williams, 1989, 1990; Vitaliano, Russo, Bailey, Young, & McCann, 1993; Weidner, Friend, Ficarrotto, & Mendell, 1989), not surprisingly, the effect is most reliably observed using stressors that are provocative in nature, especially in a context of relevant social stressors rather than non-social laboratory tasks (Christensen & Smith, 1993; Hardy & Smith, 1988; Powch & Houston, 1996; Smith, 1992).

Anger expression style also appears to influence reactivity (Diamond, Schneiderman, Schwartz, Smith, Vorp, & Pasin, 1984). An early study found that anger which is felt but not expressed openly led to a greater increase in blood pressure response than anger with an outlet for aggression (Gambaro & Rabin, 1969). However, this is a complex area as, for example, the availability of an outlet for aggression may lead to greater reactivity in women (Hokanson & Edelman, 1966). Scores on scales assessing the tendency to express anger were found to be inversely correlated with heart rate and norepinephrine responses to a challenging mental arithmetic task by Mills, Schneider, and Dimsdale (1989). There is some evidence that anger expression styles to either extreme, i.e., exaggerated expression or suppression, are associated with physiological activity linked with risk for hypertension (Harburg, Gleiberman, Russell, & Cooper, 1991; Linden & Long, 1987; Linden & Lamensdorf, 1990).

Preface to Studies One to Five

Review of the literature concerning the association between anger and blood pressure supports the idea that anger can play a significant role in cardiovascular activity and reactivity. Further, as previously noted, there is a surprising amount of evidence suggesting an effect of family history of hypertension on emotionality. The possibility that the cardiovascular hyperresponsivity noted in offspring of hypertensives may be determined in part by heightened emotionality or other personality characteristics warrants further investigation. The research conducted for this thesis addresses this idea in a variety of ways. The first two studies to be presented were reasonably straightforward questionnaire-based examinations of emotionality among normotensive college students with and without a parental history of hypertension. Due to the historical, empirical, and theoretical links between anger and hypertension, considerable attention was directed at comparing individuals with and without a parental history of hypertension in their tendencies to experience and express anger. Close to 500 subjects completed questionnaires relevant to the issue of emotional reactivity to stress. The third study of the thesis examined the emotional and cardiovascular reactions of individuals with and without a parental history of hypertension to a competitive laboratory stressor designed to elicit anger. Subjects were criticized for poor performance on a video game task which did not permit high rates of success. In an attempt to elicit a variety of significant emotional responses, subjects were asked to think about and discuss a variety of stressful life experiences in the fourth study while measures of cardiovascular activity and mood were obtained. The fifth and final study examined the reactions of individuals with and without a parental history of hypertension to the naturalistic and fairly intense stressor of blood donation.

The use of stressors which attempted to elicit emotional reactions in Studies 3 - 5 is related to the other main goal of this thesis. That is, an important criticism levelled at virtually all the research concerning physiological and behavioral differences between offspring of hypertensives and normotensives is that it may not be generalizable to the stressors people encounter in everyday life, i.e., the issue of "ecological validity" (Pickering and Gerin, 1990). Thus, another goal of the present research was to further evaluate the generalizability of group differences between individuals with and without a parental history of hypertension in cardiovascular and emotional reactivity to stressors which are more "ecologically valid" than those typically reported in the literature. In part, this was addressed by looking at reactions to more emotionally relevant stressors than typically employed in laboratory research. In Study 3, subjects were criticized for ostensibly poor performance on a video game task, a manipulation which also included an interpersonal component. In Study 4, subjects were asked to recall and discuss a number of important emotional events in their own lives, a manipulation which also benefitted from the general similarities in physiological response to real and imagined stressors (Lang, Kozak, Miller, Levin, &

McLean, 1980). Finally, Study 5 was an examination of group differences in response to a real life stressor, albeit an uncommon one, blood donation.

The dissimilarities between stressors which subjects are typically exposed to in laboratory research and those they face in real life are due in part to the understandable desire to develop psychological stressors which are as standardized as exercise tasks. However, while a number of investigators have observed significant correlations between individual differences in reactivity in laboratory and field settings (Coats, Radaelli, Clark, Conway, & Sleight, 1992; Johnston, Anastasiades, & Wood, 1990; Matthews, Owens, Allen, & Stoney, 1992; McKinney, Miner, Ruddell, Buell, Eliot, & Grant, 1985; Pollack, 1994; Turner, Ward, Gellman, Johnston, Light, & van Doornen, 1994) the associations have often been quite modest and the stability of group differences in cardiovascular reactivity outside the laboratory is by no means assured. Thus, there is a movement towards a greater use of field studies to increase the ecological validity of stressors. For example, Wilson, Ferencz, Dishinger, Brenner, and Zeger (1988) found that adolescents with a parental history of hypertension had greater diastolic blood pressure levels than offspring of normotensives during school hours, but not at rest. Similarly, young normotensive individuals with a family history of hypertension were found to exhibit higher daytime heart rate and blood pressure levels than individuals without a family history, while there were no differences between the two groups during sleep (Fredrikson, Robson, & Ljungdell, 1991). Additionally, in a prospective study, Theorell et al. (1988) found that increases in work demands in relation to decision latitude were associated with increased systolic blood pressure during workhours, especially among those with a family history of hypertension. However, Matthews, Manuck, and Saab (1986) found no differences between offspring of hypertensives and normotensives in heart rate or blood pressure response to the naturalistic stressor of public speaking. These results offer evidence of greater reactivity to the stress of daily life in parental history positive subjects, although this literature is quite small.

Finally, a third, but less important, goal of the present research was to examine the effects of individual differences in anger experience and expression on the effects of parental history of hypertension on cardiovascular reactivity. That is, to determine whether or not the effects of parental history of hypertension on cardiovascular reactivity are modulated, rather than mediated, by individual differences in emotionality. Manuck, Proietti, Rader, and Polefrone (1985) found that offspring of hypertensives and normotensives did not differ in state anxiety or anger during a laboratory stress protocol. However, differences in heart rate reactivity to a mental arithmetic task were observed only among those reporting the most anxiety and anger. Similarly, Miller (1992) found that normotensive males with a parental history of hypertension who scored high on a measure of trait anxiety exhibited greater increases in heart rate and forearm blood flow during a stressful video game than parental history positive males with low trait anxiety or parental history negative subjects.

In summary, substantial evidence exists that psychological factors may play a causal role in the development of hypertension, at least for some individuals. Models of mechanisms by which psychological stressors can influence physiological processes leading to the development of chronically elevated arterial blood pressure were reviewed. These hypotheses highlight the interactional nature of the biopsychosocial factors involved in the pathogenic process. A clearer understanding of the relationships between family history of hypertension, life stress, cardiovascular reactivity to acute stress, and high blood pressure needs further exploration of the involvement of affective factors. The present research focused on possible differences between offspring of hypertensives and normotensives in affective reactivity to stress, with a particular interest in styles of anger experience and expression. In addition, stressors with greater ecological validity than those typically used in this area of study were employed. As a consequence, the resulting information concerning affective and cardiovascular reactivity should be more representative of reactions to real-life stress than often obtained in the past.

Identification of characteristics relevant to the occurrence of hypertension has several practical benefits. For example, identification of such characteristics within an individual may serve an alerting function, sensitizing the identifier to the potential risk facing the individual possessing the characteristics. In addition, if these characteristics are causally involved in the development of hypertension, manipulation of these characteristics may diminish the likelihood of developing hypertension and its life threatening consequences.

STUDY ONE

Method

Participants

Two hundred and forty-five individuals (132 females, 113 males) were recruited from the general community of McGill University through the use of in-class announcements, questionnaire distribution tables, and contact with participants of previous studies. Subjects were asked to participate in a study of health and personality by completing a questionnaire packet in return for entry into a lottery with prizes of $100 and $50. The majority of participants were undergraduate students. Ten subjects indicated either a personal history of high blood pressure or uncertainty about their hypertension status on their questionnaires. The data from these ten individuals were dropped from all analyses. Individuals were regarded as having a parental history of hypertension if they reported at least one biological parent with a history of hypertension in the absence of a history of kidney disease or diabetes. The absence of these two diseases was used in an attempt to eliminate, or at least significantly reduce, the representation of individuals with a parental history of secondary rather than primary hypertension (Jorgensen & Houston, 1986). Subjects were classified as being without a parental history of hypertension if they reported that neither of their biological parents were hypertensive. The data from 14 women and 16 men who said they were not sure of the hypertension status of one or both of their parents or who reported a parental history of hypertension in the context of diabetes or kidney disease were dropped from all analyses. Of the remaining 205 subjects, 66 women and 58 men reported having two normotensive parents. Forty-nine women and 32 men reported having a parental history of high blood pressure. The relatively high proportion of individuals with a parental history of hypertension was due to the recruitment of subjects from previous studies. Similar to the others, these subjects were told only that the present study concerned the relationship between health and personality. Nevertheless, the use of subjects who had participated in previous studies involving cardiovascular measurement may have influenced some results. This issue is discussed later and this aspect of subject recruitment was not employed in Study 2. Although no attempts were made to confirm the parents' health status in this study, offspring reports of parental hypertension status have been found to range from 89 - 93% correct in a number of studies (Allen et al., 1987; Adler, Ditto, France, & France, 1994; Ditto, 1986; France et al., 1991; Jorgensen & Houston, 1986).

Materials

Health Questionnaire. Embedded within other questions concerning health, the questionnaire obtained subjects' reports of their personal and parental histories of hypertension as well as appraisals of their personal chances of developing hypertension and a number of other diseases in the future (0-100% likelihood rating). The questionnaire also requested demographic information (e.g., age, parents' ages, height, weight) and information regarding a number of personal health habits (e.g., exercise, diet, smoking). The questions concerning other behavioral risk factors for hypertension were included to deflect attention away from the focus on anger and high blood pressure. Finally, the health questionnaire included three questions assessing different aspects of anger expression. The first asked subjects how often (never to always; 0-5) they avoid situations due to the potential they may lead to angry confrontations. The second question asked how badly they feel if they do not express their anger in anger provoking situations (not at all to extremely; 0- 4). The third the amount of guilt they felt the last three times they expressed their anger (none to extreme; 1-4).

State Anger Reaction Scale (SA-Rn Scale). The SA-Rn Scale (Johnson et al., 1987) is a 23-item questionnaire which assesses the intensity of anger experienced in a variety of stressful and frustrating social situations. Each situation is rated on a four-point scale.

Anger Expression Scale (AX). The AX (Spielberger, Johnson, Russell, Crane, Jacobs, & Worden, 1985) measures the frequency that anger is expressed. The present study used two of the scale's original non-orthogonal scores. These were the anger-in subscale, which assesses the tendency to suppress anger expression, and the anger-out subscale, which assesses the tendency to express anger behaviourally. The study also used two other subscales which were recent additions to the AX at the time the study was conducted (E.H. Johnson, personal communication). These were the fear subscale which measures the fear of expressing anger, and the control-reflection subscale, which assesses the tendency to control and reflect upon one's anger.

Data Analyses

To identify possible confounding factors, a series of 2 (parental history of hypertension) X 2 (gender) analyses of variance (ANOVAs) were conducted on variables which might influence the psychological variables (e.g., age, parental age, body mass index). Subjects with a parental history of hypertension were significantly older ($\bar{X}$ = 24.9 $\pm$ 6.8 (SD) vs. 21.8 $\pm$ 4.2 years; $F(1,205) = 16.74$, $p < .01$) and had significantly older parents ($\bar{X}$ = 55.5 $\pm$ 8.5 vs. 50.5 + 6.2 years; $F(1,187) = 19.93$, $p < .01$) than subjects without a parental history of hypertension. No other significant effects involving parental history were observed. As a result, age was used as a covariate in a multivariate analysis of covariance (MANCOVA) in which parental history of hypertension and gender served as the independent variables. The MANCOVA examined group differences in anger styles using the scores on the following eight items as the dependent variables: all four AX subscales, the SA-Rn scale score, and the three questions from the Health Questionnaire which assessed aspects of anger experience and expression. All statistical tests were two-tailed.

Results

The parental history of hypertension X gender MANCOVA examining group differences in anger styles revealed a significant main effect of gender ($F(8,174) = 5.06$, $p < .01$). Overall, women had greater scores on the State Anger Reaction Scale than men ($\bar{X}$ = 55.5 $\pm$ 7.9 vs. 51.8 $\pm$ 9.9; $F(1,181) = 8.94$, $p < .01$), lower scores on the control-reflection subscale of the Anger Expression Scale than men ($\bar{X}$ = 34.2 $\pm$ 8.4 vs. 38.2 $\pm$ 7.3; $F(1,181) = 16.15$, $p < .01$), and reported feeling more badly after not expressing their anger ($\bar{X}$ = 2.4 $\pm$ 0.9 vs. 2.1 $\pm$ 0.9; $F(1,181)$

$= 5.64$, $p < .01$). The MANCOVA also yielded a significant parental history of hypertension X gender interaction effect ($F(8,174) = 1.97$, $p < .05$). Univariate analyses revealed significant interaction effects on report of feeling badly after anger suppression ($F(1,181) = 5.53$, $p < .05$) and both the control-reflection ($F(1,181) = 8.56$, $p < .01$) and the anger-out subscales of the AX ($F(1,181) = 5.12$, $p < .05$).

The interaction effect on report of feeling badly after anger suppression was due to the fact that female subjects with a parental history of hypertension had higher scores than the other three groups ($X = 2.7 \pm 0.9$ vs. 2.1 ± 0.9, 2.0 ± 0.8, and 2.1 ± 1.0 for parental history positive and negative women and parental history positive and negative men, respectively). Women with a parental history of hypertension also had generally lower AX anger control and reflection subscale scores than women without a parental history of hypertension ($X = 32.0 \pm 8.4$ vs. 35.7 ± 8.4), although this trend was reversed for men ($X = 40.6 \pm 7.0$ vs. 37.0 ± 7.4 for parental history positive and negative men, respectively). Similarly, within the female sample those with a parental history of hypertension obtained higher AX anger-out scores than those without a parental history of hypertension ($X = 16.2 \pm 4.2$ vs. 14.7 ± 3.1) whereas parental history was associated with lower anger out scores in males (15.4 ± 3.7, and 16.4 ± 3.3 for parental history positive and negative men, respectively).

