BIOFEEDBACK TREATMENT OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE UNDER STRESS AND NO-STRESS CONDITIONS

DISSERTATION

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This study compares the relative efficacy of systolic and diastolic biofeedback in lowering the systolic and diastolic blood pressures of normotensives. The importance of testing these biofeedback procedures lies in assessment of their potential as blood pressure self-control techniques for the treatment of essential hypertension. Evidence demonstrates that the elevated pressure levels in essential hypertension result from exposure to stress. Groups that received either systolic or diastolic feedback were compared to an habituation control group under both no-stress and stress conditions. The systolic biofeedback and habituation control groups consisted of 10 subjects, whereas the diastolic biofeedback group consisted of 12 subjects. The subjects were volunteer undergraduate students with a mean age of 21 years. Subjects were taught to use the electronic sphygmomanometer that served as the device to measure blood pressure during the pretreatment and posttreatment phases of the study, as well as to provide biofeedback during the training sessions. The reliability of blood pressure
readings between the subjects and experimenters was shown to be .98 for systolic pressures and .91 for diastolic pressures. Blood pressure was measured under no-stress and stress conditions during pretreatment and posttreatment phases of the study. These phases each consisted of three 19-minute periods of no-stress, stress, and return to no-stress periods, respectively. Between the two phases of measurement periods, the subjects in the biofeedback groups received five sessions of biofeedback training which consisted of 66 minutes each. The cold pressor was utilized to induce blood pressure elevations during the stress conditions. The cold pressor contained water maintained at 0° to 2° centigrade into which subjects immersed their feet. This stressor was demonstrated to reliably elevate all groups' blood pressure during the stress condition, compared to the no-stress period ($p \leq .000001$). The blood pressure levels returned to the no-stress levels during the return to no-stress conditions. The cold pressor was also demonstrated to decrease skin temperatures from the no-stress to the stress conditions ($p \leq .000001$). Skin temperatures remained lowered during the return to no-stress conditions. Skin temperatures were shown to increase from pre- to post-test ($p \leq .00002$), but this effect was hypothesized to be due to increases of outdoor temperatures during the pre- and posttest phases and not related to the effects of either
the cold pressor or treatments. This study also measures the reported levels of pain experienced by subjects during the cold pressor. The treatments were demonstrated to have no effects on the reported pain. All groups were shown to lower pain perception significantly from the pre- to post-test ($p < .001$). The reduction in pain perception was not accompanied by physiological changes in blood pressure.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>v</td>
</tr>
</tbody>
</table>

**BIOFEEDBACK TREATMENT OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE UNDER STRESS AND NO-STRESS CONDITIONS**

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofeedback, Stress, and Blood Pressure Regulation</td>
<td>37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td></td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
<tr>
<td>Procedures</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results</th>
<th>44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability between Experimenters' and Subjects' Recordings of Blood Pressure</td>
<td></td>
</tr>
<tr>
<td>Comparison of Biofeedback and Control Groups</td>
<td></td>
</tr>
<tr>
<td>Systolic and diastolic blood pressures</td>
<td></td>
</tr>
<tr>
<td>Skin temperature</td>
<td></td>
</tr>
<tr>
<td>Subjective Ratings of Pain</td>
<td></td>
</tr>
<tr>
<td>Credibility and Involvement Questionnaire</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion</th>
<th>47</th>
</tr>
</thead>
</table>

| Appendices | 58 |

| References | 104 |
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Three-Way Analysis of Variance—Systolic Blood Pressure</td>
<td>95</td>
</tr>
<tr>
<td>2.</td>
<td>Three-Way Analysis of Variance—Diastolic Blood Pressure</td>
<td>96</td>
</tr>
<tr>
<td>3.</td>
<td>Summary of Systolic Pressure Means and Standard Deviations across Three Conditions</td>
<td>97</td>
</tr>
<tr>
<td>5.</td>
<td>Three-Way Analysis of Variance—Skin Temperature</td>
<td>99</td>
</tr>
<tr>
<td>6.</td>
<td>Summary of Skin Temperature Means and Standard Deviations across Three Conditions in Degrees Celcius</td>
<td>100</td>
</tr>
<tr>
<td>7.</td>
<td>Two-Way Analysis of Variance—Pain Ratings</td>
<td>101</td>
</tr>
<tr>
<td>8.</td>
<td>Summary of Pain Rating Means and Standard Deviations across Phases</td>
<td>102</td>
</tr>
</tbody>
</table>
BIOFEEDBACK TREATMENT OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE UNDER STRESS AND NO-STRESS CONDITIONS

Research with blood pressure biofeedback has demonstrated that it is possible for humans to learn to exert control over their blood pressure (Schwartz, 1977; Schwartz, Shapiro, Redmond, Ferguson, Ragland, & Weiss, 1979). This biofeedback method has been based upon monitoring changes in blood pressure that occur through autonomic regulatory processes. When these monitored changes in blood pressure have been displayed as visual or auditory feedback, voluntary changes in blood pressure have been initiated (Green, Green, & Norris, 1980). Both systolic and diastolic levels of blood pressure have been used with success in controlling blood pressure, although systolic feedback has been used more commonly (Reeves & Victor, in press; Surwit, Shapiro, & Good, 1978). The learned control of cardiovascular responses has been shown in lower animals (Harris & Brady, 1974) and in both normotensive and hypertensive populations of humans (Schwartz, 1977; Shapiro, Mainardi, & Surwit, 1974). The importance of these biofeedback procedures has been (and still is) in their potential application as a treatment for essential hypertension (Shapiro, Schwartz, Ferguson, Redmond,
Blood pressure biofeedback procedures were developed with normotensive populations (Shapiro, Schwartz, & Tursky, 1972; Shapiro, Tursky, Gershan, & Stern, 1969), then applied to hypertensive populations (Benson, Shapiro, Tursky, Gershan, & Stern, 1969; Shapiro, Schwartz, & Tursky, 1972), and later applied to hypertensive populations (Benson, Shapiro, Tursky, & Schwartz, 1971; Elder, Ruiz, Deabler, & Dillenkoffer, 1973).

