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PREDICTABILITY AS A FACTOR IN BLOOD PRESSURE RESPONSE FOLLOWING ANGER AROUSAL

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James L. Abelson

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PREDICTABILITY AS A FACTOR IN BLOOD PRESSURE RESPONSE FOLLOWING ANGER AROUSAL

By

James L. Abelson

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ABSTRACT

PREDICTABILITY AS A FACTOR IN BLOOD PRESSURE
RESPONSE FOLLOWING ANGER AROUSAL

by

James L. Abelson

This study explored the role of the predictability of a frustrator's behavior in the reduction of blood pressure levels following anger arousal. Subjects were angered by a confederate in the context of an anagram solving task. They then interacted with the confederate by playing one of four different mixed-motive games. The four games were derived by crossing a predictable vs. unpredictable opponent strategy with a cooperative vs. exploitative game matrix. Systolic and diastolic blood pressures were recorded before and after anger induction and following the mixed-motive game. The instigation to anger produced elevations in both systolic and diastolic blood pressure. The cooperative vs. exploitative matrix type variable produced differences in subjects' behavior but not in blood pressure response. Systolic blood pressure decreased during the mixed-motive game regardless of matrix type and opponent strategy. Diastolic blood pressure decreased during games played against a predictable opponent strategy and increased during games played against an unpredictable opponent strategy. The differential responsiveness of systolic and diastolic blood pressure is discussed in terms of active/passive coping and vigilance. The data presented support the utility of mixed-motive games in studying the psychophysiology of interpersonal stress.

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CHAPTER I

INTRODUCTION

Aims of this Research

According to a corollary of the catharsis hypothesis, the experience of frustration arouses anger and elevates systemic arterial blood pressure; and the expression of aggression following anger arousal reduces the elevated blood pressure levels. The primary purpose of this study was to explore the role of a situational variable--called here predictability--in the arousal reducing capacity of the expression or nonexpression of aggression following anger arousal. It was hoped, further, that in attempting to identify more precisely the variables involved in blood pressure responses to interpersonal situations involving anger, a contribution would also be made to the clarification of the role of anger in the etiology of essential hypertension. Finally, this study involved the application of a new laboratory model to the study of cardiovascular response to social interaction. The efficacy of this model is of great interest as its full exploitation may contribute tremendously to our understanding of human physiological response to interpersonal stress.

Background and Theory

The Catharsis Hypothesis

The catharsis hypothesis of aggression has been the subject of intensive research ever since it was first stated in testable form by Dollard, Doob, Miller, Mower, Sears, Ford, Hovland, and Sollenberger in 1939. Despite over 36 years of research, however, catharsis continues to be the focus of considerable controversy, with a major new theoretical explanation appearing quite recently (Hokanson, 1974). Furthermore, catharsis has occupied a central position in many psychotherapeutic procedures (Worschel, 1957); and Nichols (1974) maintains that "emotional catharsis is currently enjoying a rennaissance of interest among psychotherapists" (p. 403). Nichols goes on to suggest that the "cathartic" display of emotion alone can produce desired behavioral changes. This idea resurrects Freud's original belief, which he later discarded, that the "display or experience of emotion could, by itself, bring therapeutic improvement" (Berkowitz, 1970, p. 2). While Freud did reject this proposition, the dynamic, drive-energy theory of emotion which underlies such an idea was maintained. It was the conceptualization of aggression as an innate drive energy that presses for expression and that, once expressed, leaves less to be expressed later on, that led to Dollard et al.'s (1939) original formulation of the catharsis hypothesis: "The expression of an act of aggression is a catharsis that reduces the instigation to all other acts of aggression" (p. 53).

A corollary of this proposition maintains that an instigation to aggression leads to a physiological arousal state that is sustained until cathartically released. Catharsis is here conceptualized as a feeling of pleasure or tension reduction following performance of aggressive responses. This latter proposition represents an entirely seperate aspect of catharsis in that the reduction of tension or emotional arousal does not necessarily imply a decreased likelihood of aggressive behavior (Berkowitz, 1958; Gambaro and Rabin, 1969).

The primary focus of research bearing on catharsis as tension reduction has been on the physiological concommitants (principally hemodynamics) of frustration and aggression. Much of the work has been done by J.E. Hokanson and his colleagues; and their findings have seriously complicated the simple hydraulic notion that frustration induces physiological arousal and aggression reduces that arousal.

Upon receiving aggression from another person, experimental subjects do show a reliable increase in vascular arousal, operationalized as increased systolic blood pressure (Stone and Hokanson, 1969). Hokanson and Shetler (1961) found, furthermore, that when a male recipient of aggression makes an aggressive counterresponse, there is a rapid reduction in systolic blood pressure; while males prevented from aggressing against their frustrator maintained elevated blood pressure levels. However, this rapid blood pressure reduction following an aggressive counterresponse did not occur when the frustrating agent was perceived by subjects as being of higher status, i.e., a professor as opposed to a fellow student. The authors suggest that tension reduction may take place when the subject makes a response which he perceives to be appropriate to the situation (aggression towards a lower status frustrator, nonaggression or withdrawal from a high status frustrator). Blocking these "appropriate" responses maintains systolic blood pressure at an elevated level. Aggression against a substitute target (someone other than the frustrator) is likewise ineffective in reducing elevated blood pressure (Hokanson, Burgess, and Cohen, 1963), supporting the idea that the perceived "appropriateness" of a response to a frustration determines its arousal reducing capacity.

Although "appropriateness" is utilized as an explanatory concept in both of the studies just cited, it is not clearly defined in either. The term is somewhat ambiguous because there are at least two related but different ways in which a given response can be perceived to be "appropriate" in a frustrating situation. A response can be perceived by a subject to be "appropriate" on the basis of his knowledge of social norms, or it can be perceived to be "appropriate" on the basis of the subject's present assessment of the conflict situation and the likely consequences of his available responses. These two perceptions are related in that knowledge of social norms could be gained through past experiences with the consequences of aggressive or nonaggressive responses to different frustrators. In any given situation, both prior experiences (which have shaped perceptions of social norms and expectancies) and present assessment of the immediate stimulus configuration probably play a role in determining the perceived "appropriateness" of available responses. In the above experiments there is nothing in the immediate stimulus configuration presented to subjects to counter the possible expectancy (based on prior experience) that aggression against a high status frustrator or an innocent bystander will result in negative consequences for the subject. Nonaggression is therefore perceived to be the "appropriate" response and reduces arousal. Used in this manner, the "appropriate" response is understood to mean: That response which is expected to be instrumentally effective in procurring positive consequences or in preventing negative ones. This definition will be implied whenever the word "appropriate" is used in this paper.

It is important to note that subjects in these experiments were placed in a forced-choice paradigm, i.e., whether they responded aggressively or nonaggressively was determined by random assignment to cells in the experimental design. In another experiment, subjects were merely given an opportunity to counteraggress against a frustrator (Hokanson and Burgess, 1962). In this non-forced-choice paradigm little acutal aggression was expressed; but the opportunity to respond to a low status frustrator reduced elevated blood pressure, while the opportunity to respond to the high status frustrator maintained elevated pressures. A control group that did not experience the initial frustration was also given an opportunity to evaluate the high status experimentor, and a slight elevation of systolic pressure resulted. These data indicate that the mere opportunity to aggress against a person of high status is physiologically arousing. These subjects are perhaps being placed in a conflict situation in which they cannot clearly determine what is the "appropriate" response, i.e., neither prior experiences nor present cues allow them to clearly determine the consequences which are likely to accrue to either friendly or aggressive responses.

Gambaro and Rabin (1969) further illuminated the effects on blood pressure of aggression against a frustrator and against a substitute (i.e., "displaced" aggression). They found, like Hokanson, that anger-elevated blood pressure is significantly lowered following aggression against the frustrator. They also found that aggression against a substitute target did not significantly lower blood pressure. However, Gambaro and Rabin divided their subjects into two groups--those high in "aggression-guilt" and those low in "aggression guilt" (measured on the Mosher Incomplete Sentences Test; Mosher, 1961), and found that subjects who had little aggression-guilt did show a significant reduction in blood pressure after aggressing against a substitute target, while high guilt subjects in this situation actually showed a slight increase in blood pressure.

How can we account for these findings? Like Hokanson and Shelter (1961) the paradigm employed by Gambaro and Rabin involved forced aggression. Subjects aggressing against a substitute target are therefore being forced to aggress against an "innocent" bystander. It is highly likely that they experience some uncertainty as to the likely consequences of this response; perhaps it is such uncertainty that maintains arousal levels. This seems clearly to be the case for high guilt subjects aggressing against a substitute. These subjects are forced to engage in what they perceive to be inappropriate, punishable behavior, and their blood pressure stays high. Low guilt subjects, on the other hand, probably have less difficulty in perceiving aggression to be appropriate to the experimental situation in which they find themselves; and therefore they do show arousal reduction even when aggressing against a substitute.

Schill (1972) explored the aggression-guilt variable in a non-forced choice paradigm. He found that counteraggression against the original frustrator did reduce elevated blood pressure and that this effect was greater in low-guilt than in high-guilt subjects. However, high-guilt subjects expressed nearly as much aggression as did low-guilt subjects, a finding which Schill could not explain. He expected high-guilt subjects to inhibit aggressive responses. It appears however, that "aggression-guilt" may be a measure of the degree to which a person is conflicted about aggression; but the intensity of such an internal conflict is not the sole determinant of response to frustration. High and low guilt subjects behave similarly, but high-guilt subjects are more conflicted and therefore less certain of the likely consequences of their chosen response, which results in a continuing vascular arousal.

Hokanson and Edelman (1966) demonstrated a sex difference in the arousal reduction property of aggressive acts--females counter-aggressing against an equal status female frustrator do not show arousal reduction as do males. However, Hokanson, Willers, and Koropsak (1968) were able, by rewarding females for aggressive responses, to increase the amount of aggression expressed in response to frustration and to give the expression of aggression an arousal reducing capacity. Males rewarded for friendly responses showed only slight increase in friendliness but friendliness did then reduce arousal more effectively than aggression. It has even been found possible to imbue self-punitive behavior with a tension-reducing capacity if such behavior reduces aggression from others (Stone and Hokanson, 1969). These data suggest that the reduction in blood pressure associated with aggressive counterresponses to aggression may be an acquired phenomenon. The cathartic-like effects are a function of the instrumental aspects of the counterresponse. It is important to note in this regard that in the studies just cited, experimental contingencies involving electric shock make the consequences of aggressive or friendly responses crystal clear to subjects.

In a more recent study Hokanson, DeGood, Forrest, and Brittain (1971) drew a parallel between an external locus of control (Rotter, 1966) and "learned helplessness" (Mair, Seligman, and Solomon, 1969) and seem to suggest that the percept of operant control over the influx of aversive stimuli reduces arousal levels. They found that availability of an avoidance response while under stress significantly reduced blood pressure relative to yoked controls who experienced identical patterns of stress and avoidance but no control of the avoidance response. Weiss (1968) presents similar results with rats. Haggard (1943), and Pervin (1963) present data from humans demonstrating a reduction in physiological arousal and subjective anxiety among subjects who felt they had control over the delivery of aversive stimulation to themselves. Using a paradigm similar to that used by Hokanson et al. (1971) but including the personality variable of locus of control, DeGood (1975) presents data suggesting that relevent attitudes and expectancies are a factor in blood pressure responses.

Glass and Singer (1972) review some literature and present the results of their own extensive work with noise stress and conclude that behavioral and autonomic indices of stress are reduced by (a) control of the onset and/or offset of stressful stimuli, (b) the expectation of having such control, and (c) the belief, even if untrue, that one can control the amount and/or occurrence of the stressor by instrumental responding. They also discuss the relationship between their concept of "perceived control" and "learned helplessness."