Supplementary analyses examining possible group differences in health-related behaviours such as frequency of heavy exercise revealed no significant effects involving parental history of hypertension. Not surprisingly, ratings of the likelihood that they would develop high blood pressure obtained from offspring of hypertensives were significantly greater than those obtained from offspring of normotensives (X = 32 vs. 23%; $F(1,197) = 12.74$, $p < .01$).

Discussion and Preface to Study Two

The present findings provide only modest evidence of an association between risk for hypertension and anger. As expected, male offspring of hypertensives had generally lower anger-out and greater anger control and reflection scores than male offspring of normotensives. However, female offspring of hypertensives had relatively high anger-out and low anger control and reflection scores and reported feeling more badly when they suppress their anger compared to female offspring of normotensives. While the present investigation was a useful preliminary study, it is difficult to know the degree to which the results were influenced by subjects' attitudes and hunches concerning the purpose of the study. It is possible that people who were more aware of hypotheses linking the failure to express anger with the development of high blood pressure and other illnesses, including many women and offspring of hypertensives, reported the use of "healthy" emotional expression, or actually use it (Keane, Martin, Berler, Wooten, Fleece, & Williams, 1982). Research associating anger with hypertension and the inhibition of anger with hypertension is a fairly popular topic for mass media scientific reports (e.g., Blakeslee/New York Times, 1989; Spielberger & London/Psychology Today, 1990).

As a result, a second study was conducted to further obscure the focus on the relationship between risk for high blood pressure and anger. That is, individuals who had previously participated in studies in this laboratory were not recruited, the study was described in more general terms as an investigation of behavioral factors (i.e., not personality) in health, the health questionnaire was expanded to include further items about different diseases and other behaviours which might influence disease, and several questionnaires assessing other aspects of personality were included in the packet. As well, the more widely used Hostility subscale of the MMPI was employed in Study 2 (Costa, Zonderman, McCrae, & Williams, 1986; Christensen & Smith, 1993; Sallis, Johnson, Trevorrow, Kaplan, & Hovell, 1987; Smith & Frohm, 1985). The Hostility (Ho) scale measures a slightly different construct than the SA-Rn, that is, anger based in a cynical mistrust of people (Costa et al., 1986; Smith & Frohm, 1985). Finally, measurements of blood pressure were also obtained in Study 2, allowing for an additional estimate of risk for hypertension.

STUDY TWO

Portions of this research were presented at the Society for Behavioral Medicine meeting: Adler, P.S.J., Ditto, B., & France, C. (1992, April). The relationship of hostility and parental history to resting blood pressure. Paper presented at the meeting of the Society for Behavioral Medicine, New York.

Method

Participants

Two hundred and sixty three individuals (148 females, 115 males) drawn from two university communities, McGill University (Montreal, Canada) and Ohio University (Athens, Ohio) completed a questionnaire packet. The Canadian sample consisted of 153 subjects, the American sample included 110 subjects. The majority of participants were undergraduate students. Subjects were asked to participate in a study of behavioral factors in health and entered into a lottery with cash prizes of $100 and $50 if they agreed. Data from three subjects were dropped from analyses because they reported a personal history of hypertension. None of the remaining subjects had a systolic blood pressure greater than 140 mmHg, a diastolic blood pressure above 90 mmHg, or reported any significant health problems. Individuals were regarded as having a parental history of hypertension if they reported at least one hypertensive biological parent without a history of kidney disease or diabetes. Subjects were classified as being without a parental history of hypertension if they reported that neither of their biological parents ever suffered from hypertension. The data from 20 subjects who said they were not sure of the hypertension status of one or both of their parents or who reported a parental history of hypertension in the context of diabetes or kidney disease were dropped from all analyses. Thus, the final sample consisted of 240 subjects, 178 without and 62 with a parental history of hypertension. Of these 240 subjects, 211 individuals (158 parental history negative, 53 parental history positive) had their blood pressure and heart rate measured. There were no significant differences between subjects who had their blood pressure measured and those who did not in age, parental age, or parental history of hypertension.

Materials and Apparatus

Cook-Medley Hostility (Ho) Scale. A total scale score (Cook & Medley, 1954) and three subscale scores were obtained from the Ho Scale: Costa et al.'s (1986) Cynicism and Paranoid Alienation subscales, and Houston, Smith, and Cates' (1989) Reactivity subscale. The Ho total scale score is seen as being multidimensional. It has been variously described as assessing "cynical hostility" (Smith & Frohm, 1985) and "cynical mistrust" (Costa et al., 1986). High scores on the Paranoid Alienation subscale presumably indicate feelings of persecution and emotional isolation. High scores on the Reactivity subscale were interpreted by Houston et al. (1989) as indicative of a person who has negative and aggressive feelings towards others but who suppresses aggression and denies these feelings in order not to alienate people. Subjects who scored highly on the Reactivity subscale manifested exaggerated systolic blood pressure responses to laboratory stressors in

Houston's study.

Subjects also completed scales to assess hypochondriasis (Whiteley Hypochondriasis Index; Pilowsky, 1967), neuroticism (Neuroticism Scale of the Eysenck Personality Inventory; Eysenck & Eysenck, 1968), and optimism (Life Orientation Test; Scheier & Carver, 1985; Scheier & Carver, 1987). As in Study 1, subjects completed the State Anger Reaction Scale (SA-Rn), the Anger Expression Scale (AX), and a questionnaire which inquired into present health status, participants' estimates of their personal chances of developing hypertension and other diseases, family history of other diseases, height, weight, exercise level (hours per week sweat through exercise), as well as caffeine, nicotine, and alcohol intake during the hour prior to participation.

Blood pressure was measured using Lumiscope Model 1060 digital monitors. Manufacturer documentation for this device indicates an accuracy of $\pm$ 3 mmHg.

Procedure

After completing the questionnaire packet the subject sat for a five minute rest period. Two recordings of blood pressure were then obtained three minutes apart. The cuff was placed on the subject's non-dominant arm which was supported at heart level. The subject was informed of the readings and debriefed.

Results

Parental history of hypertension was not found to be significantly associated with age ($X = 21.3 \pm 3.6$ years), body mass index ($X = 22.3 \pm 2.9$), or any other potential confounding variable (e.g., exercise level, recent caffeine or nicotine, or alcohol consumption).

A parental history of hypertension X gender X site MANOVA was conducted using the scores on the following nine scales as the dependent variables: SA-Rn, all four AX subscales, and the Ho's Total, Cynicism, Paranoid Alienation and Reactivity scales. The main effect of site was significant ($F(9,223) = 5.48$, $p < .01$). The American sample obtained higher scores on the Ho Total, Cynicism, and Reactivity scales (all ($F(1,231) > 8.60$, $p < .01$). The significant main effect of site, however, must be interpreted in light of a significant parental history of hypertension X site effect ($F(9,223) = 2.31$, $p < .05$). Univariate tests revealed significant parental history of hypertension X site interaction effects for the Ho Reactivity ($F(1,231) = 7.98$, $p < .01$) and AX/Fear subscales ($F(1,231) = 5.30$, $p < .05$). American subjects with a parental history of hypertension had significantly greater Ho Reactivity and AX/Fear scores when contrasted with the other three sub-groups (Table 1).

This association seems to have been specific to anger as the results of a comparable parental history of hypertension X gender X site MANOVA of neuroticism, hypochondriasism, and optimism scores did not reveal a significant parental history effect. This MANOVA revealed only significant main effects of site ($F(3,229) = 4.36$, $p < .01$) and gender ($F(3,229) = 2.83$, $p < .05$). Univariate tests revealed significant effects of site and gender for neuroticism ($F(1,231) = 9.87$ and 5.61 respectively, both $p < .05$). American subjects had higher neuroticism scores than Canadian subjects (13.7 ± 4.1 vs. 11.8 ± 4.1) and females had higher scores than males (13.5 ± 3.9 vs. 11.7 ± 4.4).

Table 1

Anger Coping Scores (mean +/- SD) of Canadian and American Subjects With and Without a Parental History of Hypertension

		Canada	U.S.A
Ho Reactivity			
	PH-	13.0 $\pm$ 1.6	13.2 $\pm$ 2.0
	PH+	12.3 $\pm$ 2.1	14.1 $\pm$ 2.1
AX Fear			
	PH-	8.3 $\pm$ 2.9	8.0 $\pm$ 2.8
	PH+	8.0 $\pm$ 2.8	9.8 $\pm$ 2.5

A parental history of hypertension X gender X site ANOVA was conducted using subjects' ratings of their perceived risk for hypertension as the dependent variable. Significant parental history ($F(1,225) = 17.70$, $p < .01$) and site main effects were found ($F(1,225) = 12.24$, $p < .01$). Parental history positive subjects rated their chances of developing hypertension as greater than parental history negative subjects (X = 41 vs. 30 %). American subjects rated themselves as being at higher risk of developing hypertension than Canadian subjects (X = 37 vs. 30%). These results do not change with the addition of neuroticism, optimism, and hypochondriasism scores as covariates suggesting that the elevated perceived risk of offspring of hypertensives is mainly due to their awareness of their parental history of hypertension and not due to more global "neurotic" traits.

To examine the relationship between parental history of hypertension, hostility, and resting blood pressure, a Ho Scale (low, medium, high terciles) X parental history of hypertension X gender X site MANOVA was conducted using systolic and diastolic blood pressure as the dependent variables. Significant main effects of gender ($F(2,186) = 30.01$, $p < .01$) and site ($F(2,186) = 3.38$, $p < .05$) were found, as was a significant Ho Scale X parental history of hypertension interaction ($F(4,374) = 2.43$, $p < .05$). In univariate analyses, men averaged higher systolic blood pressure than women (X = 119.3 ± 10.6 vs. 107.7 ± 9.2 mmHg; $F(1,187) = 46.02$, $p < .001$). Univariate ANOVAs did not reveal significant site differences in either systolic or diastolic blood pressure although the significant multivariate effect was due to a tendency of American subjects to manifest higher levels. Finally, subjects with a parental history of hypertension who scored either in the middle or top third of Ho scale scores had the highest resting diastolic blood pressures ($F(2,187) = 3.82$, $p < .05$; Figure 1).

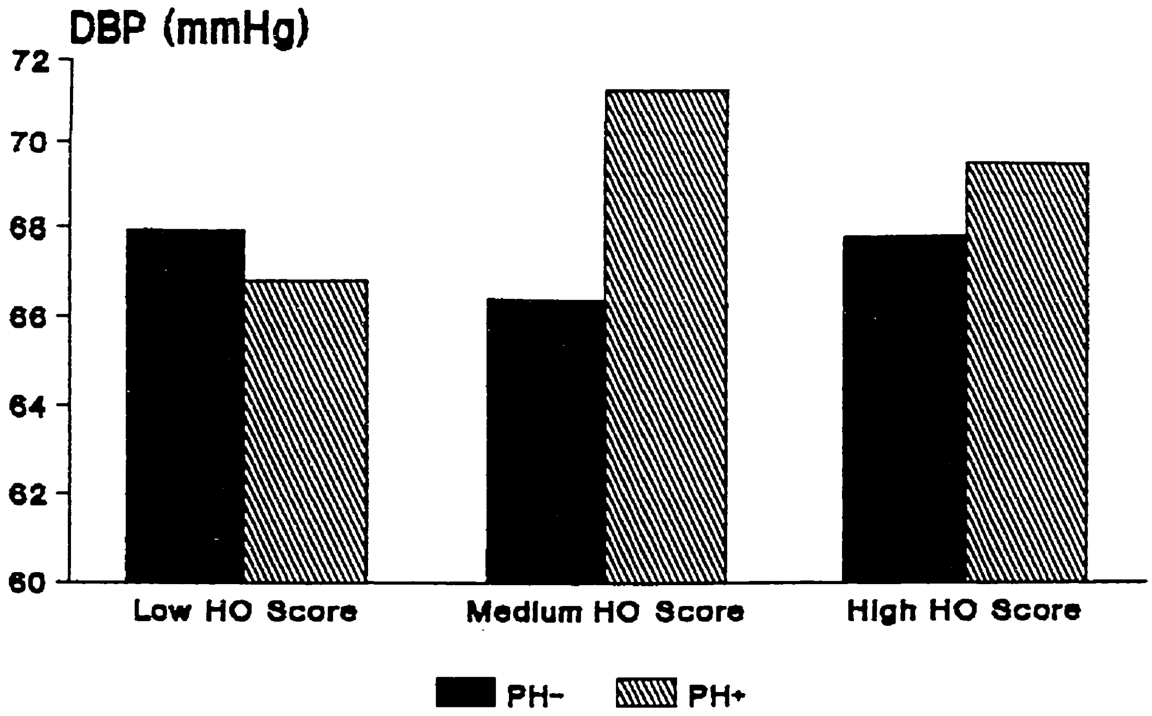

Figure 1. Mean diastolic blood pressure (DBP; mmHg) for subjects with and without a parental history of hypertension (PH+,PH-) within terciles of HO scale scores.

Discussion and Preface to Study Three

There was no evidence of an association between emotionality, at least as defined by subjects' self-reports of their tendency to experience anger, and the presence or absence of a parental history of hypertension in the first two studies. On the other hand, some modest group differences between offspring of hypertensives and normotensives in reports of coping with anger provoking situations were observed. In Study 1, male offspring of hypertensives had lower Anger Expression Scale anger-out and higher anger control-and-reflection scores than male offspring of normotensives, although this trend was reversed among women. In addition, women with a parental history of hypertension reported the greatest tendency to feel badly after suppressing anger. In Study 2, American college students with a parental history of hypertension had greater Anger Expression Scale "fear of anger" scores and higher scores on another measure reflecting the suppression of anger, the Ho Reactivity Scale, although there were no differences in a comparable Canadian sample. These results are somewhat consistent with evidence of more gaze aversion on the part of offspring of hypertensives during simulated conflict (Baer et al., 1983) or interpersonal challenge (Semenchuk & Larkin, 1993), and with previous observations of a tendency to suppress anger in established hypertensives (Dimsdale, Pierce, Schoenfeld, Brown, Zusman, & Graham, 1986; Esler et al., 1977; Schneider et al., 1986). Nevertheless, despite the design improvements in Study 2, there is reason to be skeptical of the value of these self-reports. For example, offspring of hypertensives consistently rated their chances of developing the disorder themselves as higher than offspring of normotensives, and they may have had opinions about this risk. Many people in the general population confuse high blood pressure with being emotionally "hypertense" (Blumhagen, 1980) and it may not be surprising for a high risk group to report greater "fear of anger". However, when ratings of probability for developing hypertension were added as a covariate to the parental history X gender X site MANCOVA of anger variables the parental history X site interaction effect remained significant.