Hypertension has been considered a pathological condition of chronic, elevated blood pressure. No absolute consensus has been established for dividing normotensive from hypertensive levels of blood pressure, as blood pressure measurement exists along a continuum (Pickering, 1968). However, elevations of 160 millimeters of mercury (mm Hg) of systolic blood pressure and of 100 mm Hg of diastolic blood pressure have been generally considered to be the criterion for hypertensive disease. Systolic levels of 140-159 mm Hg and diastolic levels of 90-99 mm Hg have been regarded as borderline levels of hypertension.

Hypertensive disease may be divided into primary and secondary hypertension. Primary hypertension has been commonly called essential hypertension and accounts for as much as 90% of the cases of hypertensive disease (Galton, 1973). The diagnostic criterion for essential hypertension has been that no causal etiological factors can be identified.
Epidemiological studies have shown that the presence of several factors may increase the risk of its occurrence. These include a family history of hypertension (Levy, White, Stroud, & Hillman, 1945; Stamler, Stamler, & Pullman, 1967), obesity (Chiang, Perlman, & Epstein, 1967), smoking (Moriyama, Krueger, & Stamler, 1971; Stamler, 1967), elevated serum cholesterol (Stamler, 1967; Stamler et al., 1967), and emotional stimuli (Pickering, 1968; Wolf & Goodell, 1968). Some researchers have suggested that essential hypertension may be exacerbated by psychosocial stress (Patel, 1977; Stoyva, 1976). In contrast, secondary hypertensive illnesses have been shown to be the result of the physical dysfunctions of either the afferent or efferent control mechanisms of blood pressure and blood volume (Gnatt, 1967). Secondary hypertension has been diagnosed when these etiological factors have been detected. These secondary disorders include renovascular, malignant, neurogenic, and Goldblatt's hypertensive diseases.

The presence of hypertensive diseases has posed a severe public health hazard. Elevations of blood pressure have been correlated with increased incidents of illness and mortality (Kannel, Gordon, & Schwartz, 1971). Between 10% and 15% of the adults in the United States has been estimated to have hypertension (Schwartz & Shapiro, 1973). Only about 50% of the hypertensive population has been detected. Twenty-three million new cases of hypertension
have been found each year, and hypertension has been a contributing factor to the death of 200,000 Americans annually (Deabler, Fidel, Dillenkoffer, & Elder, 1973). Current practices of classifying and recording deaths have resulted in hypertensive disease being included in mortality statistics in only about 25% of the cases in which hypertension was actually a contributing factor (Moriyama et al., 1971).

Hypertension is an important factor in the onset of several fatal diseases (Galton, 1973). Hypertension has been ranked as the most significant risk factor in the development of atherosclerotic disease, kidney failure, congestive heart failure, coronary heart disease, heart attack, and stroke. About 50% of the morality rate due to hypertension has been associated with cardiovascular dysfunction. At least 100,000 heart attacks have been documented annually in the United States, and another 200,000 cases have been recorded as being victims of strokes. These two causes of death alone accounted for 775,337 deaths in the United States in 1967 (Galton, 1973). In persons with hypertensive disease, the incidence of stroke has been three times that of normotensives (Kannel, Wolf, Verter, & McNamara, 1970), and congestive heart failure occurred six times more often in hypertensives (Kannel, Castelli, McNamara, McKee, & Feinleib, 1972).
Levy, White, Stroud, and Hillman (1945) reported that in a study of 22,841 army officers, those who exhibited temporary elevations in blood pressure had disability retirement three to four times higher than those without these elevations. The mortality rate of this group was also three times higher than for normotensives. Similar findings have been reported by Thompson (1950) who evaluated a group of employees in the Metropolitan Life Insurance Company.

The treatment of essential and secondary hypertension has differed in some respects. Since incidents of secondary hypertension have had clearly defined etiologies of either an anatomical or physiological nature, direct surgical or pharmacological interventions for these disorders have been established. In contrast, a substantial amount of research has failed to determine the specific cause of essential hypertension. At present, no consensus has existed concerning its treatment. Since 1950, essential hypertension has typically been treated pharmacologically. Recent studies have shown the effectiveness of drugs in reducing the morbidity and mortality in persons with moderate elevations of blood pressure (Veterans Administration, 1970; Veterans Administration, 1976). These same studies indicate that a proportion of the treated essential hypertensive population has not responded to treatment. Other drawbacks in the use of antihypertensive medication also exist.
The effectiveness of these drugs in controlling borderline hypertensives has not been firmly established. In addition, the use of this medication produces side effects in some individuals. These include elevations of blood sugar, drowsiness, lethargy, depression, increased secretion of gastric acid, hypotension, dizziness, reduced cardiac reserve, and impotence (Herting & Hunter, 1967; Veterans Administration, 1972). These side effects and the expense of medication have made many hypertensives reluctant to undergo drug treatment.