The belief that one has control over a stressor, labelled by Glass and Singer (1972) as "perceived control" seems to be closely related to the concept of "appropriateness" discussed earlier. Placed in a situation in which he experiences aversive stimulation, a subject attempts to respond in such a way as to reduce the aversive stimulation or prevent any additional influx of such stimulation. The decision as to how to respond can only be based on an interaction of the present stimulus configuration, the person's perception and interpretation of that stimulus configuration, and his past experience with such types of stimuli. If the contingencies present in a given stimulus configuration are clear and direct (as in Hokanson's conditioning experiments) then the "appropriate" response is immediately apparent and the subject experiences an ability to control the influx of aversive stimulation. An appropriate response is here defined as one which is likely to reduce or prevent the additional influx of aversive stimulation, and such a response reduces vascular arousal. If the stimulus configuration is ambiguous, as it usually is in real life, then the subject's perception and past history become more important in determining both his behavioral and vascular responses. If, however, the ambiguity is so great that no available response is clearly more appropriate than another, then the subject cannot predict the consequences of his own responses and experiences a lack of control. As a result his vascular arousal is maintained. In less unpredictable situations, if a given subject has in the past usually been successful in reducing the influx of aversive stimulation, then he will choose a response, expect it to be successful, and show a reduction in vascular arousal. If, however, a subject has often in the past been unsuccessful in reducing the influx of aversive stimulation, then he will still choose a response but be uncertain of its likely consequences, and his vascular arousal will not decrease. In either case, the behavioral response chosen--whether it be aggressive or friendly--should have less effect on vascular arousal than the subject's ability or inability to predict the consequences of his responses and thus to experience control over incoming stimuli. This latter proposition, which suggests that the experience of an ability to control aversive stimulation is the key factor in lowering anger elevated blood pressure, whether control is achieved through aggressive or friendly counterresponding, was the focus of this investigation.

Prospectus 1

Psychological stimuli designed to arouse anger have been clearly shown to elevate arterial blood pressure. The catharsis hypothesis implies that angered subjects, if placed in a continuing interpersonal interaction with the frustrating agent, will experience arousal reduction most quickly by cathartically releasing aggressive energy through aggressive behavior. The model developed above however, suggests that stimulus aspects of the interpersonal situation which affect a subject's ability to predict the consequences of his responses are more important in reducing arousal than cathartic retaliation. This research considered the question: "Does unpredictability in a continuing interpersonal interaction contribute to the maintenance of anger-elevated blood pressure?"

In order to explore a question such as this in the laboratory one must be able to place subjects in interpersonal situations in which the stimulus configuration can be manipulated, subjects' perceptions can be explored, and physiological responses can be closely monitored and directly related to interpersonal events. There are very few models available in the literature for the study of interpersonal processes under laboratory conditions which permit continuous monitoring of physiological systems. Most of the work on aggression cited above employed a version of the Buss "aggression-machine" (Buss, 1961) on which subjects press buttons to give electric shocks to the experimentor or his associates. Stone and Hokanson (1969) acknowledge the extreme artificiality of such an interpersonal situation. The present research employed an untested laboratory model which uses competitive, two-person games to simulate real life social situations. The game format reduces continuous behavior to discrete "plays" of short duration, makes the conditions of behavior clear to the participants, allows for experimental control of the conditions of behavior, and permits continual monitoring of physiological responses to an ongoing social interaction (Van Egeren, 1976).

Of course, the relevance of gaming situations to real life cannot be taken for granted. However, competitive games played for points and monetary reward are probably more similar to real life events than the giving and receiving of electric shocks. Moreover, Carson (1969) makes a strong case for the idea that all dyadic interpersonal interactions can be analyzed in terms of matrices identical to the kinds of matrices used in the experimental games in this study. This suggests that the social forces at work in playing a matrix game may well be quite similar to the forces at work in all interpersonal interactions. Given the acute responsiveness of the cardiovascular system to environmental influence and the resultant necessity to study the system under highly restricted conditions, the game format seems to provide an ideal combination of relevance and control.

Essential Hypertension: A Related Problem

Systemic arterial blood pressures above 140 to 150 mmHg systolic and/or 90 to 100 mmHg diastolic are generally considered hypertensive. Pressures chronically elevated to these levels pose a significant threat to the human organism as they are closely associated with cerebrovascular accidents, congestive heart failure, coronary heart disease and renal damage (Forsythe, 1974). In approximately 90% of the clinically diagnosed cases of hypertension, no known cause or etiology can be found, and the label "essential" or "primary" hypertension is applied. "Secondary" hypertension describes raised arterial pressures that are manifestations of well-defined organic diseases. The search for the cause of "essential hypertension" has been intensely pursued for decades, yet the etiology of the syndrome is still the subject of considerable controversy. Though originally considered an organic pathology of unknown physical origin, Pickering (1968) has persuasively argued that essential hypertension is not a true 'disease' entity but rather a syndrome characterized by a quantitative deviation from the norm. He defines essential hypertension as "that section of the population having arterial pressures above a certain value selected on arbitrary gounds and having no disease to account for the raised pressure" (p. 178). Pickering goes on to suggest that "the causal factors in essential hypertension are to be sought in the hereditary and environmental factors which determine the arterial pressure in the population at large" (p. 178). He also suggests that "factors operating through the mind" may be significant.

Psychological and environmental variables have long been implicated as causal factors in the development of essential hypertension. A brief exploration of the psychosomatic literature related to hypertension reveals a striking parallel between the development of research in this area and the development of theory and research relating to the catharsis hypothesis. The parallel is all the more striking since the two sets of literature are almost entirely seperate, with few, if any, cross-references.

Just as the original catharsis hypothesis was based on Freudian energy concepts, the earliest psychosomatic theories of hypertension came out of a psychoanalytic, hydraulic model (Alexander, 1939). According to this school of thought hypertension results from a conflict between chronic anger, close to conscious awareness, and a need to repress this anger for fear of loss of love and esteem. This conflict results in a chronic inhibition of impulses to action, producing elevated blood pressure levels. A number of psychoanalytically oriented investigators have supported this "repressed-hostility" hypothesis (Binger, et al., 1945; Kaplan, et al., 1961; Miller, 1939; Saul, 1939); but methodological problems such as subject selection bias and the question of causality (Cochrane, 1973; Ostfeld and Shekelle, 1967; Benson and Gutman, 1974) attenuate the strength of this support.

Wolf and Wolff (1951) have provided perhaps the strongest evidence for a relationship between repression and hypertension. However, analysis of their data and conclusions suggest a reinterpretation of the simple "repressed-hostility" hypothesis. Wolf and Wolff found that both hypertensives and normotensives responded to certain types of emotional conflict with increases in blood pressure. However, the increase is greater in hypertensives. Anxiety and resentment increase cardiac output but this increase is somewhat compensated for by vasodilation and a fall in peripheral resistance. In hypertensives there appears to be less general vasodilation resulting in a greater increase in blood pressure. Other researchers have pointed out the parallel between human hemodynamic response to stress and the defense-alarm reaction of animals, both of which appear to prepare the organism for muscular exertion (Brod, 1970) by increasing cardiac output and redistributing blood flow from the viscera and skin to the skeletal muscles, myocardium, and brain. Wolf and Wolff's finding that hypertensives show less vasodilation in response to stress might then suggest that these people are in fact inhibiting impulses to action, and thus preventing a decrease in peripheral resistance and elevating their blood pressures.

Wolf and Wolff (1951) suggest that hypertensives show many signs of excessive skeletal muscle tension and appear mobilized for combat in which they do not engage; and they conclude that the hypertensive vascular response "was typical of reactions in which restraint was prominant and in which the subject displayed a striking need to supress the recognition or repress the manifestations of his conflict" (p. 321). No direct reference to hostility appears in this conclusion and in fact the experimental manipulation on which their conclusion is based involved a stressful interview which elicited feelings of being "meanaced and trapped" but not necessarily hostility. Although Wolf and Wolff do suggest that subjects in this situation must repress aggressive drive, it is just as plausible to suggest that their vascular response results from being placed in a threatening situation over which they have no control and to which no "appropriate" responses seem to be available. The model underlying such an interpretation suggests that (a) social stress activates the defense-alarm reaction, (b) neither fight nor flight are appropriate and in fact no clearly appropriate response is available, and (c) the resultant conflict and need to inhibit any impulses to action raises peripheral resistance and elevates blood pressure.

Recently Harburg, Erfurt, Havenstein, Chape, Schull, and Schork (1973) have attempted to analyze the internal processes of "suppressed hostility" in terms very similar to those used above in reinterpreting Wolf and Wolff's (1951) conclusions. They differentiate between the suppression of awareness of hostility and the problem of whether or not to diplay felt hostility. The lack of awareness, they claim, must reveal itself through overt communication and behavioral "faults." Chronic faults probably create heightened psychological tension through <u>uncontrolled feedback</u> from others. In the second case, in which hostility is actually experienced, the omission or commission of a hostile act may or may not be "appropriate" to the situation, depending on status roles and norms. The aroused person must assess the situation and choose a response under the pressure of an acquired awareness that there are many "inappropriate" responses which would have consequences then or later for the person. In both cases a perceived inability to control the influx of aversive stimulation from others could be the key factor in raising blood pressure. It is interesting to note that despite the striking similarity between this formulation and Hokanson's work, neither set of investigators seems to have heard of the other.

Before turning to other recent explorations into the etiology of essential hypertension, a brief discussion of one of the major problems of such research is in order. The acute cardiovascular changes in response to environmental stimulation--the defense-alarm reaction described earlier--are well established (Forsythe, 1974). However, the correlation between these normal acute rises in blood pressure and the development of hypertension has been difficult to establish. The strongest support for such a connection has come from animal studies. Gilmore (1971) has reviewed a number of such studies, which have found in the hypothalamus of a wide variety of animals a specific area that instigated the defense-alarm reaction. Since the cardiovascular changes accompanying the defense reaction in experimental animals are the same as those in man in response to emotional stress, and since periodic chronic stimulation of the hypothalamic defense area produces permanent hypertension in animals, Gilmore concludes that it is reasonable to assume that repeated periodic emotional stress may lead to the same result in man. Harris and Forsythe (1973) cite studies in which chronic stressful environmental stimuli produced permanent hypertension in laboratory animals. It is of course impossible to collect similar experimental evidence using human subjects. The closest parallel can be found in the work of Sokolow and his colleagues (e.g., Sokilow, Werdegar, Perloff, Cowan, and Brenenstuhl, 1970) who have used a portable blood pressure recording device to continuously monitor blood pressure responses to daily life events. These investigators conclude that frequently recurring pressor episodes occurring as part of the emotional responses to daily life experiences, eventually lead to permanent structural changes in blood vessels, baroreceptors, or sites still unknown, which then sustain the elevation of arterial pressure found in hypertension. Harris and Forsythe (1973), after an extensive review, come to a similar conclusion, using the neurogenic hypothesis of essential hypertension suggested by Folkow and Neil (1971) as the basis for a psychogenic hypothesis. According to this hypothesis, certain individuals, due to genetic predisposition and/or learning, experience many kinds of personal interactions as stressful. The experience of stressful life situations activates a "corticothalamic mechanism which, if engaged often enough over long periods of time, may act as an efficient trigger factor in the development of adaptive structural changes in the peripheral vasculature, for example, a hypertrophic increase in the ratio of wall to lumen" (Harris and Forsythe, 1973, p. 132). Such an hypothesis suggests the detailed exploration of stress responses in interpersonal situations as a fruitful line of research.

Recent studies into the etiology of essential hypertension have in fact focussed increasingly on how individuals interact with their interpersonal environments and how the interaction is related to the development of hypertension (Benson and Gutman, 1974). Extensive epidemiological data (see Henry and Cassel, 1969 for a partial review) has provided considerable evidence that social change and a resulting departure from traditionally defined norms of behavior is related to elevated blood pressure. Stamler, Berkson, Lindberg, Miller, Stamler, and Collette (1967) found a number of specific attitudes associated with environmental change (such as disliking one's new neighbors, a desire to have gone elsewhere, a desire to actually move but uncertainty as to ones's chances) were also associated with higher blood pressures and a greater incidence of hypertension. These attitudes all are indicative of and perhaps contribute to a difficult adjustment in a new environment. Benson and Gutman (1974), citing the higher incidence of hypertension in urban settings, among blacks, in higher income groups, and in "high stress" neighborhoods, as well as evidence from animal experiments, suggest that elevated systemic arterial blood pressure is "consistently related to environmental situations which require continuous behavioral adjustments on the part of the individual" (p. 15). Conflict and <u>uncertainty</u> necessarily elicited by such demanding environmental situations seems to be associated with pressor responses which may increase arterial blood pressure.