A finding of note was the significant interaction between parental history and hostility on diastolic blood pressure which is suggestive that hostility is related to resting blood pressure in normotensives, at least among those genetically at risk for hypertension. Given that current blood pressure is the best predictor of future blood pressure (Julius & Schork, 1978) the present results suggest that parental history positive individuals who scored in either the mid or high range of cynical hostility are at increased risk for future hypertension. Whether this reflects the "triggering" of genetic risk by hostility or the possibility that hostility is one component of risk remains an interesting question.

In sum, while useful initial studies, these investigations led to several studies in which direct observations of the reactions of individuals with and without a parental history of hypertension to emotional situations were made.

STUDY THREE

The present study examined the behavioral and physiological responses of offspring of hypertensives and normotensives to the cold pressor test and a laboratory analogue of an anger provoking situation. This allowed an examination of possible group differences in emotional reactivity to stress which was less affected by biases in recall than may have been present in the first two studies. Subjects were also divided on the basis of self-reported propensity to experience anger and anger-out scores to examine moderation of the effects of parental history of hypertension on physiological reactivity to stress by emotionality, a possibility suggested by the results of Study 2 and other research (e.g., Manuck et al., 1985). Finally, the use of a non-traditional laboratory stressor involving interpersonal interaction makes the findings useful in regards to the issue of the generalizability of past findings concerning family history of hypertension to real-life stress due to the greater ecological validity of the stressor.

Method

Participants

Twenty-four undergraduate males who indicated parental hypertension on the health questionnaire of either Study 1 or Study 2 and 24 who did not indicate parental hypertension were tested in the present study. A questionnaire was sent to each parent to confirm the presence or absence of hypertension. Replies were obtained from 92 of the possible 96 biological parents. Only one subject provided an incorrect initial report of the hypertension status of his parents. The absence of kidney disease and diabetes in a hypertensive parent was used as a criterion in an attempt to eliminate from consideration subjects whose parent's hypertension was secondary to a common medical condition (Jorgensen & Houston, 1986). With the following two exceptions, data from subjects whose parents did not return their questionnaires or who reported accompanying kidney disease or diabetes were not included in the analyses. That is, for two subjects, one parent returned a questionnaire indicating a history of hypertension without kidney disease or diabetes while the other parent did not return the questionnaire. These subjects were coded as confirmed offspring of hypertensives. To confirm each subject's normotensive status, his blood pressure was measured after a 10 minute adaptation period. An average resting systolic blood pressure of 140 mmHg or greater or diastolic blood pressure of 90 mmHg or greater was considered grounds for discontinuation. No subject's participation was terminated based upon this criterion. Thus, in total, the data from 44 normotensive males, 22 with and 22 without a parental history of hypertension as confirmed by parental reports, were included in the analyses. Subjects reported being abstinent from caffeine, nicotine, and alcohol for at least four hours prior to testing. Subjects received $15 and a ticket for a lottery with a prize of $50 for their participation.

Apparatus

Measurements of systolic and diastolic blood pressure (SBP, DBP; in mmHg) were obtained at three minute intervals throughout the experiment using a Critikon Dinamap 845XT automatic blood pressure monitor. The blood pressure cuff was placed on the subject's non-dominant arm. Heart rate (HR; in bpm) was derived from an electrocardiogram recorded using two disposable Medi-Trace electrodes placed in a bipolar configuration on opposite sides of the ribcage. The signal was amplified and a continuous record was obtained using a Grass Model 7P4 tachograph amplifier and a computer. Digital skin temperature (DST; in °C) was monitored using a thermistor attached to the first phalange of the subject's middle finger. The thermistor lead to a Thought Technology 201T module and the computer.

Questionnaires

State Anger Reaction Scale (SA-Rn Scale). The SA-Rn Scale (Johnson et al., 1987) assesses the intensity of anger experienced in a variety of stressful and frustrating social situations.

Anger Expression Scale (AX). The AX (Spielberger et al., 1985) measures the frequency that anger is expressed. The present study used two of the scale's original non-orthogonal scores. These were the anger-in subscale, which assesses the tendency to suppress anger expression, and the anger-out subscale, which assesses the tendency to express anger behaviourally.

Situation Appraisal Rating Scale (SARS). The SARS (Adler, 1988) is used to assess an individual's appraisals of an upcoming situation along the themes of: (1) potential for situational control, (2) potential for self control, (3) potential threat, and (4) potential challenge. The choice of appraisal themes is based mainly upon the work of Lazarus and Folkman (1984). The SARS consists of 10 bipolar items composed of contrasting statements (e.g., The experience will be pleasant vs. I may experience discomfort or pain) at the ends of 10 cm lines. Each item refers to one of the above-mentioned themes. Subjects place a mark across each line to indicate the degree to which one statement better reflects their views regarding the upcoming situation. The scores for the statement pairs associated with each appraisal target are added together and the average represents the subject's score on that particular appraisal theme.

Dimensional Coping Checklist. The DCC (Adler, 1988[2]) is used to assess the coping methods used by subjects during discrete periods of a laboratory protocol. That is, subjects indicate which type of coping efforts they used during the most recent phase or task, e.g., the cold pressor test. The DCC yields three scores. The first indicates the object of focus (environment vs. self); the second indicates the main direction of coping in relation to the object of focus (approach vs. withdrawal); the third addresses the form of coping production (active vs. passive). The DCC consists of 24 items which subjects are asked to endorse if the statement describes their thoughts or actions during the period specified. Each item has the potential to contribute to the assessment of one or more of the coping dimensions.

Profile of Mood States (POMS). The POMS is a 65 adjective rating scale used to measure six mood or affective states. For the purposes of the present study, only two of the six mood factors were included in an abbreviated version, i.e., the Tension-Anxiety (TA) and the Anger-Hostility (AH) scales. Although the original TA and AH scales are comprised of nine and twelve adjectives respectively, only five

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[2]Both the SARS and the DCC were developed by Danny Kaloupek, Ph.D.

from each scale were used. The adjectives selected received the highest factor loadings in a variety of studies (McNair, Lorr, & Droppleman, 1971).

Pain Ratings. Subjects were asked to estimate their pain on a 10 cm visual analogue scale with end legends of no pain and unbearable pain at 15 second intervals during the cold pressor test. Visual analogue scales of this type have been shown to be a fast and reliable way of recording self-reported pain (Litt, 1988).

Procedure

The experiment was conducted in a sound attenuated room with the physiological recording equipment housed in a separate room. After being seated in an armchair, the subject completed an informed consent form and questionnaires assessing video game experience and caffeine, nicotine, and alcohol consumption during the previous four hours.

The subject then witnessed a 90 second demonstration and explanation of the video game "Ms. Pacman", but was not given an opportunity to practice the game. He was told that eligibility for a lottery of $50 was contingent on his highest game score exceeding a (hypothetical) score that 75% of players had been able to reach in prior studies. After attachment of the physiological recording apparatus, the subject was allowed a 15 minute adaptation period.

The actual experimental protocol was divided into five periods consisting of two experimental stressors and three rest periods. It began with a nine minute pre-task rest period. During the first three minutes of this period the subject completed the Situation Appraisal Rating Scales with reference to the upcoming cold pressor test.

During the cold pressor the subject's dominant hand was placed up to the wristfold for two minutes in a cooler containing 4°C water. The subject was requested to keep his hand still while it was submerged. The subject was then given one minute to dry his hand. This was followed by another nine minute rest period. During the first three minutes of this rest period the subject completed the Dimensional Coping Checklist and the POMS with reference to his experiences during the cold pressor test. During the last three minutes of this rest period the subject completed the Situation Appraisal Rating Scales with reference to the upcoming video game. Six minutes of video game play was followed by a final twelve minute post-task rest period. During the first three minutes of this final rest period the subject completed the Dimensional Coping Checklist and the POMS with reference to his experiences during the video game and the Situation Appraisal Rating Scales with reference to the post-task rest period. During the post-task rest period's last three minutes the Dimensional Coping Checklist and the POMS were completed with reference to this final rest period. The subject was debriefed after the physiological recording apparatus was detached. The experimenter was kept blind to subject group classification.

Video games have been used in a number of studies as laboratory stressors (McKinney et al., 1985; Miller & Ditto, 1988; Sims, Carroll, Turner, & Hewitt, 1988). The present study sought to increase the relevance of such a stressor to a study of the associations between stress, anger, cardiovascular responsivity, and hypertension by adding three elements to the experience. First, the information regarding eligibility for a lottery ticket was meant to instill a competitive atmosphere. Second, the subject was deceived regarding the difficulty of exceeding the criterion. In fact only 8% of attempts were successful at surpassing the criterion during pilot testing. Third, in an effort to cause feelings of irritation, an experimenter in the control room activated a tape recording halfway through the video game task. The subject heard the following remark, "Excuse me, we told you to try your best, please try harder" over an intercom speaker. It was hoped that feelings of frustration and irritation would be engendered in the subject due to his not being able to beat a score supposedly exceeded by a majority of previous players and the consequent ineligibility for a lottery, in addition to being subtly accused of not trying his best.

Data Analysis

Preliminary analyses revealed no significant differences between the parental history positive and negative groups in body mass index, pre-task resting baseline systolic or diastolic blood pressure, heart rate, or skin temperature. The groups did not differ on any baseline score of the Situation Appraisal Rating Scale, Dimensional Coping Checklist, or Profile of Mood States. There were no significant group differences in experience playing video games in general or Ms. Pacman in particular, nor in highest or total scores achieved during the video game task or pain reported during the cold pressor test. However, subjects with a parental history of hypertension were older than the offspring of normotensives (M = 24.2 $\pm$ 5.8 vs. 20.9 $\pm$ 2.5 years; $t = 2.23$, $p < .05$). To deal with the potential confounding effect of age, it was entered as a covariate in all analyses.

To assess possible group differences in mood, self-reported appraisal and coping styles during the stressors, three parental history of hypertension (positive, negative) X period (cold pressor task, video game) repeated measures MANCOVAs were conducted using age as a covariate. One MANCOVA was conducted on the four Situation Appraisal Rating Scale themes (situational control, self control, threat, challenge). A second was conducted on the three Dimensional Coping Checklist scores (focus, production, direction of coping) and a third on the modified POMS anger-hostility and tension-anxiety subscales.

Measures of each of the physiological dependent variables were averaged to obtain means for the pre-task resting baseline, the cold pressor test, and the pre- and post-remark segments of the video game task period. Change scores were calculated by subtracting resting baseline values from task values. To assess the effects of individual differences in anger experience and anger expression on physiological reactivity to stress, in addition to parental history, subjects were split into groups based on the median SA-Rn and AX/anger-out scores (analyses using anger-in scores yielded comparable results). A four-way repeated measures multivariate analyses of covariance (MANCOVA) of physiological change scores was conducted with parental history of hypertension (positive, negative), anger experience (high, Low SA-Rn score), and anger expression (high, low anger-out score) as between-subjects factors, period (cold pressor task, video game pre-remark, game post-remark) as a within-subjects factor, and age and baseline values of the physiological measures as covariates (Manuck, Kasprowicz, Monroe, Larkin, & Kaplan, 1989).

Results

Behavioural Measures

Profile of Mood States. The MANCOVA of POMS scores obtained following the stressors revealed a significant period effect ($F(2,41) = 8.71$, $p < .01$) and a significant effect of parental history ($F(2,40) = 3.32$, $p < .05$). There was a significant period effect on POMS anger-hostility scores with more anger being reported after the video game ($M = 2.7 \pm 3.3$) than after the cold pressor test ($M = 0.7 \pm 1.7$; $F(1,41) = 16.96$, $p < .001$). This effect supports the validity of the manipulation. While neither main effect of parental history attained significance in univariate ANCOVAs of POMS scores, there was a mild trend for parental history positive subjects to report greater anger than parental history negative subjects across conditions ($M = 2.2 \pm 2.7$ vs. 1.2 ± 1.2, $F(1,41) = 2.97$, $p = .09$).

Situational Appraisal Rating Scales. The MANCOVA of Situation Appraisal Rating Scales revealed a significant period effect ($F(4,39) = 16.41$, $p < .01$). Univariate ANCOVAs revealed significant period effects on subjects' appraisals of potential for control over the situation ($F(1,41) = 36.80$, $p < .001$), threat ($F(1,41) = 44.05$, $p < .001$), and challenge ($F(1,41) = 5.12$, $p < .05$). Subjects saw themselves as having the potential for greater control over the environment during the video game than during the cold pressor test. They also appraised the upcoming video game as having greater potential for threat and challenge than the cold pressor.

Dimensional Coping Checklist. The MANCOVA of data derived from the DCC revealed a significant period effect ($F(3,40) = 19.34$, $p < .01$). Significant period effects were uncovered for each of the three DCC dimensions ($F(1,41) > 9.10$, $p < .01$ for all). In general, subjects reported using more self-focused, withdrawing, passive coping methods during the cold pressor test than during the video game (focus: CPT = 44.8 $\pm$ 10.4, VG = 54.3 $\pm$ 8.5; direction: CPT = 47.3 $\pm$ 8.6, VG = 54.3 $\pm$ 6.7; production: CPT = 35.1 $\pm$ 16.2, VG = 44.2 $\pm$ 14.9)). No group differences in coping styles during the stressors were noted.

Physiological Measures

The parental history X anger experience X anger expression X period MANCOVA revealed a significant period main effect ($F(8,23) = 2.68$, $p < .05$), a significant anger experience X anger expression X period interaction ($F(8,23) = 3.52$, $p < .01$), and a significant parental history X period interaction ($F(8,23) = 2.68$, $p < .05$). Significant period effects were observed in all four univariate ANCOVAs. The systolic blood pressure effect was due to greater reactions to the cold pressor test and the second, post-criticism phase of the video game compared to the first phase of the video game (Table 1). The diastolic blood pressure effect was due to greater responses to the cold pressor test than either phase of the video game. Consistent with previous research concerning the differential cardiovascular effects of "active" and "passive" coping stressors (Obrist, 1976; Obrist, Gaebelein, Teller, Langer, Grignolo, Light, & McCubbin, 1978), heart rate reactivity revealed the opposite pattern of diastolic blood pressure reactivity, that is, greater responses. Finally, skin temperature decreased only following the critical comment during the video game (Table 1).