**Biofeedback, Stress, and Blood Pressure Regulation**

Biofeedback methods have been considered a potential alternative to the control of blood pressure with drugs (Kristt & Engel, 1975; Schwartz et al., 1979). These methods have been thought to exert control over blood pressure by initiating changes in the functioning of the autonomic nervous system (Green et al., 1980). Clinical, epidemiological, animal, and stress analogue research all have demonstrated that exposure to stressful stimuli from noxious environments results in blood pressure elevations (Patel, 1977). Other evidence indicates that arousal of the sympathetic branch of the autonomic nervous system mediates this blood pressure elevation (Benson, 1977; Cannon, 1914; Green et al., 1980; Patel, 1977).
Lacey and Lacey (1958, 1962) have provided evidence that people tend to react to stressful situations idiosyncratically through specific individual patterns of physiologic arousal. Hypertensives have been demonstrated to react to stress with higher elevations in blood pressure than normotensives (Brod, Pech, Hegl, & Jirka, 1959; Innes, Miller, & Valentine, 1959; Shapiro, 1961). This combined evidence suggests that hypertension may result from blood pressure elevations mediated by sympathetic arousal elicited by stress stimuli. Biofeedback methods have been thought to modify this autonomic stress response (Benson, 1977; Green et al., 1980; Patel, 1977). The research demonstrating that exposure to stressful stimuli leads to blood pressure increases will be reviewed and a brief account of the autonomic control of blood pressure under stress and no-stress conditions will be presented. The manner in which biofeedback procedures have been hypothesized to exert influence over this system to effect blood pressure changes will also be considered.

Clinical investigations have demonstrated that elevated blood pressure often occurs in patients as a result of being exposed to stressful stimuli arising from either aversive environmental conditions or situations that require unusual behavioral responses. Miasnikov (1962) observed high blood pressure in a substantial number of
persons during the siege of Leningrad. He suggested that many of these people developed chronic hypertension. Graham (1945) similarly showed that at least 30% of a battalion of soldiers had elevations of systolic blood pressure over 180 mm Hg after exposure to 2 years of desert fighting. After an explosion of a nitrate plant, 57% of the casualties were observed to have diastolic blood pressure increases at levels over 95 mm Hg (Ruskin, Beard, & Scaffer, 1948). Cobb and Rose (1973) found a higher mean pressure prevalence and increased annual incidence of hypertension in air traffic controllers, when compared to a group of second-class airmen. In a study with unemployed workers, Kasl and Cobb (1970) found that blood pressure rose in blue-collar workers who had been suspended from their jobs after plant shutdowns. These instances have shown how diverse psychosocial and physical stressors may result in blood pressure increases.

Epidemiological studies have demonstrated that elevated blood pressure may result from a population's failure to adapt to environmental changes (Scotch & Geiger, 1963). Henry and Cassel (1969) related variation in blood pressure groups as a function of their exposure to particular kinds of social and psychological environments. They utilized data from 18 epidemiological studies to show that where cultures remain stable through time, the population does
not demonstrate arise in blood pressure with age. In contrast, in cultures where the onset of industrialization, urbanization, and migration produces a flux in the usual social, cultural, and economic values, the individual was required to make continuous behavioral adjustments of a stressful nature. In these individuals, the stress is evidenced in rises in blood pressure as they age. Cruz-Coke (1960, 1964) provided further evidence about blood pressure differences between populations with stable social environments, as compared to populations where social conditions were in a flux. He showed that when people live in isolated regions on a long-term basis, their blood pressures are consistently lower, as compared to people from the same region who migrate to highly urbanized centers. Maddocks (1961, 1967) compiled evidence that demonstrated similar blood pressure differences between populations in stable environments versus those in rapidly changing environments.

Research with animals also has illustrated how conditions of crowding and competition may result in both transient and chronic elevations of blood pressure. Henry, Meehan, and Stephens (1967) exposed mice to a number of high-stress situations, including mixing males from different colonies, crowding them in small boxes, subjecting them to the continuous threat of a predator, and inducing
territorial threats with an interconnecting box system among several established colonies. Within 6 to 12 months, all of these conditions facilitated chronic rises in blood pressure.

Blood pressure elevations have appeared to be related to coping efforts to avoid stress, active problem-solving, and several common social situations. Light and Orbrist (1980) demonstrated that cardiovascular responses to stress (including blood pressure rises) were greater for a group of human subjects that could avoid electric shock by active coping efforts when compared to a yoked group of subjects. The yoked subjects received shock identical to the coping group, based upon the coping group's performance. Forsyth (1968, 1969) conducted research that illustrated that rhesus monkeys exposed to longer and more complex avoidance schedules showed significantly more marked and persistent blood pressure rises than those animals subjected to less complex schedules. Humans engaged in complex cognitive problem-solving tasks have also been demonstrated to produce elevations in blood pressure (Brod et al., 1959). Other studies with humans have provided evidence that blood pressure increases occur during driving, heated arguments or anxiety, and while speaking in public or being under time pressure (Hinman, Engel, & Bickford, 1962; Sokolow, Werdegar, Perloff, Cowan, & Brennstuhl, 1970). Patel (1977)
hypothesized, on the basis of similar research presented here, that the urban dweller's exposure to multiple noxious environmental stimuli, crowded conditions, and complex psychosocial situations requiring problem-solving and active coping skills may partly explain high incidences of hypertension of those living in urban areas.