Henry and Cassel (1969) review anthropological data which suggest that hypertension results from a failure of the individual to meet the demands of the environment with adaptive behavior. Social and cultural change increase the incidence of such failure since expectations acquired earlier no longer apply to new environmental conditions. As a result aspirations are blocked and individuals experience increased <u>uncertainty</u> that they will be able to satisfy behavioral urges through programmed goals. Henry and Cassel theorize that psychosocial stimulation of this type leads to a chronic activation of the physiological defense-alarm reaction, which can lead to essential hypertension.

Ostfeld (1967) also postulates a relationship between uncertainty, pressor responses, and hypertension. Reviewing anthropological and epidemiological data he observes that

> there has been an appreciable increase in uncertainty of human relations as man has gone from the relatively primitive and more rural to the urban and industrial. Contemporary man, in much of the world, is faced every day with people and situations about which there is uncertainty of outcome, wherein appropriate behavior is not prescribed and validated by tradition, where the possibility of bodily or psychological harm exists, where running or fighting is inappropriate, and where mental vigilance is called for (Ostfeld and Shekelle, 1967, p. 329).

According to Ostfeld (1967) such situations evoke pressor responses, and the increasing incidence of situations having these five characteristics accounts for the greater incidence of hypertension in modern societies.

Naditch (1974) has explored the relationship between relative discontent, locus of control, and the incidence of hypertension in a large sample of American urban blacks. She found that among highly discontented subjects there was a dramatic increase in the incidence of hypertension with an increasingly external locus of control. External locus of control is a concept developed by Rotter (1966) and is described by Naditch as a perception that rewards and punishments do not occur because of one's own actions, but are due instead to forces outside of one's control such as fate, luck, chance, or powerful others.

The common theme running through all of the work just reviewed is the suggestion of a relationship between the development of essential hypertension and (1) the experience of uncertainty, and (2) the perception of an inability to control or influence environmental stimuli. These two factors seem identical to the variables which have been found in the catharsis literature to be important in blood pressure responses to anger and aggression. It would appear then that anthropological and epidemiological research into the etiology of essential hypertension has begun to focus attention on precisely those variables that laboratory work has implicated as crucial in the normal, acute blood pressure responses to a stressful interpersonal interaction. When looked at together the two sets of literature suggest a model such as the following: (1) When individuals are placed in an interpersonal situation which involves aversive stimulation--i.e., a possibility of bodily or psychological harm--and uncertainty of outcome, the defense-alarm response is activated and blood pressure rises slightly; (2) if there is no immediately available, appropriate behavioral response, i.e., a response which can be expected to reduce the uncertainty and alleviate or prevent the recurrence of the aversive stimulation, then the rise in pressure is greater and will be maintained for a longer period of time; (3) if a genetically predisposed person is chronically confronted with situations such as this, which call for mental vigilance, the repeated activation of the defense-alarm response can eventually trigger structural changes which produce permanent hypertension; (4) additionally, certain individuals due to genetic predisposition and/or learning, may experience a lack of control in the face of all stressful interpersonal situations ("learned helplessness" or "external locus of control") and are thus especially susceptible to the development of essential hypertension; (5) furthermore, modern, urban man is increasingly forced to interact with persons whose jobs, intentions, social roles, and behavior he understands only very poorly, making it increasingly difficult to determine appropriate responses to frustrations, and leading to an increasing incidence of essential hypertension in modern, urban societies.

We might speculate, on the basis of such a model, that anger and hostility have been repeatedly implicated in the etiology of essential hypertension because aggression is a very common source of aversive stimulation in social interactions, anger is a very common response to aggression, and training in the use of aggression is usually highly inconsistent (with parental punishments often contradicting parental modeling, for example) so that the appropriateness of aggressive counterresponses is especially difficult to determine, despite the fact that aggression quite often seems to be called for in our crowded urban world. The above model and speculation lead to the expectation that in a real interpersonal situation in which anger is aroused, the actual expression or nonexpression of aggression should be less important in determining an individual's vascular response than situational variables which effect the clarity or ambiguity with which appropriate responses can be perceived and their likely consequences predicted.

Prospectus 2

In order to experimentally investigate the etiological model proposed above, a number of approaches are desirable. Ideally, a "disciplined, long term study of man in his own environment" (Ostfeld, 1967, p. 330) should be pursued. Ostfeld has outlined an elaborate, five year field trial involving intensive study of two groups and the provision of jobs, counseling, and psychotherapy to one. Despite its seeming impractability, Ostfeld suggests that nothing less will provide the kinds of answers needed. Short of such massive and expensive types of research, however, seperate aspects of the above model urgently require clarification and experimental support. Ostfeld and Shekelle (1967) have stressed the need to identify more precisely the kinds of social interactions that characteristically evoke pressor responses. Forsythe (1974) has emphasized the need to explore more naturalistic types of environmental stressors. Clearly, even before longitudinal investigations such as that described above can be carried out, a clearer understanding of blood pressure responses to an individual's interaction with his/her environment is a must. The research reviewed earlier as an aspect of the catharsis hypothesis is clearly relevant to such an understanding; in fact identical variables have emerged out of the two sets of literature.

The present research, in exploring the idea that unpredictability in a continuing interpersonal interaction is a key factor in the maintenance of anger-elevated blood pressure, represents an attempt to place the etiological significance of anger in the development of essential hypertension within a more general theoretical framework which focuses on situational and individual, perceptual variables. Anger and hostility have long been implicated in the psychosomatic literature as important factors in the etiology of essential hypertension. This investigation explored the suggestion that situational factors that effect how an individual experiences and perceives interpersonal interactions are more important than the actual expression or repression of hostility, per se, in the elevation of blood pressure levels and the development of chronic hypertension.

Perhaps of even greater importance, this study represents an attempt to apply a new methodological approach to the exploration of human physiological response to interpersonal stress. The laboratory model proposed earlier, involving the use of two-person competitive games, seems to be an ideal approach to the need in hypertension research to identify more precisely the kinds of interpersonal situations that produce elevations of systemic arterial blood pressure. The direction in the research literature on psychological aspects of essential hypertension has been to move out of the laboratory and to focus increasingly on anthropological and epidemiological work, as well as to develop a technology that would permit continuous monitoring of blood pressure responses to daily life events. Although these approaches have obvious importance, the neglect of laboratory work is no doubt partly due to the difficulty of realistically simulating social events within the laboratory. However, in order to explore in detail the responses of the highly reactive cardiovascular system to such events, carefully controlled laboratory investigations are a must. Gaming situations provide social situations that are not too artificial, that are discreet in time, well-defined, and manipulable, and that can be brought into the laboratory, allowing the recording of physiological activity during the course of social interaction. A game format, described in detail below, was used in this study to test the proposition that unpredictability in interpersonal interactions is a key factor in maintaining anger-elevated blood pressure.

Games of Strategy

The competitive two-person situations for this study are derived from the mathematical theory of games of strategy (Rapoport and Chammah, 1965). A game is defined in game theory as a situation in which there are (a) two or more "players," each of whom has (b) a set of choices or "strategies," (c) knowledge of outcomes of all choices, and (d) a preference ordering of outcomes. As an example, consider the following situation. Two people (Players A and B) are brought together. Player A is presented with a choice of saying "yes" or "no." He is told that if he says "yes," he will either lose $1 or win $1, depending upon whether Player B says "yes" or "no," respectively. On the other hand, should he choose to say "no," he will either win $2 or lose $1, again depending upon whether Player B decides "yes" or "no." The decision situation is shown below. The left hand number in each cell is the payoff to Player A; the right hand number the payoff to Player B.

		Player B	
		YES	NO
Player A	YES	1, 1	-1, 2
	NO	2, -1	-1, -1

In the games of interest here, both players are shown the payoff table. They make their choices in ignorance of their opponent's choice on a given play. They are told the result of the play and then proceed to the next play. The individual player does not control the situation alone. His behavior, along with the behavior of the other player, controls the payoffs to both of them. In the upper left-hand corner of the above matrix is the "best" outcome for both players. If both say "yes" they both win $1. However, both players are tempted to defect to the "no" response which, if the opponent does not also defect, gives them $2 and penalizes the opponent $1. But if both players defect simultaniously, both lose $1. A simple game such as this provides incentives for both cooperation and competition. If both players cooperate they can both win. Both are tempted to increase their winnings by competing, but competition can also result in losses for both.

By changing entries in the payoff table, incentives for "friendly" cooperation or "aggressive" competition can be altered and new interpersonal situations created. In addition, one of the players can be replaced by a confederate of the experimenter who can play a variety of programmed responses. In this way subjects playing one of these games can be variously rewarded or punished for playing cooperatively or competitively. While formal games as an experimental tool are extremely simple, the social processes they tap may be very rich.

The literature on experimental games has been reviewed elsewhere (Wrightsman, O'Connor, and Baker, 1972), and will not be examined here. There are a few results of laboratory studies of game-conflict behavior that are particularly relevant to this study. First, although some people are highly competitive while others are more cooperative (Rapoport and Chammah, 1965), powerful situational determinants in many game matrices attenuate the effects of individual differences on game behavior (Wrightsman, O'Connor, and Baker, 1972). Second, players are influenced by entries in the payoff table. When payoffs are manipulated as independent variables players' choice behavior tends to change in systematic ways (Rapoport and Chammah, 1965). Third, both the strategy and personality characteristics of the other player effect the degree of cooperation or exploitation displayed by a subject (Wrightsman, O'Connor, and Baker, 1972). Finally, the games are taken seriously, even when played in the laboratory for pennies or mils.

Experimental game methodology offers a number of advantages for the psycho-physiological study of interpersonal stress:

(a) interpersonal behaviors are clearly defined and delimited in time;

(b) the connection between actions and outcomes is known to the participants;

(c) a wide variety of social pressures can be created by manipulating entries in the payoff table as independent variables;

(d) a series of plays results in a well-defined behavioral protocol which is amenable to mathematical and statistical analysis;

(e) physiological responses can be monitored and keyed in time to specific social behaviors and outcomes (Van Egeren, 1976).

While there is evidence that the human environment plays a major, if not decisive, role in the development of stress-related illness (Hinkle, Christenson, Kane, Ostfeld, Thetford, and Wolff, 1958), there are very few models for the study of interpersonal processes under laboratory conditions which permit continuous monitoring of physiological systems. By reducing continuous behavior to discreet "plays" of short duration and making the conditions of behavior perfectly clear to the participants, the game format for social behavior offers some distinct advantages for well-controlled psychological studies (Van Egeren, 1976).

Blood Pressure Parmaeters Briefly Considered

The physical determinants of the pressure within the arterial system at any given moment cannot presently be evaluated with much precision. Yet the arterial blood pressure is routinely measured and used for both diagnostic and research purposes, as an indicator of cardiovascular status. Three different parameters are commonly employed in blood pressure measurement. The mean arterial pressure is the average pressure during a given cardiac cycle that exists in the aorta and its major branches. The systolic and diastolic arterial pressures are the upper and lower limits, respectively, of periodic oscillations about this mean pressure. At the end of the rapid ejection phase of each ventricular systole, a maximum arterial volume is reached and a peak pressure (systolic blood pressure) is achieved. During diastole, peripheral runoff occurs in the absence of ventricular ejection of blood and both volume and pressure diminish to minimum values (diastolic blood pressure). Mean arterial pressure is generally somewhat less than the arithmetic average of the systolic and diastolic pressures (Berne and Levy, 1972).

The relationship between systolic and diastolic pressures is quite complicated and their physical determinants and relative importance are not entirely clear. Page (1951) suggests that systolic level of blood pressure is mainly determined by the activity of the heart, while diastolic pressure is more a function of the peripheral arteries. Since the rise to systolic levels is produced by the arterial blood volume increment during systole, and this increment is nearly equal to the stroke volume of the heart (Berne and Levy, 1972), then systolic pressure should in fact be highly influenced by factors affecting the heart. Obrist (1976) reports data which implicates sympathetic influences on the heart as the major determinant of systolic blood pressure changes. Diastolic blood pressure, on the other hand, seems to provide more direct information on vascular processes, as increases in peripheral resistance produce a greater rise in diastolic than in systolic pressure.