Table 1

Mean (SE) Physiological Change Values Observed During Cold Pressor Test and Video Game (Pre- and Post-Remark) for Parental History Negative (PH-) and Parental History Positive (PH+) Subjects

	Cold Pressor Test	Video Game Pre-Remark	Video Game Post-Remark
SBP (mmHg)			
PH-	14.5 (2.2)	12.9 (1.7)	17.2 (2.1)
PH+	17.6 (2.3)	9.4 (1.6)	14.9 (1.8)
DBP (mmHg)			
PH-	16.4 (2.0)	13.4 (1.6)	12.8 (2.0)
PH+	21.8 (2.5)	9.4 (1.8)	11.5 (1.2)
HR (bpm)			
PH-	3.9 (1.2)	13.0 (1.8)	12.9 (2.2)
PH+	4.5 (1.0)	9.0 (1.9)	8.8 (1.8)
Skin Temperature (°C)			
PH-	-0.2 (0.3)	-0.4 (0.4)	-1.5 (0.4)
PH+	0.7 (1.4)	0.8 (1.4)	-0.3 (1.4)

The significant three-way interaction in the MANCOVA was due to an effect on systolic blood pressure ($F(2,36) = 5.68$, $p < .01$). Individuals who reported a greater tendency to experience more intense anger but not express it behaviourally manifested larger systolic blood pressure responses than subjects also reporting a greater tendency to experience anger but who tend to demonstrate it (i.e., high SA-Rn and high anger-out), but only to the cold pressor test ($M = 23.5 \pm 9.9$ vs. 9.2 ± 10.6 mmHg). Finally, the parental history X period interaction in the MANCOVA was due to a significant effect on diastolic blood pressure ($F(2,40) = 4.15$, $p < .05$). Offspring of hypertensives manifested greater diastolic blood pressure responses than offspring of normotensives to the cold pressor test but not to either phase of the video game (Table 1).

Discussion

The present findings provide only modest evidence that normotensive offspring of hypertensive individuals exhibit greater cardiovascular responsivity to stressors relative to offspring of normotensives. The evidence is considered modest because greater reactivity on the part of individuals with a parental history of hypertension was clearly noted only in one physiological variable, diastolic blood pressure, and was manifested only during exposure to the cold pressor test and not during the video game task, a more active stressor. While differences between offspring of hypertensives and normotensives in cardiovascular reactivity to the cold pressor test have been noted (Shapiro, 1961; Johnson et al., 1991) they appear more reliably in response to active stressors (Ditto, 1986; Hastrup et al., 1982; Schneiderman &

McCabe, 1989). The lack of clearer parental history group differences in cardiovascular reactivity to the active stressor is additionally curious given the report of greater negative affect experienced by offspring of hypertensives and the fact that both groups reported greater anger during the video game.

Although it is not possible to determine with certainty whether the critical remark truly elicited anger or irritation, the higher anger scores following the video game are consistent with this belief. It is also interesting to note the skin temperature results. Comparative studies of the peripheral physiological effects of different emotional states have often pointed to particularly large increases in vascular resistance during anger (Ax, 1953; Sinha, Lovallo, & Parsons, 1992; Sternbach, 1966). For example, the results of a classic series of studies of different hypnotic suggestions indicated particularly large decreases in skin temperature when subjects were encouraged to feel the need to take hostile physical action (Sternbach, 1966). The skin temperature results, combined with the expected differential effects of cold pressor test and the video game on cardiovascular reactivity and POMS, SARS and DCC results, provide reason to believe that the experimental manipulations were at least partially successful. Thus, the overall findings of the study seem to provide another example of the relative independence of physiological and emotional reactivity to stress in offspring of hypertensives (Jorgensen & Houston, 1986; Lamensdorf & Linden, 1992). The results do, however, modestly complement past findings that offspring of hypertensives experience greater emotional reactions in response to stress than parental history negative individuals (Ditto & Miller, 1989; Jorgensen &

Houston, 1981; Holroyd & Gorkin, 1983; Melamed, 1987; Perini et al., 1990; Sausen et al., 1991), although it is curious that a significant effect was observed only in the MANCOVA of POMS scores. There were no group differences in the appraisal or coping with stressors. However, as there are few published reports regarding parental history group differences in coping style and, to our knowledge, none regarding appraisal styles, continued investigation of these two topics is in order.

Finally, just as there was no evidence that emotional reactivity mediated differences in cardiovascular reactivity between offspring of hypertensives and normotensives, it does not appear to have moderated group differences in cardiovascular reactivity as suggested by Manuck et al. (1985). That is, the differences between offspring of hypertensives and normotensives in cardiovascular reactivity did not depend on frequency of experienced or expressed anger. The only interaction involving anger came from the systolic blood pressure ANCOVA. Greater increases in systolic blood pressure were observed among subjects with a tendency for greater anger intensity and less behavioural expression of anger as compared to those who also experience anger intensely but express it. Curiously, however, this was observed only during the cold pressor test and not the task which one might think more relevant to this interaction, i.e., the video game.

In summary, the present results suggest that cardiovascular reactions to stress may be influenced not only by family history of hypertension but also by characteristics of the stressor and of the individual's personality, although there were no simple connections between these variables.

Preface to Study Four

The previous study provided modest evidence that individuals with and without a parental history of hypertension differ in both their psychological and cardiovascular reactions to stress, although the two did not appear to be related. However, it is possible that the anger-provoking stimulus in this study was not sufficiently intense or personally relevant to observe an association, and the focus on anger-provoking situations may have been too limiting. In the following study, subjects were asked to describe a number of stressful events in their lives which elicited different strong emotions.

STUDY FOUR

MANUSCRIPT UNDER REVIEW

Psychophysiological Effects of Interviews About Emotional Events on Offspring of Hypertensives and Normotensives

Perry S.J. Adler and Blaine Ditto

Department of Psychology, McGill University, Montreal, Quebec, Canada

Portions of this research were presented at the American Psychosomatic Society meeting: Adler, P.S.J., & Ditto, B. (1992, April). Cardiovascular and affective responses of offspring of hypertensives and normotensives to emotional stressors. Paper presented at the meeting of the American Psychosomatic Society, New York.

Abstract

Normotensive individuals with a parental history of hypertension have been found to exhibit greater cardiovascular reactivity to a variety of laboratory stressors than offspring of normotensives. To examine the possible generalization of these differences to real-life stressors, subjects were administered four brief interviews about different emotional events in their lives. Regardless of emotional content, offspring of hypertensives displayed greater systolic blood pressure responses to the non-verbal recollection and verbal description of personal emotional events, but not to the imagination of standardized emotional scenes or reading a non-emotional advertisement. This suggests that group differences in reactivity may generalize to real-world situations. Evidence of significantly greater vasoconstriction during interviews about sad topics was also observed, contributing to the literature on the physiological differentiation of emotional states.

Keywords: hypertension, parental history, family history, cardiovascular reactivity, naturalistic stress, emotion.

Psychophysiological Effects of Interviews About Emotional Events on Offspring of Hypertensives and Normotensives

Normotensive individuals with a parental history of hypertension have been found to exhibit greater cardiovascular reactivity to a variety of laboratory stressors than offspring of normotensives (Fredrikson & Matthews, 1990). This reactivity may be a marker or a risk factor for the development of hypertension (Menkes, Matthews, Krantz, Lundberg, Mead, Qaquish, Liang, Thomas, Pearson, 1989). However, there are a number of important outstanding issues in this research area. For example, a number of studies have not observed exaggerated cardiovascular reactivity in offspring of hypertensives (Muldoon, Terrell, Bunker, & Manuck, 1993). This is probably related to the fact that the most popular design, i.e., comparing the responses of individuals with one hypertensive parent to those of individuals with no hypertensive parents, is not the most powerful family design as most offspring of hypertensives never develop clinical hypertension. Nevertheless, individuals with one hypertensive parent are approximately twice as likely to develop high blood pressure as individuals with no hypertensive parents (Stamler, Stamler, Riedlinger, Algera, & Roberts, 1971; Williams, 1991) and it is possible that risk may be partially conferred by enhancing sensitivity to the effects of daily life stressors.

However, this possibility depends on another important question in this research area, that is, the generalizability of group differences in cardiovascular reactivity to stressors outside the laboratory. While a number of investigators have observed significant correlations between responses to laboratory and real-life stressors, the stability of group differences in reactivity is by no means assured. For example, Matthews, Manuck, and Saab (1986) found no differences between offspring of hypertensives and normotensives in heart rate or blood pressure response to the naturalistic stressor of public speaking. The present study compared the cardiovascular reactivity of individuals with and without a parental history of hypertension to laboratory stressors. The stressors are more similar to real-life stress than typical laboratory-based tasks, such as mental arithmetic or videogames.

Interviews concerning real-life stressful events may be particularly useful for such applications (Dimsdale, Stern, & Dillon, 1988). In addition to the interpersonal aspect of interviews, it is likely that discussions of real-life stressful events derive some of their impact from the similarities in response to imagined stressors and their real-world counterparts (Lang, Kozak, Miller, Levin, & McLean, 1980). For example, Orr, Pitman, Lasko, and Herz (1993) found that men with traumatic wartime experiences who were asked to imagine these experiences displayed greater heart rate and skin conductance responses than other veterans who were asked to recall their combat experiences. These differences disappeared when former ground combatants were asked to imagine a standardized combat scene. Similarly, McNeil, Vrana, Melamed, Cuthbert, and Lang (1993) found that dental phobics displayed greater heart rate responses to imagery of dental content than social phobics but normal responses to other types of imagined stressors. In contrast, social phobics were more likely to display exaggerated heart rate responses to the act of imagining a classroom speech, although there were no differences between groups in reactivity to the scene which each subject indicated as maximally arousing. This suggests that asking people to think about and discuss events which are most troubling to them will elicit responses which are comparable in magnitude, at least in rank order, to those displayed in real life.

Further, while responses to thinking about and discussing previous events are typically smaller than those observed in real life, such activities can sometimes have quite strong effects on peripheral physiological activity. Dimsdale, Stern, and Dillon (1988) found that an interview about the most troubling event in a person's life can have quite pronounced effect on blood pressure within a brief period of time, such as 2-4 minutes. The interview increased normotensives' systolic blood pressures approximately 20 mmHg, compared to a more modest value of approximately 10 mmHg for mental arithmetic. Thus, the present study focsused on asking offspring of hypertensives and normotensives to think about and discuss stressful life experiences.

Lamensdorf and Linden (1992) used this strategy in a previous study. They found that offspring of hypertensives exhibited greater diastolic blood pressure responses to a group of stressors which included discussion of the most frustrating person or event in their lives. However, this difference was also noted when the subjects discussed a neutral topic, the weather. To address the issue of the importance of speech, the present study expanded on this approach by including periods during which subjects simply thought about stressful events. Subjects were also asked to think about and discuss experiences consistent with four different emotional states, anger, anxiety, sadness, and happiness, as well as a neutral topic. It was hoped that this would provide a more complete picture of their reactions to a variety of emotional experiences.

Finally, given the use of interviews about emotional events, the present study also addressed the classic question of the physiological differentiation of emotions. Curiously, this question has received relatively little study, at least in relation to its status as one of the classic issues in psychophysiology (Averill, 1969; Ax, 1953; Levenson, Ekman, & Friesen, 1990; Sinha, Lovallo, & Parsons, 1992; Schwartz, Weinberger, & Singer, 1981).

Method

Participants

Twenty-four healthy normotensive male undergraduate offspring of hypertensives and 18 offspring of normotensives were tested in the stress protocol described below. Potential subjects were recruited from the general student population of McGill University using in-class announcements, sign-up sheets, and questionnaire distribution tables around campus. Requests for confirmation of hypertensive status were sent to a number of individuals whose sons had indicated they were hypertensive as well as age-similar individuals whose sons had indicated they were normotensive. The offspring of hypertensives used in the present study each had at least one parent who returned a questionnaire indicating that they had been told by their doctor they were hypertensive, defined as a sustained blood pressure over 140/90 mmHg. None reported a history of diabetes or kidney disease.

Both parents of the other 18 subjects returned questionnaires indicating no history of hypertension. Offspring of hypertensives and normotensives did not differ significantly in age (M = 22.9 $\pm$ 3.5 vs. 22.5 $\pm$ 3.9 years), parental age (M = 53.4 $\pm$ 6.0 vs. 53.4 $\pm$ 7.5 years), body mass index (M = 22.5 $\pm$ 5.0 vs. 22.9 $\pm$ 2.0 $wt/ht^2*10000$), ethnicity (all of European descent), or current medication use (none). Subjects were asked to refrain from caffeine and nicotine for six hours prior to the experiment. They were paid $15 for participating in the study.

Apparatus

Measurements of systolic and diastolic blood pressure (in mmHg) were obtained at three minute intervals throughout the experiment using a Critikon Dinamap 845XT automatic blood pressure monitor. The blood pressure cuff was placed on the subject's non-dominant arm. Heart rate (in bpm) was derived from an electrocardiogram recorded using two disposable Medi-Trace electrodes placed in a bipolar configuration on opposite sides of the ribcage. The signal was amplified and a continuous record obtained using a Grass Model 7P4 tachometer, Coulbourn A/D equipment, and a computer. Continuous measurements of an index of vascular constriction, blood volume pulse amplitude (in units), were obtained using a Grass Model PPS photoplethysmograph attached to the first phalange of the subject's non-dominant third finger. The signal was amplified by another Grass Model 7P4 amplifier and transmitted to the computer. Skin conductance readings (in uSiemens) were obtained continuously through the protocol using a Grass DC amplifier, the computer, and large Beckman electrodes attached to the first phalanges of the subject's non-dominant index and second fingers. The computer used Dataq CODAS software and sampled heart rate, blood volume pulse, and skin conductance at 10HZ. The equipment was housed in a separate room from the one in which the subject was interviewed.

Questionnaires

Profile of Mood States (POMS). The POMS (McNair, Lorr, & Droppleman, 1981) is an adjective rating scale used to measure six mood or affective states: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment.

Questionnaire Upon Mental Imagery (QMI). A shortened, 35-item version (Sheehan, 1967) of Betts' original 150-item questionnaire was used. The QMI attempts to measure an individual's ability to produce vivid imagery. Each of the 35 images are rated on a 1 (perfectly clear and as vivid as the actual experience) to 7 (no image present at all) scale.