Another line of research that has related stress to rises in blood pressure has used analogue stressors to induce blood pressure changes in normotensives and hypertensives under controlled laboratory conditions. In a study that measured the effects of a number of analogue stressors with hypertensives, Shapiro (1961) showed that knowledge of getting an injection, performance of a reaction-time task to avoid shock, and the immersion of limbs in ice-cold water all caused reliable increases in blood pressures. Some studies have provided important evidence that hypertensives have higher blood pressure elevations than normotensives when exposed to stressful stimuli, such as the threat of shock, immersion of limbs in cold water, and frustration promoted by an irritating lab technician (Patel, 1977). These studies have suggested that hypertensives may be specifically prone to react to stress by cardiovascular responses in a manner consistent with Lacey and Lacey's (1958, 1962) evidence demonstrating idiographic physiological stress reactance.
In conclusion, exposure to a wide variety of stressful stimuli has been demonstrated to result in blood pressure increases. These blood pressure elevations are hypothesized to be one component of a fight-flight stress reaction mediated by the emergency arousal of the sympathetic branch of the autonomic nervous system (Benson, 1977; Cannon, 1914; Green et al., 1980; Patel, 1977). A brief account of the manner in which the autonomic nervous system regulates blood pressure under normal and emergency conditions will be presented. This will provide background for understanding the manner in which biofeedback techniques have been hypothesized to impact on blood pressure regulatory mechanisms.

Evidence has indicated that the autonomic nervous system initiates changes in blood pressure through many different interacting pressure-control mechanisms (Guyton, 1976). These various mechanisms have been divided into those that affect short-, intermediate-, and long-term blood pressure changes. Short-term mechanisms have been shown to be initiated instantaneously when blood pressure deviates from normal levels. Short-term regulation systems have included either neutral components, such as the baroreceptor reflexes, the atrial arterial reflexes, and the pulmonary arterial reflexes or hormonal mechanisms, such as the release of norepinephrine, epinephrine, renin,
angiotension, and vasopressin from diverse glandular sites (Guyton, 1976). Effects of these systems have generally lasted for several minutes, although sometimes these effects have been somewhat longer. Intermediate regulation systems have included the capillary fluid shift mechanism and the vascular stress-relaxation mechanism. These have been initiated within several minutes of deviations from normal blood pressure and have lasted up to several hours in their effects. The long-term arterial-pressure control mechanisms have been represented by the renal-body fluid-pressure control system and by the aldosterone control system. These systems have been demonstrated to act slowly, requiring several hours before they effect blood pressure.

The limbic system, especially the hypothalamus, has been demonstrated to play a major role in integrating these diverse autonomic mechanisms to achieve the normal maintenance of blood pressure (Green et al., 1980). The hypothalamus has been shown to achieve these effects by controlling a large portion of the autonomic neural circuitry and the pituitary gland that initiates hormonal and renal mechanisms of blood pressure regulation (Carlson, 1977). The hypothalamus also has been thought to integrate fight-flight responses elicited by stressful stimuli through the same control systems (Green et al., 1980). This stress response has been related to a general arousal
of the sympathetic autonomic nervous system that includes increases in catecholamine production and the rate of respiration, as well as desynchronization of the electroencephalograph (EEG) waves (Abrahams, Hilton, & Zybrozyna, 1960; Benson, 1977; Cannon, 1914; Gellhorn, 1970; Patel, 1977). Cardiovascular changes in this stress response have consisted of rises in blood pressure, increases in heart rate, and vasoconstriction in the skin, splanchnic, and renal vessels (Abrahams et al., 1960; Brod et al., 1959; Folkow & Rubinstein, 1966).

Both central and peripheral nervous system processes have been hypothesized to initiate fight-flight responses (von Eiff, 1970). In this model of stress-responding, stimuli are received by the brain through sensory inputs. This information is analyzed in the cortex which interprets stressful events and relates them to past conditioning, experiences of early life, attitudes, cognitions, and other features particular to an individual's cortical information processing (Patel, 1977). If the cortical interpretation of stimuli is one of threat, then the fight-flight physiologic reaction is initiated through the interconnected neural pathways of the cerebral cortex, hypothalamus, pituitary gland, and reticular activating system. Research has shown that by stimulating these neural areas either directly through electrical and mechanical means or
indirectly through environmental stress, a fight-flight reaction has resulted with its arousal and cardiovascular components (Folkow & Rubinstein, 1966). When these neural areas were stimulated for prolonged periods of time, rats developed chronic elevated blood pressures (Folkow & Rubinstein, 1966). This evidence has suggested that excessive and prolonged hypothalamic stimulation may be an important etiological factor in the development of essential hypertension. Biofeedback techniques have been hypothesized to mitigate against autonomic arousal that has resulted from stress reactions. Biofeedback procedures have also been thought to influence both normal and hypertensive blood pressure levels by impacting upon the control centers of the autonomic nervous system.