Both diastolic and systolic blood pressures are relevant to the development of hypertension. The literature indicates that in the early stages of the disease, sympathetic influences on the heart and hence on cardiac output are the primary determinants of the elevated pressure (Obrist, 1961) and these are more directly reflected in systolic levels. In later stages, the elevated pressure is, in general, entirely due to increased total peripheral resistance which more directly effects diastolic levels. Most patients with chronic hypertension show elevations in both systolic and diastolic blood pressure.

Both measures have also been used as indicators of vascular arousal in catharsis research. Hokanson and his colleagues used systolic blood pressure almost exclusively in their research. Gambaro and Rabin (1969) measured both systolic and diastolic levels. They found that a frustration sequence raised both measures but following the subsequent direct, indirect, or non-expression of anger significantly different changes were produced in diastolic but not systolic blood pressure.

Obrist (1976) presents some very interesting data and speculations bearing on the differential reactions of diastolic and systolic levels to behavioral processes; and he attempts to relate his ideas to the problem of the role of life stress in the etiology of cardiovascular disease. It appears, however, that we do not yet have sufficient knowledge to make specific predictions about the differential responsiveness of diastolic and systolic pressures to different kinds of stressors. The relative significance of the two parameters in the etiology of cardiovascular disease is also not yet clear. In the present study, therefore, both systolic and diastolic blood pressure levels were recorded and analyzed.

CHAPTER II

PROBLEM AND HYPOTHESES

Previous research has shown that an aggressive counterresponse following anger induction lowers blood pressure more quickly than does a friendly counterresponse; but this simple relationship has been found to be more complicated when other variables such as reinforcement have been included in experimental paradigms. The present study explored the effects on anger-elevated blood pressure of a previously untested variable--called here predictability. We addressed the question--is unpredictability in an ongoing interpersonal situation a factor in the maintenance of anger-elevated blood pressure?--utilizing a two-factor factorial design to examine the seperate and interactive influences on blood pressure of (1) predictability and (2) reinforcement for aggressive or friendly counterresponse following anger induction. The following specific hypotheses were tested:

1. The stimulation to anger of experimental subjects will raise systemic arterial blood pressure to a significantly greater extent than will the subjugation of control subjects to a similar procedure lacking anger inducing aspects.

Comments: Earlier research has consistently supported the hypothesis that stimulation to anger raises blood pressure levels. It is always difficult, however, to know precisely the nature of the impact on subjects of experimental manipulations, especially when dealing with emotions where self-reports can be quite unreliable. By testing this hypothesis as stated we can at least be sure that any effects on blood pressure are produced by the manipulations designed to induce anger and not by other aspects of the experimental procedure.

2. A continuing interpersonal interaction with a frustrating agent in which the frustrator behaves predictably will produce a significantly greater decrease in blood pressure than a similar interaction in which the frustrator behaves unpredictably, regardless of whether reinforcement is given for cooperative (friendly) or exploitative (aggressive) responding.

Comments: When the frustrator's behavior is unpredictable the subject will not receive cues as to which is the rewarded response. He will therefore experience uncertainty, or an inability to control the outcomes of his own responses, and anger-elevated blood pressure is expected to be maintained. When the frustrator behaves predictably however, the rewarded response will be clearly indicated both by the available payoffs and by the frustrator's predictable strategy. The expected resultant experience of certainty, or an ability to control the outcome of one's responses, should reduce anger-elevated blood pressure.

3. In a continuing interpersonal interaction with the frustrating agent in which rewards can be procurred by exploiting the frustrator, subjects will exploit more and will experience a greater reduction in arterial blood pressure than will subjects who are rewarded for cooperation.

Comments: This hypothesis is based upon the original idea of catharsis as arousal reduction following counter-aggression. Exploitation is considered here an aggressive counterresponse. This response will be effective in reducing arousal levels because the game matrix will make it the clearly favored response, in that exploitation will maximize point gain for the subject and minimize point gain for the opponent. The opportunity to thus release frustration induced drive energy through counter-aggression should, according to the catharsis hypothesis, contribute to a maximization of arousal reduction.

CHAPTER III

METHOD

The Interpersonal Interaction

Subjects were stimulated to anger in the context of an anagram solving task in which they competed with a confederate of the experimenters whom they believed to be a fellow subject. The "continuing interpersonal interaction" in this study was in the form of a matrix game which was played between the subject and confederate following the anagram task. In order to control all aspects of this interpersonal situation, subjects played against a computer-simulated opponent, although they believed that they were playing against the confederate. Matrix payoffs were manipulated to encourage either cooperation or exploitation and the computer was programmed to play either a predictable or unpredictable strategy. The computer also controlled the displays on the subjects' display screen and collected and stored the subjects' plays and physiological activity.

Subjects

The subjects were 31 male undergraduates enrolled in introductory psychology classes at Michigan State University. These students were offered extra points towards their final course grade in return for their participation in psychological experiments. Computer-monitered behavioral and reinforcement data of three subjects were lost due to equipment failures, so the sample size is reduced for these analyses.

Instruments and Apparatus

Blood Pressure Measurement

Blood pressure was measured indirectly on the subject's right arm by the experimenter using a cuff sphygmomanometer of the aneroid type and employing the auscultatory technique. Each time blood pressure was recorded two seperate measurements were made, with the cuff being deflated completely between measures. The average of the two measures was used in all analyses.

Subjective Rating of Anger

Subjective ratings of anger were obtained from all subjects following an anagram task and/or frustration sequence. Subjects were presented with a six item scale and were instructed to respond by checking the item that best expressed their feelings during the previous part of the experiment. The items were: very pleased, pleased, indifferent, mildly annoyed, angry, very angry (Gambaro, 1966). This scale was one of four scales given to the subject at the same time, so as not to give away the real purpose of the experiment. The other scales tapped the perceived difficulty of the anagrams, subjective level of anxiety, and level of interest in the experiment (see Appendix B).

Additional Physiological Measures

In addition to blood pressure a number of other physiological measures were recorded during this experiment. These additional physiological data were analyzed seperately from the blood pressure data reported in this thesis. An electrocardiogram was recorded using a single lead. Digital blood volume pulse was recorded using a transmissive photoplethysmograph transducer placed on the ring finger of the left hand. Respiration was recorded using a mercury-in-rubber strain guage placed around the chest. An electromyogram from the forehead frontalis muscle was also recorded.

Procedure

Subjects reported individually to the laboratory where they were met by the experimenter and seated in a light-sound-temperature controlled room next to a curtain seperating two identical chairs, sets of measurement apparatus, and response panels. They were asked to read a brief set of orientation instructions which introduced them to the experiment (see Appendix A) and to sign a departmental research consent form. The experimenter then told subjects that a second subject was expected to arrive momentarily and that in the meantime he would begin preparing them for the experiment. Measurement apparatus was then attached. While this was being done the second subject (actually a confederate) arrived. He was greeted by a second experimenter who treated him as if he were a real subject--he was given orientation instructions and a consent form and measurement apparatus was attached. After both subjects were prepared they were told that their physiological activity was probably somewhat elevated from their walk up to the laboratory, and they were asked to sit quietly and try to relax during a five-minute rest period. Following this rest period the experimenter returned to the room and took the first and resting blood pressure recordings. Subjects then read written instructions for the first task--the anagram task (see Appendix C).

Groups

Subjects were randomly divided into five groups--four experimental groups and one control group. Subjects in each experimental group went through an anger-induction sequence--presented as an anagram task--and then played one of two different matrix games (designed to reinforce cooperative or exploitative responding) against two different kinds of opponent strategies (predictable and unpredictable). Subjects in the control group engaged in an anagram task like that given to experimental subjects but without its anger-induction components. The groups and procedures are schematically described in Figure 1.

Anger-induction Sequence (experimental groups)

The anger manipulations used in this study employed a type of frustration similar to that designed by Hokanson (1961) in that the subject attempted to complete an intellectual task but was interrupted and insulted by an individual previously put in some disrepute. The manipulation itself was altered, however, to increase its realism and to allow for a smoother transition from the frustration sequence into the experimental games.

The frustrating agent was an accomplice of the experimenter and a peer of the subjects. He was presented to subjects simply as another subject. An attempt was made to portray this accomplice as a suitable target for anger by making him appear somewhat unreliable and as a source of irritation to the experimenter. This was done after subjects in the experimental groups had signed the consent form. The

			Anagram Task		Interpersonal Task matrix type/opponent strategy	
Experimental Groups	1 n = 5	resting blood pressure recorded following 5 min. rest	anger induction sequence: confederate solves 8 of 10 anagrams and harasses S.	blood pressure recorded and rating scales completed	cooperative matrix/predictable opponent strategy	blood pressure recorded
	2 n = 5				cooperative matrix/unpredictable opponent strategy	
	3 n = 8				exploitative matrix/predictable opponent strategy	
	4 n = 5				exploitative matrix/unpredictable opponent strategy	
Control Group	5 n = 8		no anger induction: confederate solves about as many anagrams as S and makes no comments.			

Figure 1. Schematic Summary of Experimental Conditions and Procedures

experimenter told these subjects that a second subject was expected to arrive momentarily and he added, with some irritation, that this subject had failed to show up for a previously scheduled session and that "he had better get here this time."

The anger-induction itself was embedded in the anagram solving task. The instructions for this task explained to subjects that they would have 35 seconds in which to solve each anagram and that at the end of the experiment they would be paid 1¢ for each second under 35 seconds in which they reached solution. Ten anagrams with known time to solution norms were presented (see Appendix D). The confederate solved eight of them before the subject had a chance and on a few he harrassed and insulted the subject for his slowness while the subject continued to search for a solution. Immediately following the tenth anagram the experimenter returned, took blood pressure readings, and administered the set of rating scales among which was a subjective rating of anger scale.

<u>No Frustration Sequence</u> (control group)

In the control condition the confederate made no remarks whatsoever to the subjects, and he varied his performance according to the subject's performance so that after ten anagrams subject and confederate had solved about the same number of words. After completion of the anagram task blood pressure recordings were taken and the rating scales administered. This group served as a control for the effects of solving anagrams so that the actual effects to the anger manipulations could be seen.

Interpersonal Task (experimental groups)

Immediately after completing the rating scales subjects in the experimental groups engaged in a continuing interpersonal interaction with the frustrating agent in the form of a matrix game. A standardized set of game instructions were presented to both subject and confederate, along with a copy of the game matrix to be used. The instructions informed subjects that absolutely no communication was permitted during the task and that they would receive 1¢ or 2¢ (depending on game) per point earned and that they should strive to maximize their point total. Subjects in groups I and III (predictable strategies) were paid 1¢ per point while subjects in groups II and IV (unpredictable strategies) were paid 2¢ per point, in an attempt to ensure equal total reinforcement to all groups. Final blood pressure recordings were taken immediately following the games, which were allowed to continue until 20 plays had been made (approximately 20 minutes). Payoff matrices and opponent strategies for the four experimental groups are shown below. The confederate's plays were actually made by the computer.

Cooperative Matrix

		Confederate	
		B1	B2
Subject	A1	5,5	0,1
	A2	1,0	-3,-3

Group 1 (Cooperative matrix, predictable strategy): The computer played B1 on the first play of the game. On plays 2 through 20 the computer played a matching (tit-for-tat) strategy--if the subject

played A2 the computer played B2 on the following trial, if the subject played A1 the computer played B1 on the following trial.

Group 2 (Cooperative matrix, unpredictable strategy): Regardless of subject behavior the computer played B1 with a probability of .60 on every trial.

Exploitative Matrix

		Confederate	
		B1	B2
Subject	A1	0,5	-3,-1
	A2	5,0	-1,-3

Group 3 (Exploitative matrix, predictable strategy): The computer played B1 on the first play of the game. On all subsequent plays the computer played B1 with a probability of .90.

Group 4 (Exploitative matrix, unpredictable strategy): Regardless of subject behavior the computer played B1 with a probability of .60 on every trial.