Imagery and Absorption Ratings. Two ratings were obtained at various points in the study to assess the subject's ability to visualize a situation and the extent to which he felt that what he was imagining was actually happening. The vividness ratings were obtained using the same 7-point scale as the QMI. The absorption ratings were obtained using a 7-point scale with anchors of 1 (felt as if really happening to me) and 7 (felt totally detached).

Marlowe-Crowne Social Desirability Scale. An abbreviated version of this scale which assesses the tendency to present oneself in a socially desirable manner which may not be reflective of the truth (Reynolds, 1982).

Procedure

The subject was seated in an armchair and underwent a 25 minute adaptation period during which he provided informed consent for the experiment, had the physiological recording equipment attached, and completed the Marlowe-Crowne Social Desirability Scale, the QMI, and a questionnaire concerning recent consumption of caffeine and nicotine, and other activities. The experimenter then asked the subject to sit quietly for seven minutes while resting baseline measurements were obtained and left the room. A three-minute period during which the subject completed the first POMS followed. Four nine-minute stress interview procedures concerning angry, anxious, happy, and sad events were then completed in a counterbalanced order.

During the first three minutes of each procedure, the subject was asked to read and vividly imagine three brief self-referent descriptions (full list available on request) of situations with a common emotional theme, such as sadness (e.g., Someone very close to you has died. You begin to realize that you will never see, hear, or touch them again. Any plans that you had which involved this person will never be realized.). For each emotion, ten hypothetical scenarios were initially created. These were reduced to three by examining the ratings of a group of 16 male university students regarding the degree to which they judged them to be emotionally evocative. To reduce the impact of experimental demand, the scenarios were not labelled as sad situations, happy situations, etc. After three minutes of imagining these standardized scenes, the subject was asked to recall a situation from his past that was similar to one of the more emotionally evocative descriptions he had just read and remember the details as vividly as possible. Two minutes were allowed for this phase of the interview. During the final four minutes of each procedure, the subject was asked to describe this past event to the experimenter, a practicing clinical psychologist. To increase the likelihood of the subject recounting his past experiences as vividly as possible, he was told that experimenters would review a recording of his recollections (which were not actually taped) and score the vividness of detail and strength of emotion experienced. Similar to previous research (Dimsdale, Stern, & Dillon, 1988), the experimenter prompted the subject to continue his description whenever he fell silent for more than ten seconds (e.g., where are you...what are you doing...what do you feel). The number of prompts given was noted. Except for the prompts offered by the experimenter, all instructions for the imagery procedures were delivered via pre-recorded audio tapes to maximize consistency in administration. To minimize eye contact and demand characteristics, the experimenter sat to the side facing in the same direction as the subject. The experimenter who interacted with subjects was blind to their parental history of hypertension.

Each interview was followed by a six minute inter-task rest period. During the first minute of this period, the subject completed the imagery and absorption scales with reference to the preceding interview. He then completed a POMS and sat quietly for the remainder of the time. The experimenter was not present in the room during these periods.

After completion of the four interviews and their corresponding rating periods the subject completed a three minute neutral speech period and a nine minute post-stress recovery period. During neutral speech the subject read aloud a magazine advertisement for an automobile.

Following the experimental protocol, the subject was debriefed and paid. Debriefing included asking the subject about his reactions to the imagery procedures and having him complete a POMS which was reviewed to insure that he did not report being in an overly negative state. A subject would be identified as being in an excessively negative state if he reported feeling two or more of the negative affect descriptors at a moderate or greater than moderate level and if these last ratings were elevated compared to his baseline ratings. No subject met this criterion or requested additional time for discussion.

Data Analyses

Measures of the physiological variables were averaged to obtain means for the pre-task baseline and neutral speech periods, as well as for each of the three phases within each of the four stress interview periods. The effects of group and the different stress interview procedures were assessed using 2 (Parental History) x 4 (Stress Interview) x 3 (Stress Interview Phase) repeated measures of covariance (ANCOVAs) of change from pre-stress resting values using pre-task baseline values as a covariate. To allow direct comparisons between subscales of the Profile of Mood States, each subscale score was converted to a measure of the percentage of the highest obtainable score. The effects of group and stress interview procedures on

POMS scores were then determined using a 2 (Parental History) x 4 (Stress Interview) x 6 (POMS Subscale) ANOVA. To guard against possible violations of the assumption of the homogeneity of covariance, multivariate tests of significance were used for all effects involving repeated measures. The criterion for statistical significance used in the study was $p < .05$.

Results

There were no significant group differences in imagery ability (QMI score), social desirability (Marlowe-Crowne score), initial mood (first POMS), or baseline physiological activity (Table 1). Two (Parental History) x 4 (Stress Interview) repeated measures ANOVAs revealed no significant effects on post-interview imagery (M = 2.7) or absorption (M = 3.4) ratings, or in the number of prompts during each interview (M = 2.1). The imagery and absorption ratings suggested fairly vivid recollection of past events.

Physiological Response to Stress Interviews

Significant main effects of Stress Interview Phase were observed for all five physiological measures indicating increasing arousal as each period proceeded. Since the different parts of the interview procedures were not counterbalanced (e.g., imagining hypothetical emotional events always preceded imagining a personal emotional event) it is not possible to make any firm conclusions about their relative impact, although this may suggest a greater effect of the recollection of personal experiences. The only other significant effect in the systolic blood pressure ANOVA was the Parental History x Stress Interview Phase interaction ($F(2,38) = 3.91$).

Separate analyses for each of the three phases revealed that this was due to significantly greater systolic blood pressure responses to both the imagination and discussion of personal emotional events in offspring of hypertensives compared to offspring of normotensives regardless of interview topic (Figure 1). The Parental History x Stress Interview Phase interaction effect also approached significance in the ANOVA of heart rate responses ($F(2,38) = 2.69$, $p = .08$) suggesting a similar trend.

The only other significant effects in the ANOVAs of the other physiological measures were main effects of Stress Interview on diastolic blood pressure ($F(3,37) = 4.21$) and finger pulse amplitude ($F(3,37) = 3.32$) responses. The diastolic blood pressure effect was due to significantly greater responses to the interview about sad events ($M = 11.5 \pm 5.2$ mmHg) compared to the interviews concerning angry ($M = 10.0 \pm 6.5$), anxious ($M = 10.0 \pm 5.7$), and happy ($M = 9.9 \pm 6.5$) events (all $t(41) > 2.01$). No significant differences in diastolic blood pressure response were observed between the latter three interviews. Similarly, the finger pulse amplitude main effect was due to evidence of significantly greater vasoconstriction during the interview about sad than anger-provoking events ($M = -1.45$ vs. - 1.31 units, $t(40) = 2.54$). The interview about anxiety-provoking events also produced greater vasoconstriction than the interview about anger-provoking events ($M = -1.44$ vs. - 1.31 units, $t(40) = 2.47$). Response to the interview about happy events was intermediate ($M = -1.36$) and not significantly different from any of the others.

Mood Scores

The POMS ANOVA produced significant main effects of stress interview topic ($F(3,38) = 11.70$) and subscale ($F(5,36) = 14.94$) as well as a significant stress interview topic by subscale interaction effect ($F(15,26) = 4.29$). While it cannot be determined if these changes were due to demand characteristics or the genuine production of emotion, the patterns of POMS subscales scores were consistent with the interview topics (Figure 2). For example, the anger subscale was most elevated following the interview about anger-provoking events, the depression subscale was most elevated following the interview about sad events, etc. The only other significant effect in this ANOVA was the Parental History x Stress Interview interaction effect ($F(3,38) = 5.05$). This effect is difficult to interpret as post-hoc analyses failed to reveal any significant group differences following specific interviews. The interaction seems to have been due to a trend for subjects with a parental history of hypertension to report more dysphoria following the interview about anger-provoking events and less following the others.

Physiological Response to Non-Emotional Speech

For each physiological measure, change from pre-stress baseline to the person's average level observed during reading an ad was calculated. One-way analyses of covariance, using pre-stress baseline as the covariate, were conducted for each measure. There were no group significant differences in response. There were also no group differences in absolute levels (Table 1).

Discussion

Offspring of hypertensives displayed greater increases in systolic blood pressure than offspring of normotensives while thinking about and discussing emotional events in their lives. This suggests that this group, or at least male offspring of hypertensives, exhibits greater blood pressure responses to daily stressors (Dimsdale, Stern, & Dillon, 1988; Lang et al., 1980). Clearly, one limitation of the present results is the lack of generalizability to women. As well, the question of whether or not subjects experienced genuine and distinct emotions in this study remains open. While steps were taken to minimize demand characteristics, it is possible that the increase and modest patterning of Profile of Mood States scores following the different stress interviews was influenced by the social environment. Nevertheless, the group differences in systolic blood pressure response seem to have been at least somewhat dependent on the elicitation of affect as the act of reading a non-emotional advertisement did not produce group differences in cardiovascular activity, nor did the imagination of standardized emotional scenes.

Assuming that the results were at least somewhat dependent on the elicitation of emotion, one interesting finding is the greater reactivity of sons of hypertensives to thinking about and discussing both negative and positive events. This is a potentially important finding as, to our knowledge, no previous study comparing offspring of hypertensives and normotensives has examined reactions to the elicitation of positive affect. On the other hand, cardiovascular responses to joy, happiness, and humour have been found to be generally similar to those associated with fear (Schwartz, Weinberger, & Singer, 1981; Sinha, Lovallo, & Parsons, 1992) and thus the present findings may not be too surprising.

The other main finding of the study was the apparent effect of sadness on vasoconstriction, as suggested by greater diastolic blood pressure responses to the interview about a sad topic. The finger pulse amplitude results were also consistent with this conclusion, although the interviews about anxiety-provoking events produced similar reductions in finger pulse amplitude to those produced by the interviews about sad events. Previous research concerning the effects of different emotional states on cardiovascular activity has indicated that both sadness and anger are often associated with increases in vasoconstriction (Averill, 1969; Ax, 1953; Sinha, Lovallo, & Parsons, 1992; Schwartz, Weinberger, & Singer, 1981), possibly due to their common link with the idea of frustration. For example, Sinha, Lovallo, and Parsons (1992) found that an anger imagery procedure produced significantly larger diastolic blood pressure responses than those for fear, action, sadness, and joy. However, sadness had the next most potent effect on diastolic blood pressure, producing significantly larger responses than fear, action, and joy. Further, only sadness produced a significant increase in total peripheral resistance as measured by impedance cardiography. Schwartz, Weinberger, and Singer (1981) suggest that there may be a more stable effect of sadness than anger on vasoconstriction as they observed similar responses to depressing imagery before and during physical exercise. They noted that "sadness was the one case in which emotional state seemed to interfere with the cardiovascular adjustments normally associated with exercise" (p. 358), i.e., vasodilation. They speculate that this may be due to the fact that sadness is not a state conducive to action whereas anger may or may not be expressed in vigorous behaviour. The clinical importance of these findings remains to be seen. However, further study of the psychophysiological correlates of sadness seems particularly relevant in light of recent evidence linking depression to mortality in post-myocardial infarction patients (Lesperance, Frasure-Smith, & Talajic, 1996).

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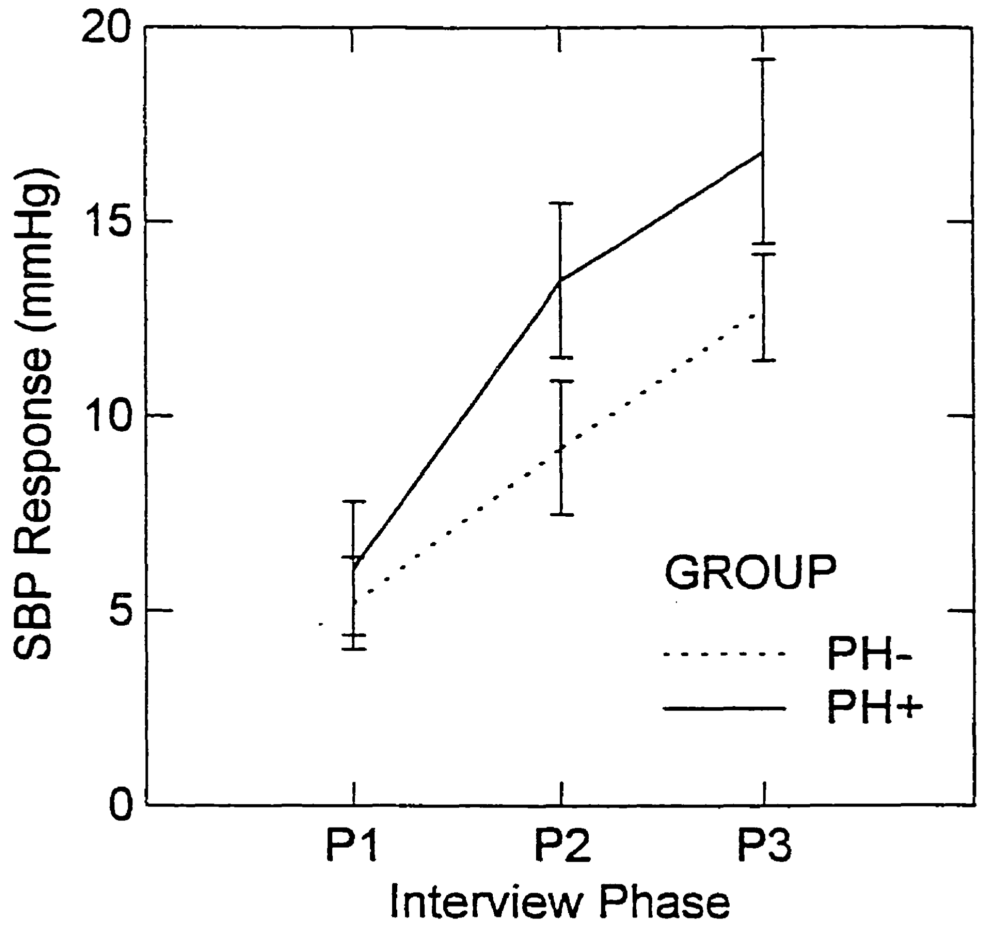
Table 1: Mean (SD) Physiological Values Observed During Pre-Stress Resting Baseline and Neutral Speech Periods