**Biofeedback Methods of Blood Pressure Control**

Biofeedback methods for the control of blood pressure have included the monitoring and display of pressure levels that enable voluntary changes in these levels to occur. Changes in blood pressure that have resulted from these procedures have been thought to be mediated by autonomic processes controlled by the hypothalamus (Green et al., 1980). Green, Green, and Norris (1980) have stated that the neocortex normally influences physiological processes without conscious awareness. These influences have been thought to be carried out by the diverse corticohypothalamic
pathways previously mentioned (Green et al., 1980). When feedback provided a record of cortically mediated physiological changes to conscious centers, it became possible to learn what covert responses normally correlated with changes in physiological parameters. An individual could therefore initiate those covert responses that have been learned to be associated with the desired physiological changes. As a result, voluntary control of physiological parameters, such as blood pressure, have been able to come under the partial control of cortical centers.

Both systolic and diastolic pressure feedback have been utilized to lower blood pressure (Reeves & Victor, in press). Blood pressure reductions with each of these methods have been achieved in both normotensive and hypertensive populations (Fey & Lindholm, 1975; Surwit et al., 1978). Since an increased health risk and morbidity rate have been associated with both elevations of systolic and diastolic pressures, biofeedback treatments of hypertension that reduce either of these levels would be beneficial. An ideal treatment would produce both systolic and diastolic pressure changes. The studies that have used either systolic or diastolic feedback and reported quantitative changes in systolic and diastolic measures of blood pressure will be examined, to evaluate the relative efficacy of these two feedback methods in controlling overall blood pressure.
Benson, Shapiro, Tursky, and Schwartz (1971) showed that hypertensives could lower their systolic blood pressure with systolic feedback. Seven moderate to severe hypertensives were provided with systolic feedback. Six of the subjects were receiving antihypertensive medication. No measures of diastolic feedback were reported; therefore, the effects of systolic feedback on diastolic levels of blood pressure could not be evaluated. A baseline session established the subjects' usual blood pressure, and then each subject underwent from 5 to 16 feedback sessions. Each session had 30 biofeedback trials. The sessions were conducted until there were no reductions in blood pressure for five consecutive sessions. Feedback was given in the form of a light and tone signaling systolic blood pressure changes. Within-session blood pressure reductions were shown to be significant. The mean amount of change for these seven subjects was 16.5 mm Hg in systolic pressure. Pressure decreases ranged from 0 to 33.8 mm Hg, with six of the seven subjects responding to treatment. The one subject who failed to achieve blood pressure reductions had a renal artery stenosis.

Elder, Leftwich, and Wilkerson (1974) provided 16 normotensive undergraduate subjects with automated systolic biofeedback. Eight of these subjects received three 40-minute training sessions to lower blood pressure, while
another eight received feedback to raise blood pressure. Pre- and posttreatment systolic and diastolic blood pressure levels were recorded for each subject. The follow-up was carried out 3 weeks after the end of training. No reductions were demonstrated during the follow-up. However, blood pressure decrements within sessions were demonstrated. Subjects significantly reduced both systolic and diastolic blood pressure. Systolic levels were lowered an average of 6 mm Hg which represented a 5.6% decrease. Diastolic pressure levels were also reduced 6 mm Hg, but this showed an 8.8% decrease. Subjects who received feedback to raise blood pressure were shown to have no significant pressure changes.

A study by Goldman, Kleinman, Snow, Bidus, and Koral (1975) attempted to train 11 essential hypertensives, ranging in age from 35 to 68 years, to self-regulate both systolic and diastolic pressure levels with systolic feedback. None of the subjects were taking antihypertensive medication. Seven subjects were assigned to a group receiving feedback consisting of a light and a tone contingent upon a decrease in systolic pressure. Four subjects acted as a no-treatment control group but were instructed to relax as much as possible during the sessions and to relax at home for at least 30 minutes each day. The biofeedback group received 9 weekly sessions, whereas the
control group received 4 sessions. Each feedback session consisted of three to five initial blood pressure readings, followed by 25 to 30 training trials. The biofeedback group significantly reduced both systolic and diastolic pressures within sessions, as compared to the control group. Systolic reductions averaged 8 mm Hg per subject, representing a 5% pressure decrease. Five out of the seven subjects lowered systolic pressures. The range of blood pressure changes were from 19 mm Hg to 41 mm Hg. All of the subjects reduced diastolic pressures. The decreases ranged from 5 mm Hg to 26 mm Hg. The average reduction for the group was 14.7 mm Hg which represented a 19.3% pressure change.

Blanchard, Young, and Haynes (1975) conducted four single-subject experiments, using an innovative systolic feedback procedure to train essential hypertensives in blood pressure control. Two subjects were hospitalized, psychiatric patients and two were outpatients; they ranged in age from 25 to 50 years. Feedback was provided by points plotted on a graph by the experimenter and displayed to the subject over a closed-circuit television. Subjects viewed their present systolic pressure relative to their pretreatment baseline. The number of 40-minute sessions ranged from 1 to 20 per subject. During the first, 20 minutes of each session, there was an adaptation period, while the remainder of the session was used for biofeedback.
All four subjects reduced systolic blood pressures from baseline. Reductions during the sessions ranged from 9 to 51 mm Hg, but no means for this group were provided, and no data concerning changes for diastolic pressure were presented. Two subjects returned for follow-up 3 weeks later and were able to maintain some of the blood pressure reductions when receiving feedback.