Behavioral Measures

A behavioral protocol for every game played was recorded and stored in the laboratory computer. This protocol was a running record of the moves made on each trial by both the subject and the computer. From this record we could calculate the percentage of exploitative or cooperative responses made by subjects and the total amount of points or money earned by the players in each game.

Postgame Interview

All subjects were debriefed immediately following their participation in the experiment. The purpose of all experimental procedures was explained; and emotional responses to the frustration sequence were explored in an attempt to ensure that all subjects left the experiment with a positive attitude towards research, and a feeling of having made a contribution.

In addition, all subjects who participated in games were asked to share some of the feelings and thoughts that they experienced during the game. The purpose here was to gain some impression of each subject's feelings and thought processes underlying his game behavior, his perception of the gaming situation, and his perceptions of and feelings towards his opponent.

Treatment of the Data

1. To test the hypothesis that the anger manipulation would raise blood pressure to a significantly greater extent than would a similar procedure lacking anger-inducing aspects, a two-factor, mixed-design analysis of variance was performed. The between subjects factor in this analysis had two levels: (1) exposure to an anger-induction (experimental groups), and (2) exposure to a similar procedure without anger induction (control group). The within-subjects factor also had two levels: blood pressure measured before and after the experimental manipulations.

The interaction between the two factors in this analysis is our test of the significance of differences between the experimental and control groups in blood pressure change. Since the hypothesis predicts the direction of this difference a one-tailed test of significance was used. Identical, seperate analyses were performed for systolic and diastolic blood pressure measures.

2. To explore the effects of matrix type (cooperative or exploitative) and opponent's strategy (predictable or unpredictable) on anger-elevated blood pressure levels a three-factor mixed-design analysis of variance was performed, with the third factor being blood pressure measured before and after the interpersonal task.

The interaction of the opponent's strategy and blood pressure factors provides a significance test for differences in blood pressure changes between groups confronted with predictable versus unpredictable opponent strategies. We predicted a significantly greater decrease in blood pressure for subjects facing a predictable strategy; since this is a directional prediction a one-tailed test of significance was used.

The interaction between the matrix type and blood pressure factors provides a significance test for differences in blood pressure changes between groups given a cooperative versus exploitative matrix structure. We predicted a significantly greater decrease in blood pressure for subjects given an exploitative matrix; since this is a directional prediction a one-tailed test of significance was used.

Identical, seperate analyses were performed for systolic and diastolic blood pressure measures.

3. The subjective ratings of anger were scored on a scale from "1" to "6" with the high end of the scale corresponding to the greatest degree of anger. The mean "anger score" for the four groups

subjected to the anger-induction sequence was compared to the mean "anger score" of the control group, which was not induced to anger. A single classification analysis of variance was performed to test the expectation that subjects exposed to our anger manipulation would give a significantly higher mean rating of subjective feelings of anger than would control subjects. A one-tailed test of significance was used.

4. In order to determine if the game contingencies actually elicited the expected behaviors, additional one-factor analyses of variance were performed on the behavioral data. Comparisons of the mean percentage of exploitative responses were made for the predictable versus unpredictable groups and the cooperative versus exploitative groups. Similar comparisons were made of the mean earnings of subjects, mean earnings of opponent, and differences between subject and opponent earnings.

CHAPTER IV

RESULTS

Hypothesis 1

The stimulation to anger of experimental subjects will raise systemic arterial blood pressure to a significantly greater extent than will the subjugation of control subjects to a similar procedure lacking anger inducing aspects.

It was expected that if the experimental procedure was effective in inducing anger, then we would see a corresponding elevation in the mean arterial blood pressure for the four experimental groups involved in the anger-induction sequence. We hypothesized that this elevation in blood pressure would be significantly greater than any effects on blood pressure produced by a similar procedure lacking our anger inducing manipulations (control group). Mean blood pressure levels before and after the anger-induction sequence are presented in Table 1. To test Hypothesis 1 two-factor, mixed-design analyses of variance were performed for both systolic and diastolic measures, with the interaction effects in these analyses providing a direct test of the hypothesis as stated. Because the direction of the differences was predicted, one-tailed tests were used.

Looking first at systolic blood pressure (SBP), the data show a significant difference between experimental and control groups in the pressure changes produced by our experimental procedures,

Table 1. Mean Blood Pressure Before and After Anger Induction

Group	n	Resting Level (pre-task)	Post-Anagram Task Level
Systolic Blood Pressure (mmHg)			
Experimental groups	24	119.5	122.5
Control group	8	122.8	119.5
Diastolic Blood Pressure (mmHg)			
Experimental groups	24	75.6	80.5
Control group	8	71.9	75.2

$F(1,30) = 4.48$, $p < .02$. The difference is in the predicted direction--the experimental group showed a mean increase in SBP while the control group actually showed a decrease.

Looking at diastolic blood pressure (DBP), the data show no significant difference between groups in the pressure changes produced by our experimental procedures, $F(1,30) = .36$, $p = .28$. Both the experimental and the control group showed increases in mean DBP; and the overall increase for the two groups combined was found to be significant, $F(1,30) = 9.32$, $p < .005$. However, when the pre-anagram task to post-anagram task changes in DBP were analyzed seperately for the experimental groups and the control group, the increase in pressure shown by the experimental groups was found to be significant, $F(1,23) = 13.98$, $p < .005$, while the pressure increase shown by the control group was not significant, $F(1,7) = 1.74$, $p > .2$.

To explore the possibility of a sampling bias in the constitution of the experimental and control groups the mean resting blood pressure levels of the two groups were compared using a t-test. The analysis revealed no significant differences for either SBP or DBP.

Subjective Ratings

In order to investigate the effectiveness of our anger-induction procedure all subjects were asked to complete a subjective rating of anger scale immediately following the first experimental task. This scale was scored in such a way that the "highest anger" response was scored "6" and the "lowest anger" response was scored "1." The mean anger rating of subjects in the control (no anger-induction) condition was 3.6 while the mean anger rating of subjects in the experimental groups was 4.3. Although this difference does not appear large, the variance involved was extremely small and the difference was significant, $F(1,30) = 4.25$, $p < .05$, with the experimental groups reporting significantly greater feelings of anger.

Single classification analyses of variance were also performed to compare the mean ratings of the experimental and control groups on three other scales completed at the same time as the subjective rating of anger scale. No significant differences were found between groups in the perceived difficulty of the anagrams or the subjective level of anxiety. However, the control group did express significantly more interest in the experiment than did the experimental groups, $F(1.30) = 5.29$, $p < .05$.

Hypotheses 2 and 3

2. A continuing interpersonal interaction with a frustrating agent in which the frustrator behaves predictability will produce a significantly greater decrease in blood pressure than a similar interaction in which the frustrator behaves unpredictably, regardless of whether reinforcement is given for cooperative (friendly) or

exploitative (aggressive) responding.

3. In a continuing interpersonal interaction with the frustrating agent in which rewards can be procurred by exploiting the frustrator, subjects will exploit more and will experience a greater reduction in arterial blood pressure than will subjects who are rewarded for cooperation.

To investigate hypotheses 2 and 3, three-factor, mixed-design analyses of variance were performed on both systolic and diastolic blood pressure data. Group means for the four experimental groups are presented in Table 2. The three factors in the analyses are as follows: (a) Predictability--the strategy of the subjects' opponent in the interpersonal task was either predictable or unpredictable; (b) Matrix type--two different game matrices were used, one in which subjects could clearly maximize their winnings by cooperating and allowing the opponent to also gain points, and one in which subjects could clearly maximize their winnings by exploiting the opponent and maximizing his losses; and (c) Blood pressure--SBP and DBP were recorded for each subject before and after the interpersonal task.

Blood Pressure Change and Opponent's Strategy

The interaction between Predictability and Blood pressure factors provides a direct test of Hypothesis 2; and since the hypothesis predicts the direction of the differences between the groups a one-tailed test was used. The hypothesis was not confirmed for SBP, i.e., there was no significant difference between the group exposed to a predictable opponent strategy and the group exposed to an unpredictable strategy in the effect of the interpersonal task on SBP.

Table 2. Mean Blood Pressures Before and After Interpersonal Task for Four Experimental Groups

Opponent Strategy and Matrix Type	n	Pre-Task Level	Post-Task Level
Systolic Blood Pressure (mmHg)			
Predictable Strategy			
Cooperative Matrix	5	125.7	119.8
Exploitative Matrix	8	125.9	123.7
Unpredictable Strategy			
Cooperative Matrix	5	116.7	113.8
Exploitative Matrix	5	118.9	116.9
Diastolic Blood Pressure (mmHg)			
Predictable Strategy			
Cooperative Matrix	5	79.1	76.8
Exploitative Matrix	8	81.7	80.6
Unpredictable Strategy			
Cooperative Matrix	5	79.7	83.8
Exploitative Matrix	5	80.7	79.9

Although this hypothesis was also not confirmed for DBP, the $\underline{F}$ value in this case did approach significance, $\underline{F}(1,20) = 2.04$, p. = .08.

Blood Pressure Change and Cooperation Versus Exploitation

The interaction between Matrix Type and Blood pressure provides a direct test of Hypothesis 3; and again, since the hypothesis predicts the direction of the differences between the groups a one-tailed test was used. However, this hypothesis was not confirmed for either SBP or DBP, i.e., the effects on blood pressure of the interpersonal task were not found to differ significantly between a group given a matrix favoring cooperation and a group given a matrix favoring exploitation.

Additional Analyses

In our three factor analyses of variance we found that the main effect for SBP was significant, $\underline{F}(1,20) = 5.78$, $\underline{p} < .05$, indicating that the interpersonal task significantly reduced SBP regardless of opponent's strategy and matrix type. Looking at the data in Table 2, we see a reduction in SBP for all four experimental groups.

However, DBP does appear to have been differentially affected by the experimental manipulations. As stated above, the difference between the predictable and unpredictable groups in DBP changes approached but did not reach significance. The entire difference, however, is contained within the groups given the cooperative matrix. The two groups given the exploitative matrix showed little DBP change regardless of the opponent's strategy (mean decreases of .8 mmHg and .9 mmHg), while of the two groups given cooperative matrices, the one exposed to a predictable opponent strategy showed a mean decrease of 3.3 mmHg in DBP and the group exposed to an unpredictable opponent strategy showed a mean diastolic increase of 4.1 mmHg. A seperate two-factor analysis of variance was performed to see if this differential change in blood pressure between the two groups was significant; but it was not, $F(1,8) = 2.21$, $p < .20$, perhaps partially due to the very small number of subjects involved in this comparison (n = 5 for each group).

Summarizing the data thus far reported for systolic blood pressure, we found: The instigation to anger of experimental subjects significantly raised systolic blood pressure. Because this increase was significantly greater than that experienced by the control group, we can conclude that it was a result of the anger-inducing aspects of our procedure. When angered subjects, with elevated SBP levels, then engaged in an interpersonal (matrix-game) task with the frustrating agent, their mean SBP was significantly reduced, regardless of the predictability of opponent's strategy and matrix type.

The results for diastolic blood pressure changes are somewhat more ambiguous. The instigation to anger of experimental subjects did significantly raise their mean DBP level. However, this increase was not significantly greater than that experienced by the control group, so it cannot be conclusively attributed to the anger-inducing aspects of our procedure. When angered subjects then engaged in an interpersonal (matrix game) task with the frustrating agent no significant changes in DBP were observed. However, the trend of the data does appear to support the idea that the predictability of the opponent's behavior can produce a differential effect on DBP; and this effect seems to be more clearly reflected when subjects are rewarded for cooperating than when they are rewarded for exploiting the frustrating agent.

Analysis of Behavioral Data

It was expected that subjects given a matrix whose reward structure clearly favored the exploitative (non-friendly) response would respond exploitatively to a significantly greater extent than would subjects given a matrix favoring the cooperative (friendly) response. A single-factor analysis of variance was performed and the prediction supported, $F(1,16) = 2.97$, $p = .05$ (one-tailed test), with subjects given the exploitative matrix responding exploitatively 71.5% of the time while subjects given the cooperative matrix responded exploitatively 47.9% of the time. When similar analyses were performed seperately for subject's responses during the first ten trials and subjects' responses during the last ten trials, it was found that subjects given the exploitative matrix responded significantly more exploitatively during the first half of the interpersonal task, $F(1,16) = 3.79$, $p < .05$; but although the difference was in the expected direction during the second half of the task it did not reach significance, $F(1,16) = 1.78$, $p = .09$ (one-tailed test).