	PH-	PH+
Systolic Blood Pressure (mmHg)		
Baseline:	112 (8)	116 (9)
Reading:	118 (11)	124 (10)
Diastolic Blood Pressure (mmHg)		
Baseline:	63 (6)	66 (9)
Reading:	71 (10)	76 (9)
Heart Rate (bpm)		
Baseline:	69 (14)	66 (9)
Reading:	70 (11)	66 (9)
Blood Volume Pulse (units)		
Baseline:	2.8 (1.4)	2.1 (1.2)
Reading:	1.1 (1.0)	0.8 (0.9)
Skin Conductance (uSiemens)		
Baseline:	27 (12)	26 (14)
Reading:	38 (7)	36 (11)

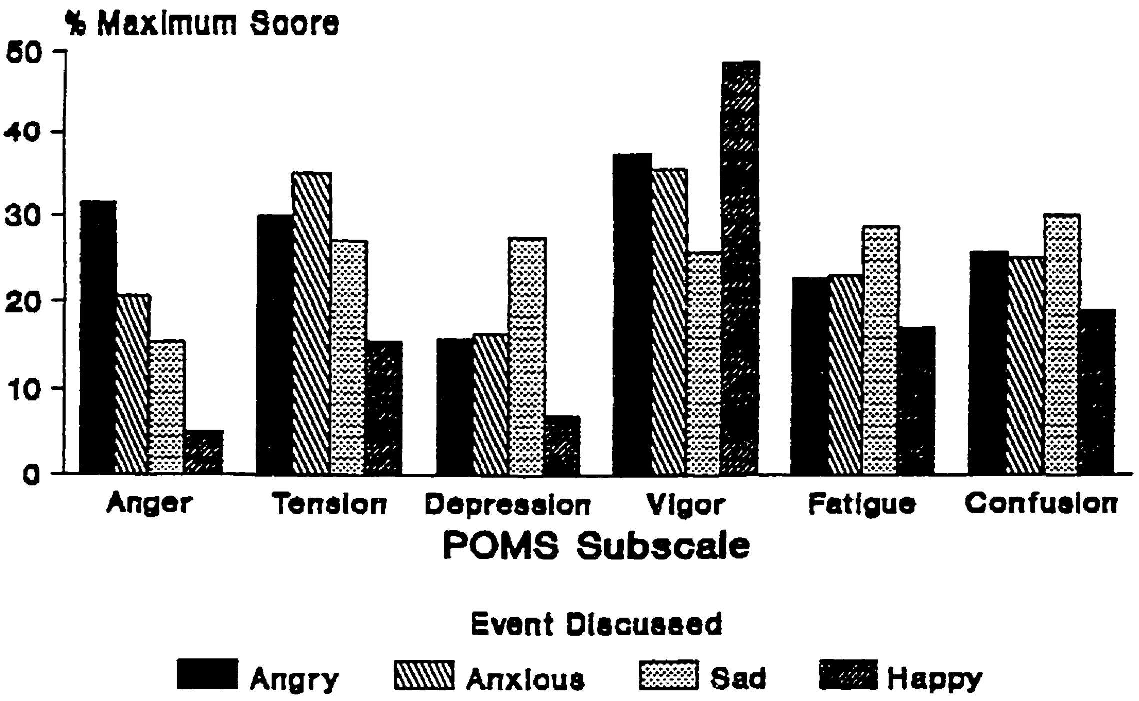
Figure Legends

Fig. 1. Systolic blood pressure responses (± SE) to thinking about standardized events, personal events, and discussing personal events.

Fig. 2. POMS subscale scores following different interviews.



20
15
10
5
0
SBP Response (mmHg)
GROUP
PH-
PH+
P1
P2
P3
Interview Phase


% Maximum Score
50
40
30
20
10
0
Anger
Tension
Depression
Vigor
Fatigue
Confusion
POMS Subscale
Event Discussed
Angry
Anxious
Sad
Happy

Preface to Study 5

The results of the previous study were consistent with those of the first three studies in that few differences between individuals with and without a parental history of hypertension in emotionality were noted, despite the use of stressors specifically designed to elicit affective responses. However, there was a trend for parental history positive subjects to report greater dysphoria during the anger induction. More importantly, individuals with a parental history of hypertension were found to exhibit significantly greater systolic blood pressure reactions to stressors which may have been more ecologically valid than those typically employed in this research area. To further examine the cardiovascular and emotional reactions of the two parental history groups under conditions even more akin to "real-life", while maintaining a high degree of standardization of stressor stimulus, the next and final study was conducted.

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CARDIOVASCULAR REACTIONS TO BLOOD DONATION IN OFFSPRING OF HYPERTENSIVES AND NORMOTENSIVES

PERRY S. J. ADLER,* BLAINE DITTO,* CHRISTOPHER FRANCE† and JANIS FRANCE*

(Received 12 February 1993; accepted in revised form 24 November 1993)

Abstract—Blood pressure and heart rate reactions of 182 confirmed offspring of normotensive (110 female, 72 male) and 112 offspring of hypertensive (66 female, 46 male) individuals to the stressor of blood donation were examined. Subjects were tested at two sites, one in the United States and one in Canada. Although influenced by site, young normotensive offspring of hypertensives generally exhibited significantly greater blood pressure levels in anticipation of donating blood than offspring of normotensives. The higher reactivity of offspring of hypertensives observed in stressful laboratory settings may generalize to more ecologically valid settings, even those which, like blood donation, require passive coping efforts.

Keywords: Blood Pressure, Parental History, Stress, Blood Donation.

REPEATED exposure to demanding or aversive stimuli has been linked to the development of sustained blood pressure increases in epidemiological research [1–4]. This has led to suggestions that exposure to stress may be a risk factor for essential hypertension. However, the relationship between stress and hypertension remains unproven. This is possibly because the influence of individual differences in susceptibility to the effects of stress has not been adequately addressed. The results of several prospective studies suggest a modest relationship between exaggerated blood pressure reactions to acute stress and the subsequent development of hypertension [5–9]. This association is strengthened by the results of a considerable literature linking family history of hypertension, a well-known genetic risk factor [10, 11], and cardiovascular reactivity to acute laboratory stress [12–21].

Unfortunately, the question of whether or not the results of this research concerning reactivity and genetic risk for hypertension are generalizable to responses to 'real life' stressors has been left virtually unaddressed. Fredrikson *et al.* [22] found that young normotensive individuals with a family history of hypertension exhibited higher daytime heart rate and blood pressure levels than individuals without a family history, while there were no differences between the two groups during sleep. Similarly, Wilson *et al.* [8] found that adolescents with a parental history of hypertension had greater diastolic blood pressure levels than offspring of normotensives during school hours, but not at rest. These results are encouraging as are those of several studies examining the comparability of individual differences in reactivity to laboratory stressors to those observed in the field [23, 24]. However, the comparability of lab and field measurements have at times been small and the

*Department of Psychology, McGill University.
†Department of Psychology, Ohio University.
Address correspondence to Perry Adler, Douglas Hospital, Behaviour Therapy Unit, 6617 Lasalle Blvd., Verdun, Quebec, Canada, H4H 1R3.

generalizability of the previously observed effect of family history of hypertension on cardiovascular reactivity to the field is by no means assured. In a study of the effects of parental history of hypertension on cardiovascular response to public speaking, Matthews and colleagues [25] found no differences between groups. However, only eight subjects with a parental history of hypertension participated. Thus, the main goal of the present research was to determine if the association between family history of hypertension and cardiovascular responsivity could be observed in a setting more akin to 'real life' conditions than typically found in laboratory-based studies.

Like Matthews *et al.* [25], it was decided to select a predictably stressful non-laboratory situation in which to assess blood pressure and heart rate responses. For several reasons, it was decided to use the stress of anticipating blood donation. First, although a voluntary and socially beneficial activity, blood donation is considered a stressful experience [26]. Second, blood donation clinics often process large numbers of volunteers, presenting the possibility of recruiting large numbers of subjects. This was hoped to reduce variance and increase confidence in results. Third, the standardized nature of blood donation procedures allows for greater confidence in between-subject comparisons than afforded by many naturalistic stressors. As such, the stressor used in the present study may be considered to be more naturalistic than those typically used, while maintaining a degree of standardization seldom obtainable outside the laboratory.

METHOD

Participants

Permission was obtained from the directors of several upcoming blood drives in Montreal (Canada) and in southeastern Ohio (U.S.A.) to recruit individuals who were presenting themselves to donate blood. The directors were assured that it would be clearly stated that participation in the study was an extra voluntary activity not part of the blood donation procedure, and that nothing would be done to discourage potential donors. Given that the requests made of potential participants were light, individuals were generally in a volunteering mood, and an incentive of a lottery ticket for a prize of $100 was offered, most individuals approached agreed to participate in the study.

Thus, 738 individuals were assessed briefly before and after their donations. Of these, it was possible to obtain blood pressure and heart rate measures from 469 individuals. The drop-off in subjects was primarily due to the limited number of available blood pressure monitors and our desire not to impede the donation process. A comparison between those who had blood pressures and heart rates measured and those who did not revealed no differences in age, body mass index, or gender distribution. The Red Cross policy is to accept blood only from healthy individuals. Some volunteers were rejected for reasons which included being infected with a contagious virus, iron deficiency, or reporting a personal history of hypertension. Thus, the present sample consisted of fairly healthy, young adult individuals.

Confirmation of parental history of hypertension was later obtained through return-mail self-reports from about 70% of the parents of those subjects from whom both questionnaire and cardiovascular data were obtained. A comparison between subjects whose parents did and did not return questionnaires revealed no differences in body mass index ($F(1,286) = 1.52$, $p = 0.22$; $M = 23.2 \pm 4.0$) or gender distribution. However, the two groups did differ in age ($F(1,462) = 8.571$, $p < 0.01$). Subjects whose parental histories were confirmed were generally younger ($M = 22.1 \pm 5.1$ vs 23.7 ± 6.6 yr). Primary reasons for an inability to confirm parental history were insufficient information to locate both natural parents due to subject adoption, or parental separation, divorce, or death and insufficient address information. This probably explains the finding that subjects whose parental medical history were confirmed were somewhat younger. That is, these parents were somewhat easier to locate.

Of the subjects from whom complete data were obtained, 182 individuals (110 female, 72 male) had no parental history of high blood pressure (PH−). In addition, 112 individuals (66 female, 46 male) were found to have at least one parent with high blood pressure not secondary to either kidney disease or diabetes (PH+). While the Canadian group was significantly larger than the U.S. group with 140 PH− and 76 PH+ subjects vs 42 PH− and 36 PH+ subjects, both sites produced good samples. Data was collected in two communities to increase sample size and generalizability of results. Enhanced generalizability was afforded by differences between the cities which included nationality of participants, population (3 million vs 40,000), and cultural background (Montreal being more multi-ethnic). That said, one limitation of the study was that subjects were virtually all Caucasian (96%).

Materials

Pre-donation questionnaire. This very brief questionnaire asked subjects to rate their current level of anxiety on a five-point scale ranging from 'not at all' to 'extremely anxious or nervous'. Respondents also reported whether they were hungry, and estimated their number of previous blood donations. Several questions shown to predict vasovagal reactions were also included [27].

Nurse's rating sheet. This questionnaire obtained the attending nurse's report of the subject's phlebotomy. The nurse rated the subject's anxiety level and the difficulty of needle insertion on five-point scales. The former scale ranged from 'not at all' to 'extremely anxious or nervous', whereas the latter ranged from 'much less' to 'much more difficult' in comparison with the average phlebotomy the nurse performs. The nurse also reported whether it was necessary to adjust the needle, whether the subject experienced unpleasant sensations severe enough to require the reclining of the donor's chair, and if a full unit of blood was obtained. A semi-standardized group presentation explaining the use of the questionnaire was made to nurses before the start of each donation clinic.

Post-donation questionnaire. This questionnaire obtained demographic information (e.g., age, height, weight), estimates of caffeine, cigarette, and alcohol consumption during the previous 6 h, and information regarding personal and parental medical history. Subjects were asked to retrospectively rate their pain levels at different points in the procedure. The pain information is the focus of a separate report [28]. Subjects were also asked to indicate their current anxiety level and which, if any, of eleven sensations sometimes associated with vasovagal reactions they experienced since arrival at the blood donation clinic.* The questions relating to vasovagal symptoms were part of another investigation. In addition, abbreviated versions of the Marlowe-Crowne Social Desirability [29] and Taylor Manifest Anxiety scales were completed [30].

Procedure

Subjects were solicited as they presented themselves for registration for blood donation. Each donor wishing to participate was asked to sit at a table adjacent to the registration area. After providing informed consent, the first of three blood pressure and heart rate measurements was taken using a portable digital monitor (Sunbeam Model 7621) approximately 2 min after the subject sat down. The monitor uses the oscillometric principle for pressure determinations and, according to the manufacturer, is accurate to within ± 3 mmHg for blood pressure and $\pm 5\%$ for heart rate. The monitor received the highest rating for accuracy in a recent test of fifteen blood pressure monitor models [31]. The second and third measurements were taken 2 and 4 min later. The cuff was placed on the subject's non-dominant arm which rested at heart level on the table.

In order to minimize the delay, the subject completed the pre-donation materials during the 4 min devoted to obtaining heart rate and blood pressure measures. The subject was asked to stop working, sit still, and not to talk during measurements. The subject then passed through the Red Cross blood donation procedure. The procedures used at the two sites were virtually identical, the main exception being that samples for blood typing were taken from a finger in Canada and from an ear lobe in the United States. The samples were taken after the pre-donation assessment and before the phlebotomy.

After completion of the phlebotomy, the subject proceeded to a rest area and the attending nurse completed the nurse's rating sheet. After resting on a cot for 5–10 min the subject proceeded to a refreshment area where food and beverages were provided free of charge. The donor was encouraged to complete the study protocol before consuming refreshments. The subject sat at a table seated in a position similar to that used for the pre-donation measurements and completed the post-donation materials while three additional blood pressure and heart rate measurements were obtained. Again, the subject stopped working, talking, and sat still during measurements. The results of a recent study indicate that the act of completing questionnaires during baseline periods does not significantly influence blood pressure and heart rate values [32]. As with the pre-donation measurements, each recording was separated by a two minute interval. The subject received a succinct debriefing as the last step of the procedure. Questionnaire data

*Nausea or upset stomach, lightheadedness, weakness, rapid or pounding heart beat, dizziness, excessive perspiration, blurred vision, rapid or difficult breathing, difficulty hearing, hot flushes, disturbance/loss of consciousness.

concerning the subject's family history of hypertension were not examined until after termination of the protocol. Thus, the experimenters were blind to parental history status throughout the procedure.