The ability of subjects to control systolic and diastolic pressure with systolic feedback was evaluated by Kristt and Engel (1975). In this study, there were five volunteer subjects, ranging in age from 46 to 70 years, with essential hypertension. All subjects were taking medication and were hospitalized during the 3-week training period of the study. Subjects recorded their blood pressure at home for 5 weeks prior to training, to establish a baseline. For the 1st week of training, the subjects were provided feedback to raise systolic blood pressure; the 2nd week, they received feedback to lower systolic pressure; and the 3rd week, they alternated between these two procedures. Feedback consisted of a yellow light which remained on as long as the subject was initiating the desired blood pressure changes. A digital meter displayed a cumulative record of successful responses. There were approximately 14 sessions per week. Each session consisted of 5 baseline trials, followed by 3 blocks of 10 training
sessions. Before training ended, subjects were taught to use a blood pressure cuff at home to perform a self-administered blood pressure feedback technique. With this technique, the blood pressure cuff was held constant at the established systolic level. By making the Kortokoff sounds disappear, blood pressure was indicated to have been lowered. Cuff pressure was then released until Kortokoff sounds reappeared at the new systolic levels. Subjects significantly reduced systolic pressure but not diastolic pressure levels during treatment sessions. Systolic levels were reduced an average of 11.2%. The mean decrease in blood pressure was 18 mm Hg. All five subjects responded to feedback, and reductions of blood pressure ranged from 9 to 36 mm Hg. Two of the five subjects reduced diastolic pressures to 7 and 20 mm Hg. Subjects also successfully raised blood pressures.

Kleinman, Goldman, Snow, and Koral (1977) evaluated the effects of systolic feedback in altering both systolic and diastolic blood pressure levels. Eight outpatient, essential hypertensives participated as subjects. They ranged in age from 26 to 63 years and were not taking hypertensive medication. After a 3-week baseline period, these subjects attended 3 sessions weekly; sessions lasted 2 hours each over a 9-week period. The sessions included approximately five baseline measurement periods and 25 to
30 training trials. Feedback consisted of a light and a tone presented when systolic blood pressure was decreased. This group significantly reduced both diastolic and systolic levels of blood pressure. Seven out of the eight subjects reduced their systolic blood pressures. The mean change for all eight subjects was 8 mm Hg, which represented a 4% pressure decrement. Blood pressure reductions of up to 15 mm Hg were reported. The diastolic reductions averaged 9 mm Hg, which was equivalent to 8.6% pressure changes. Diastolic reductions ranged from 5 to 17 mm Hg, but only five out of the eight subjects responded with decreases. The subjects maintained these effects without feedback for up to 3 months.

Walsh, Dale, and Anderson (1977) studied biofeedback from arterial pulse-wave velocity. This measure represents the pulse transit time between the heart's right ventric- ular action and the finger's pulse divided into the arterial distance between these two points. Twenty-four hypertensive subjects were randomly assigned to either a feedback group or a progressive relaxation group. This study consisted of two phases. During the first phase, each group received five sessions of 1.5 hours duration of their respective treatments. In the second phase, biofeed- back and progressive muscle relaxation were combined. Biofeedback was demonstrated to be superior to relaxation
within session, but both treatments were equally effective in lowering systolic pressure during a follow-up session after the training in Phase I was completed. In the biofeedback group, systolic pressures were reduced an average of 13 mm Hg. This represented an 8.9% decrease in pressure. No data for diastolic pressure was maintained. In Phase II, the combination of relaxation and biofeedback did not enhance the subjects' abilities to decrease pressure.

Shannon, Goldman, and Lee (1978) compared the effect of three types of systolic feedback. One form of feedback was the continuous automated feedback that has been commonly used in most of the other studies. The other two forms of feedback gave either intermittent feedback (every 75 seconds) or delayed feedback (10 seconds after pressure changes). Eighteen normotensive subjects were divided into three groups of six subjects each. The subjects ranged from 18 to 26 years of age. All subjects received three sessions of 40 minutes of feedback during a 1-week period. A 10-minute adaptation period was presented prior to each treatment session and served as a baseline. Systolic levels of blood pressure were recorded continuously while feedback was provided. Diastolic pressures were only recorded every 40 seconds. The subjects were required to transfer any self-regulatory effects to a no-feedback condition that served as a follow-up trial, 1 day after
treatments were completed. Although all groups established some control over their blood pressure, the continuous feedback group lowered systolic blood pressure significantly better than the other two groups. The continuous feedback subjects lowered systolic pressure an average of 3.1 mm Hg from baseline periods to posttraining periods. Diastolic blood pressure in this group was not significantly reduced, although the mean reduction for the group equaled 5.6 mm Hg.

Surwit, Good, and Shapiro (1978) compared a blood pressure feedback group to two groups receiving relaxation training. The biofeedback group was given binary feedback for simultaneous reduction of systolic feedback and heart rate. The first relaxation group received combined forearm and frontal EMG feedback for deep-muscle relaxation. The second relaxation group underwent a meditation procedure that had been demonstrated to lower blood pressure (Patel, 1977). All subjects attended 10 initial sessions twice weekly, plus follow-up sessions that occurred 6 weeks and 1 year after treatment. The first two sessions served as 1-hour baselines. The eight treatment sessions were 1.5 hours long. No feedback was provided during the follow-up sessions. Three blood pressure readings were taken at the beginning of each session to serve as a within-session baseline. There were no significant main effects or interactions related to differences between the treatment
conditions or to changes in blood pressure over the course of training sessions, from baseline sessions to the follow-up sessions. However, the groups significantly reduced their blood pressure within sessions, although there were no differences between the groups. The blood pressure biofeedback group reduced its systolic pressure a mean of 5.2 mm Hg and its diastolic pressure a mean of 1 mm Hg. The authors attributed the failure of the subjects to produce within-session, blood pressure decrements of a similar magnitude to other hypertensive studies, in that the other studies did not combine the heart-rate biofeedback with the blood pressure biofeedback.