Identical analyses were performed to explore the possibility of differences in degree of exploitation between predictable and unpredictable opponent strategy groups. No significant differences were found.

Analysis of Reinforcement Data

A possible confounding factor in the design of this experiment was the amount of reinforcement given to subjects. Under the predictable-cooperative conditions the computer could have responded as much as 100% cooperatively, depending upon the subject's responses; under the predictable-exploitative conditions the computer responded cooperatively 90% of the time for all subjects. However, under the unpredictable conditions the computer responded only 60% cooperatively, thus lowering the total potential earnings for subjects in the two unpredictable groups. Because differences in total amount of reinforcement (earnings) could confound any differences found in post-task blood pressure levels, an attempt was made to control this factor by paying subjects in the predictable conditions 1¢ per point and subjects in the unpredictable conditions 2¢ per point. A single-factor analysis of variance revealed significant differences among the four experimental groups in mean subject earnings, $F(3,16) = 4.92$, $p < .02$. However, when paired comparisons were made it was found that the predictable and unpredictable groups did not differ in mean subject earnings, $F(1,16) = 1.07$, $p = .32$; but subjects in the exploitative matrix group earned significantly more than did subjects in the cooperative matrix group, $F(1,16) = 6.27$, $p < .03$.

Additional single-factor analyses of variance revealed significant differences among the four experimental groups in the mean earnings of the opponent and in the mean difference between subject and opponent earnings. Paired comparisons were made and no significant differences were found between predictable and unpredictable groups; but the cooperative and exploitative matrix groups did differ significantly in the mean difference between subject and opponent earnings, $F(1,16) = 28.14$, $p < .001$. The reinforcement data for all paired-comparison analyses performed are summarized in Table 3.

Table 3. Mean Earnings During Interpersonal Task

Group[a]	Subject Earnings(¢)	Opponent Earnings(¢)	Difference(¢)
Grouped by Matrix Type			
Cooperative Matrix	36.3	37.3	-.6
Exploitative Matrix	77.3	10.7	66.6
Grouped by Opponent Strategy			
Predictable Strategy	48.7	17.4	31.3
Unpredictable Strategy	65.4	30.6	35.6

[a] *n* = 10 for each group.

It appears, then, that the exploitative behavior of subjects given the exploitative matrix is reflected in their earnings. Relative to subjects given the cooperative matrix they earned more money while allowing their opponent to earn less.

CHAPTER V

DISCUSSION

The results of this experiment do not provide solid support for the proposition that unpredictability in a continuing interpersonal interaction is a key factor in the maintenance of anger-elevated blood pressure. However, in interpreting the data and drawing conclusions from them the exploratory nature of the study must be taken into consideration. Although the theoretical and empirical foundation of this research is relatively highly developed and allowed the formulation of specific hypotheses, the methodology employed in the experiment represents a new, untested, and innovative approach to the problem addressed.

Our major area of interest here has been the physiological (in this case, blood pressure) concomitants of interactive, interpersonal events involving frustration and aggression. Although there has been a fair amount of laboratory research done in this area, there has been very little variation in the kinds of experimental procedures used. Most of the early empirical exploration of the frustration-aggression hypothesis employed a version of the Buss "aggression machine" (Buss, 1961) on which subjects pressed buttons to give electric shocks to the experimenter or his associates. A similar setup has been used in most studies which looked at the effects of counter-aggression on anger-elevated blood pressure levels (e.g., Hokanson and Shetler, 1961). The most common procedure has been to place subjects, after they have been frustrated, in an "interactive" situation structured as follows: Subjects are told that the researcher is interested in blood pressure response during a brief experiment in extra-sensory perception and that he is also interested in the effects of shock on guessing. The subject then thinks of a number between 1 and 10 which the frustrator (usually a confederate) tries to guess. Each time a wrong guess is made the subject presses a button to deliver a shock to the frustrator. This continues until a set number of shocks are delivered (Gambaro, 1966). The utilization of this procedure has produced a host of interesting and significant findings (see Chapter I of this paper). However, there have been few attempts to explore the generalness of these findings by varying the nature of the counter-aggressive opportunity presented to subjects; nor have there been any attempts to overcome the most serious limitation of the procedure described, i.e., the extreme artificiality of the interpersonal situation. Stone and Hokanson (1969) acknowledge that the delivery of electric shocks to a frustrator for wrong guesses is a very artificial way to force subjects to counter-aggress; but they make no suggestions for increasing the realism of their procedure.

Because the laboratory exploration of blood pressure reactions to frustration, anger, and counter-aggression is potentially relevant to clinical concerns with the etiology, prevention, and control of abnormal cardiovascular activity such as hypertension, it is especially important that the limits of previous findings and their relevance to real-life interpersonal interactions be explored. The procedures employed in the research reported here represent an attempt to (1) expand the generality of previous findings, (2) explore a new variable that may play a role in blood pressure response, and (3) increase the realism of the interactive aspect of the interpersonal behaviors studied. However, in the process of introducing a new procedural methodology we have also introduced a new potential source for variance into the data. There is very little information currently available on the effects of the type of matrix games used in this experiment on physiological activity--an extensive search of the literature turned up only one previous study which used matrix games as a paradigm for exploring the psychophysiological effects of interpersonal behavior (Hare and Craigen, 1974). As a result we were unable to predict beforehand what effects the procedures themselves might have on our dependent variables. Given that this unknown variance introduced by our procedures could possibly obscure the effects of our hypothesized psychological variables, it seems reasonable to attach greater importance to any trends in the data which lend support to our hypotheses. In other words, due to the newness and unrefined nature of the experimental procedures we employed in operationalizing our hypotheses, we suggest that the data be interpreted as preliminary and suggestive. Interpreted in this light, there are a number of interesting findings in the data reported above.

Blood Pressure Changes and the Instigation to Anger

Previous research has consistently supported the hypothesis that systemic arterial blood pressure rises when experimental subjects are angered. Almost all of this research, however, has used the same procedure to induce anger, a procedure originated by Hokanson in 1961. Because the research done in the area has been chiefly concerned with the effects of various psychological and behavioral variables on anger-elevated blood pressure, it is not surprising that researchers have stuck to a proven, reliable anger-induction procedure to initially raise blood pressure levels. As a result, though, the generality of the finding can be questioned--the instigation to anger has not yet been experimentally shown to raise blood pressure across a variety of types of frustrating interpersonal interactions.

The instigation to anger used in the present study was similar to Hokanson's (1961) in that subjects attempted to complete an intellectual task while they were interupted and insulted by an individual (confederate) previously put in some disrepute. In most other respects, however, it was quite different. For example, our confederate was introduced to subjects as another subject rather than as an experimental assistant, the task involved trying to quickly solve a series of anagrams rather than counting backwards from 99 to 1 by three's, the interruptions and insults used were more subtle than were Hokanson's, and in our procedure the interaction between subject and confederate lasted about 10 minutes as compared to only 2 minutes in Hokanson's procedure. Despite these differences our procedure produced systolic blood pressure changes quite similar to those described by other researchers. The instigation to anger significantly raised SBP and raised it significantly more than did a similar procedure which differed only in its lack of specific anger-inducing manipulations.

The effect of our anger manipulation on diastolic blood pressure however, was less clear cut. The mean DBP of experimental subjects did increase significantly. But there was also a nonsignificant increase in the mean DBP of the control group; and the difference between the two groups in diastolic change was not significant. As a result, the elevation in DBP in the experimental subjects cannot solely be attributed to those manipulations designed to induce anger. It appears that other aspects of the experimental procedures may have been involved in the DBP response. The mere need to attend to complex stimuli presented on a screen may perhaps evoke physiological processes which mask the physiological effects of the emotional processes of interest (Sternbach, 1966, p. 92). It is also possible that physical discomfort contributed to subjects' frustration and helped elevate their DBP. Subjects did have a number of recording instruments attached to them and they were asked to sit very still to avoid producing interference in the recordings being made.

It is interesting to note, however, that control subjects--who had to endure the same discomfort and work to solve anagrams but were not insulted by the confederate--did show an increase in DBP while at the same time their mean SBP actually decreased and this decrease approached significance. This suggests that if some unidentified aspect of the anagram task itself led to the general elevation found in DBP, this factor did not affect SBP in the same way. SBP appears to have been sensitive to the manipulations specifically designed to induce anger, while the effects of these manipulations on DBP, if such effects exist at all, were masked by some other more general aspect of the anagram solving task. These interesting differences in SBP and DBP responses will be discussed more fully below.

One of the difficulties in the laboratory study of emotions such as anger is the question of whether or not the affect of interest has actually been elicited by the experimental manipulations. Anger arousal in psychophysiological research has often been assumed to have occurred on the basis of the face validity of the operations designed to induce anger and the use of a control group that allows the attribution of any physiological changes to those specific operations. In the present study, as in Gambaro (1966), this assumption was further supported by subjects' own rating of their feelings of anger, i.e., subjects undergoing the anger-induction sequence rated themselves as significantly more angry than did control subjects. They also rated themselves as significantly less interested in the experiment. However, a number of observations relevant to this issue were made during debriefing sessions. First, a number of those subjects who did not rate themselves as being at all angry following the frustration sequence did in fact report anger and frustration in response to that task when given the opportunity during debriefing. Schacter and Singer (1972) have impressively shown that the subjective labelling of emotional states is strongly influenced by external stimulus factors. It may be that some of our subjects needed more external cues than were immediately available in order to consciously define their experience as anger at the confederate; or, alternatively, they may have tuned in to cues during the frustration sequence that suggested other feeling states to them. Relevant to this possibility is a second observation from debriefing sessions: Many subjects, including both experimentals and controls, expressed considerable embarrassment and self-disgust at what they perceived as their unique inability to solve anagrams. The task was structured so that experimental subjects could have attributed some of their difficulty with the anagrams to the obnoxiousness of the confederate, but this was not generally done. Subjects tended to get angry at themselves rather than at the confederate. Placed in a frustrating situation in which anger is aroused but in which the source of frustration could be seen as internal or external, most of our subjects attributed their frustration to their own failings. Whether or not this tendency to internalize anger affected the way in which subjects responded during the rest of the experiment cannot be determined. For future research, however, it would seem important to structure any anger-inducing situations in such a way that all subjects attribute their frustration to the desired object. The difficulty, though, is in designing such a structured situation that is also believable to subjects. Believability was a major factor in the development of our anger manipulations, yet a few subjects still were quite suspicious of our confederate. Hokanson's (1961) procedure was better in that any frustration produced was more clearly attributable to the confederate, but given the increasing psychological sophistication of students, at this university at least, it can probably no longer be successfully employed. If additional research in this area is to be done serious attention must be paid to the amount of control achieved in our anger manipulations, as well as to the believability of our procedures.

Blood Pressure Changes and Cooperation Versus Exploitation

We found no significant differences in blood pressure change between a group engaging a frustrator in an interpersonal interaction in which subjects are rewarded for exploiting the frustrator and a group engaging a frustrator in an interpersonal interaction in which subjects are rewarded for cooperating with the frustrator. Systolic blood pressure decreased in both groups while diastolic blood pressure showed little change. The original drive-energy theory of catharsis would lead us to expect a reduction in blood pressure in the exploitative group--subjects in both groups were frustrated by a confederate and experienced increased vascular arousal but those in the exploitative group then counter-aggressed by earning money while depriving the confederate of earnings. However, this counter-aggressive behavior did not reduce blood pressure to any greater extent than did more cooperative behavior, in which subjects earned money while allowing the confederate to also earn money. According to Hokanson's (1974) formulation the instrumental aspects of the counter-response are more important in arousal reduction than the aggressive or friendly nature of that response--subjects both counter-aggressing or cooperating with a frustrator should experience arousal reduction as long as the response chosen is reinforced. This formulation fits our data for SBP--subjects in the exploitative group were rewarded for exploitation and subjects in the cooperative group were rewarded for cooperation; and subjects in both groups showed a significant mean decrease in SBP. DBP, however, did not significantly change in either group.