This report will focus on the relationships between parental history of hypertension, blood pressure and heart rate levels, and anxiety.

Data analyses

To assess differences in blood pressure and heart rate levels in anticipation of and after participating in a blood donation procedure three 2 Parental History (PH+, PH−) × 2 Gender (male, female) × 2 Site (Montreal, Ohio) × 2 Donation Phase (pre-, post-donation) repeated measures analyses of covariance (ANCOVAs) of systolic blood pressure, diastolic blood pressure, and heart rate were conducted. Given its strong association with blood pressure and heart rate levels [33–35], body mass index was used as a covariate in analyses of cardiovascular data. In fact, body mass was significantly correlated with systolic and diastolic blood pressure values obtained at both pre- and post-donation measurements (all $r > 0.23$, $p < 0.001$). Gender was included as an independent variable to see whether the associations between parental history of hypertension and blood pressure and heart rate would be replicable across gender, as previously found [36], or if significant gender by parental history of hypertension interactions would be uncovered [37]. Site was included as an independent factor to help detect possible confounding influences on the results. Donation phase served as an independent variable due to our expectation that differences between PH+ and PH− subjects would be more pronounced during the pre-donation phase of the procedure, since this phase was considered to be the more stressful of the two.

To assess group differences in reported anxiety during the stress of proceeding through a blood donation clinic a 2(parental history) × 2(gender) × 2(site) × 2(donation phase) repeated measures ANCOVA of anxiety ratings was conducted. The Marlowe-Crowne Social Desirability score was used as a covariate in order to control for possible bias introduced by the tendency to deny behaviours or feelings not culturally-approved, e.g. admittance of anxiety. The criterion for statistical significance used in the study was $p < 0.05$. All statistical tests were two-tailed.

RESULTS

Preliminary analyses revealed a significant difference in age ($F(1,291) = 3.99$, $p < 0.05$) between individuals with ($M = 22.6 \pm 5.9$) and without ($M = 21.6 \pm 4.3$) a parental history of hypertension. The two groups did not differ, however, in blood donation experience ($F(1,289) = 0.03$, $p = 0.87$; $M = 5$ times), recent cigarette, caffeine, or alcohol consumption, or pre-donation anxiety (all $F(1,292) < 1.41$, $p > 0.24$). The two groups also did not differ on frequency of reports of being hungry, reports regarding personal health status (e.g., presence of an illness), or current medication use (all $\chi^2(1) < 0.54$, $p > 0.45$). Subjects with and without a parental history of hypertension did not differ significantly on any of the items on the nurse's rating sheet (all Fs < 2.0, ps > 0.16, all χ^2s < 1.0, ps > 0.31), the Marlowe-Crowne Social Desirability ($F(1,292) = 0.08$, $p = 0.77$), or Taylor Manifest Anxiety ($F(1,291) = 0.43$, $p = 0.51$) scales. Thus, with the exception of age, the sample consisted of comparable groups of healthy young offspring of hypertensives and normotensives. To deal with the potential confounding effect of age, it was entered as a covariate in all analyses.

Systolic blood pressure

The systolic blood pressure ANCOVA yielded significant main effects of gender ($F(1,265) = 95.52$, $p < 0.001$), site ($F(1,265) = 13.76$, $p < 0.001$), and donation phase ($F(1,265) = 89.17$, $p < 0.001$). Males had higher systolic levels than females ($M = 124.8 \pm 12.5$ vs 110.5 ± 10.7 mmHg), the American sample averaged higher levels than the Canadian group ($M = 119.6 \pm 13.9$ vs 114.7 ± 13.0 mmHg), and pre-donation levels were significantly greater than those recorded post-donation ($M = 119.4 \pm 13.4$ vs 112.6 ± 13.3 mmHg). A significant parental history × phase interaction effect was also found ($F(1,265) = 5.10$, $p < 0.05$). In general, subjects with a parental history of hypertension had higher systolic blood pressure levels than parental history negative subjects only during the pre-donation phase. However, this interaction effect must be interpreted in light of a significant parental history × site × phase interaction effect ($F(1,265) = 7.54$, $p < 0.01$; Table I). Separate parental history × phase ANCOVAs of the data from the two sites revealed a significant interaction effect for the American sample ($F(1,70) = 7.08$, $p < 0.01$) and a parental history main effect which approached significance for the Canadian sample ($F(1,194) = 3.61$, $p < 0.06$). American subjects with a parental history of hypertension manifested higher systolic blood pressure levels than their counterparts without such a history only during the pre-donation phase. Within the Canadian sample, parental history positive subjects had marginally higher systolic blood pressure levels across both donation procedure phases. No other significant effects were observed in the overall ANCOVA.

Diastolic blood pressure

The results of the ANCOVA of diastolic blood pressure levels were somewhat more complex than those for systolic blood pressure. As a result, the ANCOVA table is presented in Table II. Similar to systolic blood pressure, the main effects of gender, site, and phase were significant. Parental history positive subjects also averaged higher diastolic blood pressures than those without a parental history of hypertension. These effects, however, must be considered in light of a number of significant interaction effects. In the present context, the two most important are the parental

TABLE I.—UNADJUSTED MEANS AND SD OF PRE- AND POST-DONATION BLOOD PRESSURE AND HEART RATE

		Pre-donation			Post-donation		
Group	*N*	SBP	DBP	HR	SBP	DBP	HR
Canada							
Female							
PH+	40	115.0	72.5	77.3	107.2	71.1	82.4
		(11.6)	(8.2)	(15.5)	(10.6)	(8.6)	(14.4)
PH−	79	111.6	71.9	78.6	104.6	68.4	79.3
		(10.5)	(8.7)	(14.3)	(9.0)	(6.7)	(12.2)
Male							
PH+	34	127.6	75.9	75.6	122.4	73.6	75.5
		(12.5)	(7.9)	(10.6)	(12.8)	(8.5)	(10.4)
PH−	46	125.3	72.4	72.3	117.8	70.7	73.3
		(11.5)	(8.7)	(13.5)	(11.8)	(9.0)	(12.9)
USA							
Female							
PH+	24	120.6	77.4	81.4	112.1	71.5	84.7
		(13.1)	(11.9)	(9.5)	(10.8)	(11.8)	(11.8)
PH−	25	113.6	71.2	79.9	110.1	70.2	84.2
		(9.4)	(8.0)	(12.1)	(10.4)	(11.0)	(11.1)
Male							
PH+	10	136.1	94.2	81.4	123.1	77.4	76.5
		(9.2)	(10.5)	(14.6)	(16.0)	(17.4)	(11.0)
PH−	16	131.9	82.8	77.8	128.4	80.4	80.3
		(11.3)	(10.6)	(13.1)	(12.9)	(12.1)	(11.5)

TABLE II.—REPEATED MEASURES ANCOVA OF DBP RECORDINGS

Effect	$F(1,265)$	$p <$
Parental History (PH)	4.74	0.05
Gender (G)	21.45	0.001
Site (S)	23.02	0.001
Donation Phase (DP)	54.43	0.001
PH × G	0.72	0.40
PH × S	0.49	0.50
G × S	12.79	0.001
PH × DP	14.42	0.001
G × DP	5.93	0.05
S × DP	13.01	0.001
PH × G × S	0.00	0.98
PH × G × DP	6.71	0.01
PH × S × DP	19.88	0.001
G × S × DP	7.77	0.01
PH × G × S × DP	2.16	0.15

history × site × phase and the parental history × gender × phase interaction effects. In regards to the first three-way interaction, separate parental history × phase ANCOVAs of data from the two sites were conducted. Within the American sample, subjects with a parental history of hypertension had significantly higher diastolic blood pressure during the pre-donation recordings only ($F(1,69) = 13.09$, $p < 0.001$; Table I). For the Canadian sample, the main effect of parental history of hypertension neared significance ($F(1,194) = 2.61$, $p < 0.11$), with parental history positive subjects having somewhat higher levels than those without a parental history of hypertension.

To explore the second three-way interaction separate parental history × phase ANCOVAs of the data from males and females were conducted. The interaction effect between parental history and phase neared significance ($F(1,102) = 3.55$, $p = 0.06$) for the males, with those having a parental history of hypertension exhibiting significantly higher DBP levels only during the pre-donation phase (Fig. 1). For the females neither the interaction nor the parental history main effect were significant. Significant phase effects were found for both males and females, with pre-being greater than post-donation levels.

Heart rate

The main effects of gender ($F(1,264) = 5.50$, $p < 0.05$), site ($F(1,264) = 5.62$, $p < 0.05$), and donation phase ($F(1,264) = 4.74$, $p < 0.05$) were all found to be related to heart rate. Females had higher heart rates than males ($M = 80.2 \pm 13.2$ vs 75.3 ± 12.3 bpm). American subjects manifested higher levels than Canadian participants ($M = 81.3 \pm 11.7$ vs 77.2 ± 13.4 bpm), and post-donation levels were on average greater than those during the pre-donation recordings ($M = 79.2 \pm 12.7$ vs 77.5 ± 13.4 bpm). These findings must be interpreted in consideration of two significant three-way interactions. Similar to diastolic blood pressure, the parental history × site × phase ($F(1,264) = 4.29$, $p < 0.05$) and the parental history × gender × phase ($F(1,264) = 4.58$, $p < 0.05$) interaction effects were significant (Fig. 2). Separate analyses of data from the two sites were conducted. Similar to the other measures a significant parental history × phase interaction was found for American

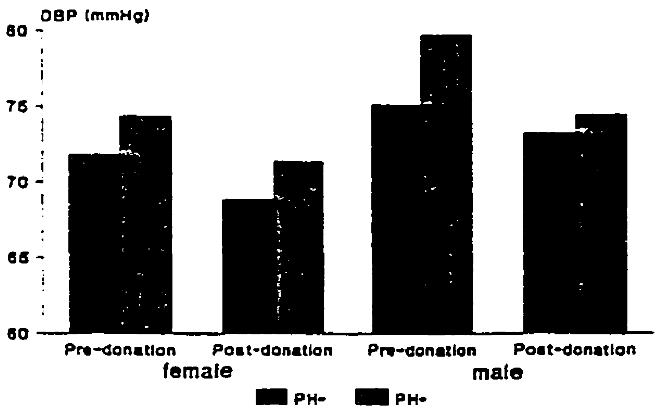

FIG. 1. Diastolic blood pressure values.

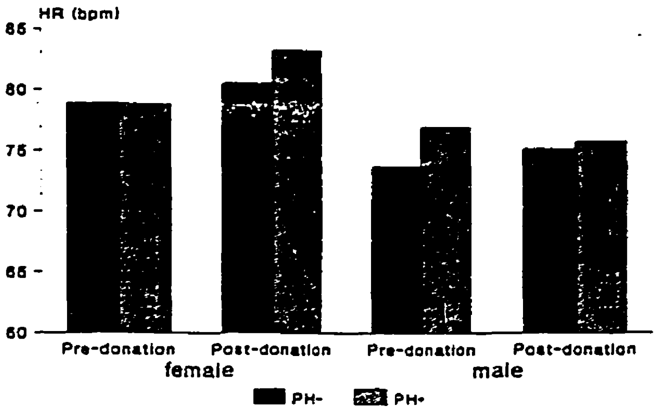

FIG. 2. Heart rate values.

subjects ($F(1,69) = 3.97$, $p = 0.05$). American individuals with a parental history of hypertension exhibited greater heart rate than those without such a history only during the pre-donation phase. There were no significant effects in the parental history × phase ANCOVA of data from the Canadian sample.

Separate parental history × phase ANCOVAs of the data from males and females found interaction effects which approached significance for both males ($F(1,103) = 3.52$, $p = 0.06$) and females ($F(1,164) = 2.71$, $p = 0.10$). Male subjects with a parental history of hypertension manifested significantly greater heart rates than males without a parental history only during the pre-donation phase. Within the female sample, parental history positive subjects had marginally higher heart rates during the post-donation phase only.

Anxiety

The anxiety ANCOVA revealed only a significant phase main effect ($F(1,270) = 19.34$, $p < 0.001$) with subjects reporting greater anxiety before ($M = 1.8 \pm 0.8$; or 'a little anxious or nervous') than after phlebotomy ($M = 1.2 \pm 0.5$; or 'not at all anxious or nervous').

DISCUSSION

The present results are consistent with the view that healthy normotensive offspring of hypertensives tend to demonstrate higher blood pressure levels during stressful situations than similar offspring of normotensives. Although a fair number of studies have shown parental history positive individuals to manifest cardiovascular hyperreactivity in response to laboratory stressors, the present study used a unique field stressor which can be considered somewhat more ecologically valid than many of those previously used. What is additionally noteworthy for a non-laboratory stressor is that a number of potential confounding variables, such as stressor duration and type, were fairly well controlled by the standardized nature of the blood donation experience. Added confidence in the study's findings is afforded by the significantly larger than usual sample size. To our knowledge, this project obtained the largest sample of confirmed parental history subjects to date.

Another notable aspect of the present study is that the majority of studies which found differences in blood pressure and heart rate between individuals with and without a parental history of hypertension used stressors requiring active coping, whereas the blood donation procedure can be considered to be more of a passive coping stressor. As such, the present findings are consistent with previous laboratory-based findings of elevated reactions to stressors which elicit passive coping, such as the cold pressor task [38] and forehead cold stimulation [39], among subjects with a family history of hypertension.

The significant effects of site on the cardiovascular measures were unexpected. They may be true reflections of differences between individuals living in the two countries in their blood pressure and heart rate responses to the stress of giving blood. For example, the Montreal sample was more ethnically diverse. The differences may, however, have been due to slight differences in the testing environments, such as ambient noise or the use of finger tip versus ear lobe blood samples.

The significant effects involving phase were expected as pre-donation recordings were expected to be influenced by anticipatory anxiety. Once the phlebotomy was finished, the subjects had but to rest, complete the protocol, and consume refreshments if desired. The ANCOVA of anxiety ratings was consistent with this view. As such, the post-donation phase was somewhat comparable to a post-stress resting baseline. One potential weakness of the study is that there were no true baseline measures obtained under sequestered, resting conditions. However, post-stress recovery periods are often used as resting baseline periods, and the majority of studies of normotensive offspring of hypertensives and normotensives have not found differences between the two groups in resting blood pressure and heart rate values [13, 14, 39, 40]. These findings may help explain the general lack of differences between subjects with and without a parental history of hypertension in blood pressure and heart rate during the post-donation phase.