Blanchard, Miller, Abel, Haynes, and Wicker (1979) compared a systolic feedback group to an EMG feedback group that serve as a relaxation group. The EMG biofeedback was from the frontal muscles. A third group received training in meditation. Thirty-three hypertensive subjects were divided into three groups. Fifteen of the subjects were on medication and were asked to keep the dosage stable. Treatment lasted for 10 to 16 weeks. Sessions were approximately 40 minutes long and consisted of a 15-minute adaptation period, a 5-minute within-session baseline, and a 20-minute experimental trial. A pretreatment baseline was established in 4 sessions over 4 weeks. There were eight follow-up sessions spaced over a 4-month period in
which no feedback was provided. When comparing pretreatment and follow-up values for blood pressure, none of the treatments resulted in significant reductions. However, within sessions, the blood pressure biofeedback significantly reduced both systolic pressure and diastolic pressure to only, 1.9 mm Hg.

Other studies have utilized diastolic feedback to learn blood pressure control. Shapiro, Schwartz, and Tursky (1972) provided 20 normotensive, college students with diastolic feedback. The subjects were divided into two groups that either received feedback to lower or to raise blood pressure. Feedback consisted of a 100-millisecond flashing white light from a continuous automated blood pressure monitoring system. Subjects also learned rewards for appropriate changes in blood pressure that consisted of the random presentation of slides of landscapes, nude women, and monetary bonuses, after every 20 feedback successes. Every subject received one 35-minute training session that consisted of 5 resting, 5 random, 35 conditioning, and 10 extinction trials. The trials consisted of 50 heart beats preceded by 5 seconds for cuff inflation. Only data for diastolic pressure were recorded. Subjects were able to significantly raise and lower blood pressure. They raised blood pressure an average of 3 mm Hg. The elevations ranged from 2 to 18 mm Hg. The subjects lowered
blood pressure an average of 2 mm Hg. The decreases ranged from 2 to 10 mm Hg.

Neil Miller (1972) trained a 32-year-old hypertensive female who had been paralyzed by stroke which produced brain stem damage to control blood pressure. She was given tone feedback contingent upon decreases and increases in diastolic feedback for 37 training sessions. She was able to increase and decrease her blood pressure over a range of 27 mm Hg and to decrease her diastolic pressure from 97 mm Hg to 76 mm Hg. This was a 22% reduction in pressure. In a later communication, Miller (1975) noted that this subject lost her blood pressure control when she returned to a stressful home environment. Two and a half years later, she returned for feedback training, after this stress had been alleviated. She was able to regain a large measure of her voluntary control.

Elder, Ruiz, Deabler, and Dillenkoffer (1973) studied the effects of visual feedback, utilizing 18 hospitalized male hypertensives. The ages of the subjects ranged from 19 to 23 years, and none were taking antihypertensive medication. The subjects were divided into groups that received diastolic feedback only, diastolic feedback with verbal approval, and a no-treatment control group. In the feedback groups, diastolic pressure was reduced up to 25% over a period of 4 days of training. This effect lasted
up to 1 week after training. Diastolic reductions averaged 19 mm Hg. In addition, the feedback group with verbal reward was significantly superior to the feedback alone condition.

In the previously described study by Elder, Leftwich, and Wilkerson (1974), a group of subjects received diastolic feedback, in addition to the group that received systolic feedback. Except for the type of blood pressure feedback that the groups received, the procedures for both groups were identical. The results indicate that the diastolic feedback group failed to achieve significant diastolic blood pressure reductions during the week follow-up period, three weeks after training. However, when within-session effects of diastolic feedback were assessed, diastolic pressure was significantly reduced by 3.0 mm Hg, which was a 4.5% reduction. These results were consistent with the Shapiro et al. (1972) study with normotensives. However, Elder et al. (1974) observed no systolic decreases in either the follow-up or within-session periods.