As discussed earlier, both our specific hypothesized psychological variables and the type of operations utilized may be contributing to the variance in our data. Although the SBP data just discussed do fit Hokanson's (1974) instrumental response formulation, we cannot rule out other aspects of the game playing task itself as causative factors in the blood pressure reduction. The mere length of time involved (about 20 minutes) may be relevant in that anger-elevated blood pressure may simply dissipate over time. Likewise, the lack of decrease in DBP could be due to unidentified aspects of the interpersonal matrix games used. It is again interesting to note the differential responsiveness of the two blood pressure measures. This issue will be further discussed in a later section.

Blood Pressure Changes and Predictable Versus Unpredictable Opponent Strategy

We found no significant differences, in either SBP or DBP change, between a group engaging in an interpersonal interaction with a frustrator who behaved predictability and a group engaging in an interpersonal interaction with a frustrator who behaved unpredictably. SBP decreased in both groups, suggesting that this measure may be relatively unresponsive to the types of variables manipulated here and may simply dissipate over time after being elevated by anger-induction. DBP change, however, did show an interesting between groups difference that approached significance--subjects interacting with the predictable opponent strategy showed a decrease in mean DBP while subjects interacting with the unpredictable opponent strategy actually showed an increase.

This trend is supportive of the major thrust of this project, which postulated that a subject's actual behavioral response to a frustrator would be less important in his subsequent vascular activity than would his ability or inability to predict the consequences of his responses. It was found that subjects in the exploitative group did respond significantly more exploitatively to the frustrator--as reflected in their behavioral responses and their earnings--than did subjects in the cooperative group; but this behavioral difference was not reflected in blood pressure change differences. The predictable and unpredictable groups, however, do appear to have responded differently physiologically, with no corresponding differences in behavior or reinforcement. Although these data are far from conclusive they do suggest that predictability may well be a relevant factor in blood pressure response to frustration and continuing interaction with the frustrating agent.

Some Comments on the Differential Responsiveness of DBP and SBP

Both systolic and diastolic blood pressure measures have been studied as indicators of vascular arousal in frustration-aggression research. Hokanson and his colleagus (e.g. Hokanson and Shetler, 1961) have used SBP almost exclusively in their studies, while some experimenters (e.g., Gambaro and Rabin, 1969) have measured both SBP and DBP. Gambaro (1966) focussed principally on DBP, claiming that this measure was more responsive to the emotion of anger than was SBP.

A few comments on the determinants of SBP and DBP are relevant here. The two major influences on arterial blood pressure are cardiac output and vascular resistance. The influences on these two factors, however, are quite complicated, as is their interaction in the determination of blood pressure. Obrist (1976) argues that sympathetic influences on the heart, which presumably are acting through changes in cardiac output, are the major determinants of changes in SBP. DBP, he suggests, is more reflective of vascular processes, particularly peripheral resistance. As a result, conditions which increase the force and rapidity of heart rate and cardiac output will produce a greater increase in SBP than in DBP. But when vascular resistive influences are more determinant, SBP would show less elevation and DBP would be more elevated. Obrist (1976) goes on to discuss and substantiate the hypothesis that an active coping or vigilance task produces blood pressure changes which are dominated by cardiac influences (reflected in SBP changes), while passive stressors evoke mechanisms which produce blood pressure changes dominated by vascular influences (reflected in DBP changes). The study described by Obrist which is most relevant to our discussion involved an avoidance task with three conditions--an easy, hard and impossible task. It was expected that in the easy and impossible tasks subjects would withdraw from active engagement in the task and sympathetic influences on the heart, and thus on SBP, would dissipate, while in the hard task subjects would remain engaged and sympathetic influences would be sustained over time. Subjects were also exposed to two passive stressors--a cold pressor test and a pornographic movie. The passive stressors produced a significantly greater DBP elevation (from baseline) than the vigilance task, while SBP was significantly more elevated during the vigilance task. Within the three vigilance task conditions, as expected, SBP remained more elevated over time in the hard condition than in the easy and impossible conditions.

These findings and interpretations provide a possible reinterpretation of the results of our experiment and suggest an explanation of the SBP and DBP differences found. The anger-induction procedure used in this study involved elements of both an active and a passive stressor. Passive stress elements were probably present in both the experimental and control groups, while the two groups may have differed in the type of active stress presented--much like Obrist's hard versus impossible vigilance task conditions. The task we presented to subjects involved solving ten difficult anagrams which were displayed on a television screen. Subjects had to record their solutions by pressing five buttons in the correct order. They were seated in a comfortable chair but they had a number of physiological recording devices attached to them and they had been asked to sit as still as possible to avoid interference with the recordings being made. The experimenter himself attempted this task and found the experience--trying to sit still, solve anagrams, and press buttons--rather stressful. Subjects had no available response with which to cope with the physically stressful aspects of this situation--so this can be considered a passive stressor and may well be a major factor in the general rise in DBP found for all groups in the experiment.

The anagrams themselves presented subjects with an active stressor. Although no actual stressor such as shock was delivered, subjects did report experiencing the failure to solve anagrams and earn monetary reward as stressful. They could actively avoid the stress of failure by searching for and discovering solutions to the anagrams. The anagrams, however, were difficult and the majority of subjects were only able to solve between one and three words. In the experimental groups the confederate solved eight of the ten anagrams and prodded subjects about their performance, while in the control group the confederate solved only as many anagrams as did the subject and made no comments. The confederate's activity in the experimental groups did anger subjects but at the same time it may also have maintained and intensified their engagement in the task by increasing competitiveness and demonstrating that the task was not impossible. In the control group, however, the confederate as well as the subject was relatively unsuccessful in finding solutions, perhaps making it easier for the subject to conclude that the task was next to impossible and to disengage from it. The experimental group may then have experienced the task as hard but possible, maintaining their engagement and sustaining sympathetic influences over time, thereby elevating SBP. The control group, on the other hand, may have experienced the task as nearly impossible, allowing them to disengage from it, thus dissipating sympathetic influences and thereby decreasing SBP.

This explanation of the differences between the groups in SBP response does not necessarily negate the role of anger in blood pressure changes. It may in fact illuminate that role, in that anger arousing interpersonal interactions can be seen as "tasks" which demand engagement and vigilance. When such an interaction is turned into a learning situation with reward and punishment clearly contingent on one's behavior, as in Hokanson, Willers and Koropsak (1968), the "task" becomes easy and sympathetic arousal decreases, regardless of whether it is aggressive or friendly responses that are rewarded.

Moving on to the second task of our own experiment--the interpersonal, matrix-game task--we can describe our experimental subjects (the angered subjects) as entering this task engaged and vigilant, with activated sympathetic mechanisms elevating SBP. We might then expect that those subjects interacting with a predictable confederate could more rapidly lower their vigilance and disengage. That is, as soon as they discovered the pattern of their opponent's responses the task would become easy, sympathetic influence on blood pressure would dissipate and SBP decrease. Subjects interacting with an unpredictable opponent, on the other hand, might be expected to maintain engagement and vigilance longer. That is, because there is no pattern to their opponent's responses the task is harder and therefore more likely to maintain sympathetic influence and elevated SBP for a longer period of time. Unfortunately, in the present study blood pressure was not measured continuously so the relative rate of decrease in SBP for the two groups could not be compared. The pre-task to post-task SBP change did not differ between groups as expected--both groups showed a decrease in SBP. This finding is not surprising however, because the task lasted for 20 minutes and undoubtedly became easy for all subjects, allowing them to disengage and allowing sympathetic influence on blood pressure to dissipate. In post-experimental debriefings almost every subject, from experimental and control groups, did in fact report that the second task became boring. This subjective report is supported by the fact that exploitative and cooperative groups differed in behavior during the first half of the task but not during the second half.

The changes in DBP during our interpersonal task are more difficult to explain in terms of Obrist's (1976) active/passive coping parameters. The passive stress components of the task were the same for all groups, yet the experimental conditions did produce differential effects on DBP. This suggests either that the experimental groups differed along the passive stress dimension in some way that we do not yet understand, or that Obrist's formulation may be a bit of an oversimplification, as he himself suggests. In either case, further experimentation is the only way to clarify the mechanisms involved.

Suggestions for Future Research

Although our hypotheses regarding predictability were not unambiguously confirmed, neither were they refuted. The data is suggestive enough that our original contention, that the relative predictability of a frustrator's behavior may have a significant impact on subjects' blood pressure responses during subsequent interactions, does appear to merit further exploration. The next step may be to more directly test this hypothesis in a paradigm parallel to that employed in this experiment but utilizing yoked controls. For example, subjects in group 1 in our experiment were frustrated by the confederate and then interacted with this confederate in a matrix game format in which the confederte used a predictable tit-for-tat strategy. The tit-for-tat strategy is predictable in that the confederate's response on a given trial is directly contingent upon the subject's previous response. The actual responses chosen by subject, and therefore by the confederate, can of course vary. A direct test of the effects of predictability could be made by comparing an experimental group such as our group 1 just described to a group of yoked control subjects, each of whom would receive the exact same responses from the confederate as were given to an experimental subject, but in a randomized, non-contingent pattern.

Of course, even if we can eventually demonstrate a significant effect of what we call here predictability on blood pressure, it remains extremely difficult to provide a completely unambiguous conceptual interpretation of such a finding. What we mean by predictability can be clearly defined in operational terms but the forces actually at work may be more parsimoniously described on other terms. In discussing our results, for example, we further dissected the possible role of predictability in terms of its effects on task difficulty and thus on subjects' degree of engagement and vigilance. The actual mechanisms involved and a decision as to the most parsimonious language to use in describing those mechanisms requires a much stronger empirical data base than is now available. The yoked control study described above may be a fruitful step in building the necessary data base. The data provided by such a study would be even more useful if, instead of merely taking pre- and post-task blood pressure measures, we recorded SBP and DBP continuously, along with other physiological measures such as heart rate. We could then observe changes over time in the sympathetic influences on the heart and compare the predictable and unpredictable groups on this dimension. We would expect those subjects interacting with a predictable strategy to more quickly experience a reduction in sympathetic influences on the heart, perhaps because a predictable strategy makes the task easy. It would be interesting to see if any decreases in SBP produced in subjects interacting with a predictable strategy occurred gradually or in a sudden large fall, perhaps in concert with the subject's recognition of the strategy being used. We would also expect those subjects interacting with a random strategy to eventually experience a reduction in SBP, as they would gradually become bored with the task and disengage from it. It might be worthwhile to attempt to develop a partially-predictable strategy which would parallel Obrist's (1976) hard condition in his avoidance tasks. This strategy would be expected to engage subjects and thus maintain sympathetic arousal for a longer period of time than either the predictable or unpredictable strategies.

Looking back to the findings reviewed in the introduction to this paper, it appears that a large percentage of those findings can be explained in terms of the ease or difficulty of the tasks presented to subjects. For example, Hokanson, Willers and Koropsak (1968) may have been able to modify the arousal reducing capacity of aggressive or friendly behavior precisely because they made behavioral contingencies so crystal clear, thus making the tasks very easy for subjects.

Glass and Singer's (1972) idea of perceived control can also be recast in terms of task ease or difficulty. When subjects are presented with a noise stress which they think they can control by pressing a button, the task is probably experienced as quite easy and sympathetic influences on the heart and SBP dissipate as Obrist's (1976) reasoning would predict. However, when subjects do not know if they can control the noise stress the task remains a challenge and sympathetic arousal is maintained. We might predict, furthermore, that if subjects in the latter condition came to the conclusion that the task was impossible, they would disengage and sympathetic influences would then dissipate. Of course, any physiological effects of the noise stress itself would continue, but because this stressor is more similar to Obrist's passive stressors we might expect these effects to be more reflected in vascular processes and DBP. The experimental exploration of these ideas appears both simple and worthwhile.

Implications

Probably the clearest implication of the data reported in this study is that the demonstrable phenomenon of increased physiological arousal during anger and decreased arousal following direct aggressive expression of anger is a far more complex event than it at first appears to be. The stimulation to anger of experimental subjects does reliably elevate both systolic and diastolic blood pressure; and this study has shown this to be true in a dyadic situation very different from any previously used. However, we have also suggested that there may well be other aspects of anger inducing interactions which are relevant to blood pressure response, and attention to these other variables may lead to more illuminating explanations of the phenomenon.