Two potential qualifications to this argument deserve note. The first concerns possible hemodynamic consequences of blood donation. That is, post-donation values may not have reflected true resting levels very well given the effects of blood loss on cardiovascular regulation. However, the maximum amount of blood loss, 450 ml or about 9% of total blood volume, did not approach the level at which adverse effects are anticipated, i.e. greater than 30–40% [41, 42]. Indeed, the effects on blood pressure are negligible with blood loss less than 15 ml/kg of body weight [43] or

750 ml for a reasonably light 50 kg individual. As such, the phlebotomy should not have produced a significant effect on the blood pressures recorded after donation. It should be noted that the addition to the covariate list of the variable of whether or not a full unit of blood was obtained had no significant impact on the current findings.

The second possible qualification to the interpretation of the findings presented above concerns the finding that heart rate values were generally lower before donation. This finding, which appears to conflict with the blood pressure results, may simply be spurious. On the other hand, it is consistent with the results of considerable research indicating that stressors which do not permit active coping behaviors are likely to influence vascular activity to a greater degree than cardiac activity, and they even produce heart rate deceleration [44–47]. Indeed, the cardiovascular data may reflect the classic vasovagal response to such situations in which vascular constriction produces baroreflex-mediated heart rate deceleration [48]. In any case, regardless of the mechanisms, heart rate values of male offspring of hypertensives were still elevated compared to male offspring of normotensives in anticipation of donation.

In the present study the effects of parental history on diastolic blood pressure and heart rate reactions, but not systolic blood pressure reactivity, were modulated by gender. These findings differ from those of Jorgenson and Houston [19]. Their PH+ female subjects showed greater systolic blood pressure reactivity than the PH− females, while PH+ and PH− males showed equivalent responses. Both females and males demonstrated significant parental history effects in diastolic blood pressure and heart rate. As such, the present findings indicate that further research is needed to clarify the issue of the possible modulation of the effects of parental history of hypertension by gender.

In conclusion, the present study provides an example of how naturalistic studies may provide information about the generalizability of differences between normotensive individuals with and without a parental history of hypertension in blood pressure and heart rate response to stress.

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GENERAL DISCUSSION

Separate discussion sections followed each of the studies presented in this thesis. As such, in order to avoid redundancy, this last section will provide only a brief synthesis of the findings in order to offer a set of general conclusions and thoughts regarding directions for future research.

This research examined how a group at risk for hypertension, i.e., normotensive offspring of hypertensives, differed from controls in terms of biopsychosocial factors theoretically or empirically linked with the etiology of essential hypertension. One consistent finding of the research presented is that normotensive offspring of hypertensives tend to manifest exaggerated blood pressure reactions to stress in relation to comparable offspring of normotensives. These results are consistent with an already substantial literature reporting cardiovascular hyperreactivity as a tendency of offspring of hypertensives (Fredrikson & Matthews, 1990). As cardiovascular hyperreactivity has been linked with the development of hypertension in a number of prospective studies (Falkner et al., 1981; Matthews et al., 1993; Light et al., 1992; Wood et al., 1984), the present results provide additional evidence for the belief that the elevated risk for hypertension of parental history positive individuals may be at least partially due to this hyperreactivity, especially since the results suggest generalization of this reactivity to non-laboratory settings.

The evidence presented in this thesis that parental history positive individuals manifest exaggerated blood pressure responses is particularly notable due to the unique nature of some of the stressors used to elicit reactions. Care was taken to enhance the ecological validity of the stress encountered by the subjects with the aim of increasing the generalizability of the findings to real life situations. It is unlikely that the "anger" which subjects experienced in Studies 3 & 4 or the "fear" experienced in Studies 4 & 5 was identical in quantity and quality to what they experience in everyday life. However, the stressors probably elicited psychological reactions which were more similar to those experienced in day-to-day life than those produced by classic laboratory stressors such as mental arithmetic and the Stroop word-color interference task, while still maintaining high levels of standardization. Indeed, while blood donation is a somewhat unusual and circumscribed stressor, Study 5 is not really an analogue study but an examination of group differences in reactivity to a real life stressor.

Little support was obtained for the idea that individual differences in affective reactivity to stress mediate the influence of parental history on cardiovascular reactivity. Studies 3 & 4 observed some significant multivariate effects suggesting greater emotionality among offspring of hypertensives but there are some important qualifications. First, they are somewhat difficult to interpret given the fact that follow-up univariate analyses were not significant. While this may simply mean that the results are unreliable, it is also interesting to consider the possibility that differences in emotional responsivity between offspring of hypertensives and normotensives may not be confined to a specific construct such as anger but a broader construct such as Melamed's (1987) "emotional reactivity". This would be consistent with recent trends in the emotion literature emphasizing the general distinction between positive and negative affect rather than individual emotions (Watson, Clark, & Tellegen, 1988). Additional research is required to incorporate this idea on an a priori basis. Further, whatever differences may have existed in emotional responsivity between offspring of hypertensives and normotensives in the present research were not clearly associated with the effects of parental history on cardiovascular reactivity. Thus, these results are consistent with other studies which observed significant differences between individuals with and without a parental history of hypertension in cardiovascular reactivity in the context of no differences in emotional reactivity (Lamensdorf & Linden, 1992; Manuck et al., 1985). It therefore seems unlikely that differences in emotional reactivity account for a significant proportion of the differences between individuals with and without a parental history of hypertension in cardiovascular reactivity. It is important to note, however, that most studies examining group differences in emotional reactions have used self-report data and it is possible that individuals with a parental history of hypertension are less forthcoming or aware of their true emotional state. However, in regards to the former possibility, it is important to note that no differences in Marlowe-Crowne Social Desirability scores were observed in the present research. The Marlowe-Crowne scale is typically viewed as reflecting a tendency to present oneself in a socially desirable manner.

The issue of whether offspring of hypertensives are equally aware of their emotional state as offspring of normotensives presents a somewhat greater problem. For example, individuals with a parental history of hypertension might be more alexithymic than those without a family history of hypertension (Henry & Grim, 1990). Thus, it might be useful in future research to employ additional behavioral measures of emotion such as facial expression (Levenson, Ekman, & Friesen, 1990). McDonald and Prkachin (1990) found that alexithymics were less prone to spontaneous facial expressions of negative affect. Nevertheless, it is worth noting that the present research failed to observe group differences in a somewhat similar "objective" measure of emotion. That is, there were no group differences in nurses' ratings of blood donor anxiety in Study 5.

Examination of the effects of stressors on the acoustic startle reflex in those at risk for high blood pressure might also be a useful approach as this probe appears to offer a window onto the individual's emotional state (Lang et al., 1992). It has been found that probe responses, usually operationalized as electromyographic activity related to eye blink, are reliably potentiated during perception and imagery of unpleasant events and reduced during pleasant events (Cook, Hawk, Davis, & Stevenson, 1991; Vrana & Lang, 1990) and that those who experience high emotion show the greatest change in startle (Lang et al., 1990).

Nevertheless, while responses to startle stimuli were not assessed in the present research, a number of other physiological measures were obtained and there was little evidence of greater reactivity in offspring of hypertensives. For example, skin conductance has been related to fearfulness and behavioral inhibition (Fowles,

1980) and there were no group differences in skin conductance in Study 4. There were also no differences in the patterning of physiological responses which might be due to emotions. As discussed in Study 4, there is evidence that different emotions produce somewhat different patterns of peripheral physiological activity (Levenson et al., 1990; Sinha et al., 1992), a view consistent with some of the results of Study 4 (as well as some from Study 3). However, with the exception of greater systolic blood pressure reactivity to the imagination and discussion of personal emotional events, offspring of hypertensives did not differ in the amount or patterning of peripheral physiological response. One additional interesting feature of Study 4 was the observation of greater systolic blood pressure reactivity in offspring of hypertensives to the imagination of both negative and positive emotional events, such as winning a game. This strengthens the overall impression that many offspring of hypertensives have a somewhat generic predisposition to respond to stress with increased blood pressure many years before they develop a health problem.

A final qualification to the general lack of group differences in emotional reactivity concerns the fact that the simple paradigm of comparing individuals with and without one parent who has high blood pressure has been criticized for lack of power (Muldoon et al., 1993). It is possible that group differences might be observed using a "higher risk" group. Waldstein et al. (1994) observed clear differences between a group of individuals with two hypertensive parents and one with no hypertensive parents on several neuropsychological measures. Individuals with one hypertensive parent were generally intermediate on these measures and not as clearly distinguished from offspring of normotensives. Nevertheless, while the use of higher risk groups is certainly worth considering, the presence of a number of group differences in cardiovascular reactivity to stress in the present research combined with the general absence of group differences in emotional reactivity does not support the view that cardiovascular reactivity is driven by high emotionality.

Further, even if evidence is found for differences in emotionality between individuals with and without a family history of hypertension, these differences could be the product rather than the origin of the physiological reactivity often observed in parental history positive individuals (Williams, Barefoot, & Shekelle, 1985). For example, Smith (1994) has speculated that differences in predisposition to anger may be partially determined by genetic influences on autonomic reactivity. Jorgensen and Houston (1986) have suggested that parental history positive individuals who inherit a tendency towards high cardiovascular reactivity to stress may learn to suppress their emotional reactions in order to avoid the unpleasantness of their exaggerated reactivity. Further, both differences in emotionality and cardiovascular reactivity between parental history groups could derive from some third factor, such as hormonal imbalance. McCubbin and colleagues (McCubbin, Surwit, Williams, Nemeroff, & McNeilly, 1989) have proposed that the autonomic and hormonal reactivity of individuals at risk for high blood pressure may be partially determined by an insensitivity of certain hypothalamic neurons to negative feedback provided by endogenous opiates, which could lead to further autonomic and hormonal activity (France & Ditto, 1996).

On the other hand, although group differences in blood pressure reactivity may not stem from differences in emotionality, the results suggest that some minimal level of emotional response to an environmental demand may be required to elicit a difference in reactivity. The groups did not differ in responses to reading a non-emotional advertisement or imagining hypothetical life stressors. Of course, the groups did differ in diastolic blood pressure response to the cold pressor test, which could be viewed as a non-emotional "physical" stressor. However, it is widely agreed that response to the cold pressor test includes an emotional/motivational component (Lovallo, 1975), so this is not necessarily inconsistent with the idea that some degree of emotional engagement is required for the production of group differences. This issue is complex as, for example, some have observed differences between offspring of hypertensives and normotensives in cardiovascular response to physical exercise (e.g., Stoney & Matthews, 1988) while others have not (e.g., Ditto, 1986). It is interesting to speculate if such different findings are related to the psychological context in which the exercise task is presented, an issue which has received recent attention (Everson et al., 1996). Similarly, Lamensdorf and Linden (1992) found that offspring of hypertensives displayed greater diastolic blood pressure responses to a simple speech about the weather. Does this suggest a generic tendency for offspring of hypertensives to respond to many stressors, physical and psychological alike, with exaggerated increases in blood pressure, or that it only requires a relatively small emotional response (e.g., mild anxiety over giving a speech about the weather) to elicit a group difference in reactivity? In sum, the present results suggest that differences between offspring of hypertensives and normotensives in cardiovascular reactivity to stress may depend on at least a certain amount of emotional stimulation, but more research is certainly required to understand the mechanisms of enhanced cardiovascular reactivity to stress in this group.

Finally, the present results do not provide much support for the idea that differences between offspring of hypertensives and normotensives in cardiovascular reactivity to stress are moderated by individual differences in anger experience or expression[3]. Of course, this could be due to a number of methodological features such as a limited range of anger, the method of assessment of anger, etc. On the other hand, the results of Study 2 suggest that the effect of parental history on resting blood pressure in healthy young individuals is observed primarily among those who would obtain at least moderate scores on the widely used Cook Medley Hostility Inventory. While this study was not a true epidemiological investigation, this is an interesting finding and certainly deserves further examination.

Another idea worth pursuing is the possibility of subgroups of individuals with increased genetic risk for high blood pressure. The idea of the existence of subgroups who are differentially sensitive to various etiological factors is not new and parallels the notion of different subtypes of hypertensive patients and multiple etiologies for hypertension (Esler et al., 1977; Schneider et al., 1986; Thailer, Friedman, Harshfield, et al., 1985). The inconsistent findings on the relationship between anger

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[3]In addition to the analyses conducted in Study 3, comparable analyses were done in Study 4 which, although not discussed, did not yield any evidence of moderation.

and parental history of hypertension may not be too surprising given the likely probability that essential hypertension is not a homogeneous disorder but includes various types differing in etiology and pathophysiology (Weiner, 1979). There is evidence that anger plays a role in the development or pathophysiology of hypertension primarily in specific subgroups of hypertensives such as those with high renin levels (Esler et al., 1977; Perini, Amann, Bolli, & Buhler, 1982). Similarly, it may be that anger plays a role in the development of the hypertension only among certain subgroups of offspring of hypertensives. There are several interesting strategies one could use to pursue this issue. For example, Jorgenson and colleagues have used cluster analysis to identify different sub-groups of individuals with a family history of hypertension based on psychological profiles (Jorgensen, Gelling, & Kliner, 1992). In contrast, it might be interesting to conduct cluster analyses to determine sub-groups of offspring of hypertensives based on their pattern of physiological responsivity to stress similar to Allen, Boquet, and Shelley (1991), and to examine psychological differences between these groups.

Conclusion

In summary, study of the cardiovascular and emotional reactions to stress of offspring of hypertensives may provide important information concerning the development of stress-related hypertension in high-risk individuals. The present findings suggest that individuals with a parental history of hypertension are at risk for the disorder at least partially by virtue of greater cardiovascular reactions to stress. The stressors used had greater ecological validity than typically used allowing for greater likelihood of generalizability of the findings to real life. The cardiovascular hyperresponsivity of parental history positive subjects did not seem to be mediated by greater emotionality. However, the present findings support Manuck's (Manuck et al., 1985) contention that some degree of emotionality is required for parental history group differences to be manifested.

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IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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Rochester, NY 14609 USA
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Fax: 716/288-5989