Our findings do not support the idea that the direct expression of aggression following anger induction reliably lowers elevated blood pressure; but rather they suggest once again that other psychological and situational variables are involved. Predictability of behavior in a dyad may be one such variable, perceived control may be another. The active versus passive nature of a stressful situation may be important, as well as the degree of engagement and vigilance demanded.

There are probably even more as yet unidentified elements of interactive situations which are relevant to blood pressure responses to interpersonal behavior. It should be clear by now that if anger as an interpersonal event is an important factor in human blood pressure response, its importance and mechanisms of action can only be understood through careful, controlled investigation of all aspects of interpersonal situations and their physiological concomitants.

I want to place special emphasis here on my reasons for focussing on interpersonal events. Anger, as it has most generally been used in both clinical and research settings, is an interpersonal event. The blocking of goal directed behavior can be said to induce anger but frustration is more commonly used to describe the effects of blocking due to material obstacles. The emotion of anger is usually discussed only in the context of interactions between people and can probably only be understood within such a context. Most of the research reported here which has explored the physiological concomitants of anger have in fact done so in interpersonal contexts. However, except for this body of literature there is very little data presently available on any other aspects of the psychophysiology of specifically <u>interpersonal</u> behavior. The concepts of perceived control (Glass and Singer, 1972) and active/passive coping and vigilance (Obrist, 1976), which we have attempted to apply to our data, were developed in non-interpersonal experimental paradigms. The knowledge provided by such research is vital, but noise control and shock avoidance may not be at all similar to the types of stressors that are most relevant to everyday human existence. Some of the most important aspects of everyday existence for most people involve interactions with other people; and some of the most potent stressors in everyday existence for many people may well stem from interpersonal interactions. Yet interpersonal behavior has received little attention in psychophysiological studies of stress, perhaps because psychophysiological research requires controlled, laboratory procedures that are not readily adaptable to interactive situations. It is difficult to produce in the laboratory realistic interpersonal situations in which: the stimulus configuration can be controlled, subjects' behavior can be recorded and perceptions explored, and physiological responses can be closely monitered and directly related to interpersonal events.

One of the important aims of this study was to explore the application of a new laboratory model to the study of cardiovascular response to social interaction. We suggested that the utilization of a two-person competitive game format could provide the methodological advance necessary to bring interpersonal behavior, and thus interpersonal stress, into range for controlled, laboratory research. We found that the games employed in this experiment did produce interesting cardiovascular responses. We failed to conclusively answer the specific questions asked, but the games generated data that raised a host of new questions and suggested avenues for further study using the game format. More experience with these games and the physiological responses they produce is probably necessary before they can be readily applied to the testing of specific hypotheses such as those explored here; but it is clear that matrix games do provide a useable format for bringing interpersonal behavior into the laboratory; and the full exploitation of their capabilities may contribute tremendously to our understanding of human physiological response to interpersonal stress.

Another major thrust of the theoretical considerations presented earlier in this paper was that the role of anger in the etiology of essential hypertension may be better understood in terms of a more general theoretical framework which focuses on interpersonal and individual perceptual variables that may mediate the effects of anger on the cardiovascular system. The results of our experiment were somewhat equivocal but our data and discussion have highlighted the fact that there are a whole host of situational, interpersonal, and perceptual variables that may be at work in the relationship between anger, expression, and blood pressure responses. These variables are of intrinsic scientific interest in our attempts to better understand the linkages between social and psychological phenomena and physiology. They take on even greater importance in their potential relevance to the role of environmental stressors in cardiovascular disease such as hypertension.

At this point in time however, any discussion of how such parameters as predictability or active/passive coping may affect the development of cardiovasuclar disease in humans must be purely conjectural. It is clear that the cardiovascular system is responsive to social and psychological stimuli, but if and how such responsiveness can contribute to the development of disease is still a mystery. However, some interesting, potentially relevant, patterns in this cardiovascular-behavioral interaction are beginning to emerge. Paul Obrist (1976) in his presidential address to the Society for Psychophysiological Research summarized his own perceptions of the patterns emerging and suggested that the tonic effects on cardiovascular activity of the situational and stimulus parameters he explored are something "in which we should invest our energies in attempting to understand" because they may provide insight into how the stresses of life contribute to the etiology of cardiovascular disease (p. 104). We would like to expand upon this conclusion and suggest that the tonic effects on cardiovascular activity of the situational and stimulus parameters of interpersonal interactions are of special interest in our attempts to understand the role of life stress in cardiovascular disease. We would like to suggest, furthermore, that the laboratory model used in this study provides an excellent vehicle for exploring the relevant issues.

APPENDICES

APPENDIX A

ORIENTATION INSTRUCTIONS GIVEN TO SUBJECTS

We are interested in psychological and physiological processes involved in thinking and decision making. The present experiment consists of two tasks: a <u>cognitive task</u> (rearranging mixed letters, called anagrams, to spell out a word) and an <u>interpersonal task</u> (interacting with another person for points). The cognitive task will last about 10 minutes and the interpersonal task about 30 minutes. You will be given detailed instructions for the tasks later.

Some physiological responses will be recorded during the experiment (electrical activity of the heart, muscle activity, changes in circulation of the finger, respiration rate, and blood pressure). We use standard recording methods and the recordings will not be painful or harmful. It is important, however, that you remain still during the experiment, and avoid abrupt changes in breathing (holding your breath, sighing, or taking deep breaths), so that we can record your physiological activity accurately.

Why are we doing this experiment? We are interested in understanding psychological and physiological changes which may accompany problem solving and decision making. When the experiment is over we will show you your physiological recording and discuss it with you, if you are interested. If you call the lab at the end of the experiment (end of May) after we complete analysis of the data, we will be glad to tell you what we learned in this experiment and explain more details of the research.

Before leaving the lab we would like you to fill out two questionnaires assessing certain aspects of behavior, feelings and attitudes. The entire experiment, including the questionnaires, will last 1 1/2 - 2 hours.

APPENDIX B

SUBJECTIVE RATING SCALES

(completed by subjects following anger induction)

Please check the item below which most accurately describes the difficulty of this task:

____ very difficult
____ moderately difficult
____ neither difficult nor easy
____ easy
____ very easy

Please check the item below which best describes your feelings during the task:

____ extremely anxious
____ anxious
____ slightly anxious
____ indifferent
____ relaxed
____ very relaxed

Please check the item below which best expresses your feelings during the task:

____ very pleased
____ pleased
____ indifferent
____ mildly annoyed
____ angry
____ very angry

Please check the item below which best describes your feelings during the task:

____ very bored
____ bored
____ indifferent
____ interested
____ very interested

APPENDIX C

ANAGRAM TASK INSTRUCTIONS GIVEN TO SUBJECTS

Your task is to figure out a series of anagrams. An anagram is a word which is presented with its letters in a scrambled order. Your job is to figure out the word and then spell it out correctly using the keyboard in front of you.

Notice that the buttons on your keyboard are labelled with numbers. The anagrams will appear on the TV screen before you and beneath each letter there will be a number. Once you have figured out the word you will have to determine the proper sequence of numbers to correctly spell the word on your keyboard. The idea is best illustrated by an example.

A typical anagram as it appears on the TV screen will look like this:

U G A R S

1 2 3 4 5

First, you should ignore the numbers and try to figure out the word. In this case the word is "sugar." Once you know the word, look at the numbers to determine the proper sequence of numbers to correctly spell the word. In this case the first letter is "s" so the first number is 5. The second letter is "u" so the second number is 1. The third letter is "g" so the third number is 2. The fourth letter is "a" so the fourth number is 3. The fifth letter is "r" so the fifth number is 4. The sequence of numbers to spell "sugar," then, is 5, 1, 2, 3, 4 and you must press the buttons on your keyboard in this order - first button 5 (for "s"), then button 1 (for "u"), then button 2 (for "g"), then button 3 (for "a"), and then button 4 (for "r").

When an anagram first appears on the screen you will see the word "think" printed below it. A few seconds later the word "think" will be replaced by "respond." DO NOT begin to press buttons until the word "respond" appears, even if you figure out the word immediately.

If you hit a wrong button while spelling a word you can press button number 8 to erase what you have pressed so far. Then you can start spelling that word over from the beginning. However, once you have pressed the fifth and last button for a word the erase button will no longer work, so you must catch your mistakes before you finish spelling the word.

We are interested in how quickly you can solve each anagram, so press your buttons as soon as you know the word.

When you both have figured out a word and spelled it correctly the results will appear on the screen. You will see the anagram, the word correctly spelled, and the amount of time each of you took to spell the word. After a short delay the next anagram will appear on the screen. There is a time limit of 45 seconds for solving each anagram. If one or both of you fail to figure out a word or spell it incorrectly in 45 seconds the words TIME UP will appear on the screen. The results will then appear, followed by the next anagram.

As an incentive for solving the anagrams as quickly as possible, we will pay you 1¢ for each second under 45 seconds you take to solve each anagram. For example, if you solve an anagram in 20 seconds, you will be paid 45 - 20 = 25¢ for that anagram at the end of the experiment.

TRY TO AVOID UNNECESSARY BODY MOVEMENTS.

APPENDIX D

ANAGRAMS USED IN ANGER INDUCTION SEQUENCE

Anagram	Solution Word	Median Solution Time (seconds)*
dpaot	adopt	42.0
ahytu	youth	18.0
eocvi	voice	4.0
bnloe	noble	34.5
nrita	train	8.0
oewrp	power	22.0
lrufo	flour	23.0
lomed	model	59.0
hicar	chair	57.0
mhnua	human	15.0

*Taken from: Tresselt and Mayzner (1966).

APPENDIX E

GAME MATRICES FOR THE INTERPERSONAL TASK

Groups 1 and 2 Game Matrix (Cooperative):

		Subject A: Green	Subject A: Red
Subject B	Green	5,5	0,1
	Red	1,0	-3,-3

Groups 3 and 4 Game Matrix (Exploitative):

		Subject A: Green	Subject A: Red
Subject B	Green	0,5	-3,-1
	Red	5,0	-1,-3

APPENDIX F

INTERPERSONAL TASK INSTRUCTIONS*

You will be interacting with the other subject for points (payoffs). You cannot by yourself control the payoff on a given trial. Rather, the points that you and the other person receive will depend on what you and he do on each trial. Each of you has a payoff table in front of you.

The procedure for this task is as follows. You are subject B and the other person is subject A. In front of you are two buttons - one green and one red. On a trial each of you may respond by pressing either your green or red button. Any decision is final - you cannot change your mind once you have pressed a button.

The payoffs to the two of you on a trial will depend on the buttons you both press. You will receive messages on the TV screen in front of you. When you see the message MAKE DECISION, decide which button you want to press. When you see the message MAKE RESPONSE, press the button you have decided upon. Your payoffs are dependent on which buttons you both press as follows: If you both press GREEN then you both receive 5 points. If you press GREEN and he presses RED then you receive 0 points and he receives 1 point. If you press RED and he presses GREEN than you receive 1 point and he receives 0 points. If you both press RED then you both receive -3 points. (Note: negative points represent points <u>subtracted</u> from your total).

After each trial the number of points gained or lost by each person will be shown on the TV screen. The total points gained or lost thus far in the game will also be shown.

There will be a brief wait between trials. Trials will continue for approximately 1/4 hour. Your goal is to gain as many points as possible. You will be paid 1¢ per point at the end of the experiment.

It is essential that you do not communicate with each other in any form whatsoever during this task. This includes laughing, sighing, or any other form of communication which might indicate how you feel about given outcomes or how you would like your partner to behave. The

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*These are the instructions given to group 1 subjects. Subjects in other groups received identical instructions with the appropriate changes in points awarded and payment per point.

experiment becomes usless should any communication take place during this game. In view of this, it will be a condition of the experiment that the session will be disbanded without compensation to the subjects for time put in should communication between partners occur.

TRY TO AVOID UNNECESSARY BODY MOVEMENTS.

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