Elder and Eustis (1975) utilized a combination of social reinforcement and visual diastolic feedback in the treatment of 22 outpatient hypertensives. Social reinforcement was contingent upon diastolic reductions of blood pressure. Four subjects participated in mass practice, receiving all training in 10 days. A second group
of subjects received distributed practice over a period of 80 days. Blood pressure baselines were established for each subject by averaging 10 measures of blood pressure over a 10-minute period in the clinic. Treatment consisted of 20 training trials with a 2-minute rest after the first 10 trials. Feedback was provided in the form of a green light presented for diastolic decreases and a red light when increases or no change occurred. Verbal reinforcement for decreases was given once every 10 successful trials. Results demonstrated that within all sessions, both groups showed significant decreases in systolic and diastolic blood pressure from the first sessions to the last sessions of training. In addition, the massed-practice group lowered blood pressure significantly more than the distributed-practice group. The subjects in both groups had mean-significant, within-sessions, systolic blood pressure reductions of 7.7 mm Hg which represented a 7.7% decrease. Out of 22 subjects, 17 responded, with the largest reduction reported being 44 mm Hg. Diastolic pressures were decreased 2.9 mm Hg on average for all subjects, which represented a 3.3% change. Fifteen of the subjects responded with diastolic pressure changes, and the maximum reduction was 13 mm Hg. No follow-up trials of blood pressure self-control abilities were reported.
By combining the results of these studies, comparisons of the effects of the two feedback methods on systolic and diastolic pressures were made. Of the studies that utilized systolic feedback with hypertensives, all showed significant within-session reductions of blood pressure (Benson, Shapiro, Tursky, & Schwartz, 1971; Blanchard, Young, & Haynes, 1975; Goldman, Kleinman, Snow, & Koral, 1975; Kleinman, Goldman, Snow, & Koral, 1977; Kristt & Engel, 1975; Surwit et al., 1978; Walsh, Dale, & Anderson, 1977). Out of the 31 subjects represented in these studies, 27 lowered their systolic pressure. The mean reduction across studies was 11.2 mm Hg of systolic pressure. In the five studies with systolic reductions, blood pressure was reduced an average of 7.2%. The greatest reduction reported for any given individual subject was 41 mm Hg (Goldman et al., 1975). Two studies utilized systolic feedback with normotensives (Elder, Leftwich, & Wilkerson, 1974; Shannon, Lee, & Goldman, 1978), and a mean reduction of 4.1 mm Hg was demonstrated. Data were not available in either of these studies to assess the number of subjects responding to treatment or the percentage of blood pressure change. In both normotensive and hypertensive populations, systolic feedback consistently reduced systolic pressure within training sessions.
Two studies have used diastolic feedback with hypertensives and evaluated the effects of systolic pressure changes (Elder & Eustis, 1975; Elder et al., 1973). Only Elder and Eustis (1975) reported reductions in systolic blood pressure. In these two studies, 15 out of 34 subjects responded to treatment in reducing systolic pressure. With normotensives, only Elder, Leftwich, and Wilkerson (1974) reported data about the impact of diastolic feedback on systolic pressure. No changes in systolic pressure occurred, although it was suggested that the length of training needed to be extended to result in reductions. The ability of diastolic feedback to change systolic pressure has been shown to have mixed results.

Five studies utilized systolic feedback with hypertensives and reported its effects on diastolic pressure (Blanchard, Miller, Abel, Haynes, & Wicker, 1979; Goldman et al., 1975; Kleinman et al., 1977; Kristt & Engel, 1975; Surwit et al., 1978). Significant reductions were observed in three studies. These changes represent an average pressure decrease of 7.9 mm Hg, or a 13.5% pressure decrement (Goldman et al., 1975; Kleinman et al., 1977; Surwit et al., 1978). In three studies that reported individual responses to treatments (two with significant reductions, one without these) 14 out of 20 subjects responded to treatment (Goldman et al., 1975;
Kleinman et al., 1977; Kristt & Engel, 1975). Of the two studies that utilized systolic feedback with normotensives (Elder et al., 1974; Shannon et al., 1978) and reported data about its effects on diastolic pressure, only the Elder et al., (1974) study showed significant results. Figures were not available to show individual response patterns. The use of systolic feedback has resulted in changes in diastolic pressure in only about half of the studies.

With diastolic feedback, all of the three hypertensive studies showed significant reductions in diastolic pressure (Elder & Eustis, 1975; Elder et al., 1973; Miller, 1972). The mean reduction for these studies was 9.2 mm Hg. In two studies, diastolic pressure was reduced an average of 4.2%, and 16 out of 22 subjects responded to treatment (Elder & Eustis, 1975; Miller, 1972). When combining the results of the two studies that provided diastolic feedback to normotensives, the mean diastolic pressure decrement equaled 2.5 mm Hg for 18 subjects. Diastolic feedback consistently reduced diastolic pressure within the feedback training sessions.

Overall, blood pressure biofeedback has been shown to consistently decrease either systolic or diastolic blood pressures within training sessions, although the simultaneous reduction of both pressure levels has not
been consistent. When comparing biofeedback procedures to no-treatment control groups, biofeedback was demonstrated to be superior in effecting blood pressure changes (Elder et al., 1975; Goldman et al., 1975). Biofeedback was also superior to attention-placebo groups that used false feedback, although these studies incompletely reported specific quantitative data about changes in blood pressure levels (Shapiro, Tursky, & Schwartz, 1970; Surwit, Hager, & Feldman, 1978).

The results with feedback have been positive, but several problems remain to be solved before blood pressure biofeedback can be considered an effective treatment for hypertension. First, the ability of systolic feedback to impact upon diastolic pressure and the ability of diastolic pressure to influence systolic pressure need to be further investigated in studies that directly compare these two types of feedback. Second, only one study with systolic biofeedback and one study with diastolic feedback demonstrated that blood pressure reductions which were achieved within sessions could be maintained during a posttraining, follow-up period. Kleinman et al., (1977) demonstrated that hypertensives could maintain significant reductions for up to 3 months but lose the effect after 4 months. In addition, these reductions were observed in the home environment. In contrast, other studies have shown that
gains from systolic feedback have not been maintained during follow-up sessions at 6 weeks, 4 months, and 1 year after training (Blanchard et al., 1979; Surwit et al., 1978). Elder et al., (1973) provided evidence that blood pressure control established within diastolic feedback sessions was maintained for periods up to 1 week without feedback. The ability for subjects to transfer blood pressure reduction skills achieved, utilizing either systolic or diastolic feedback, to follow-up sessions and the home environment has appeared limited. Finally, no studies have evaluated the ability of subjects to utilize biofeedback to lower blood pressure under stress conditions. As blood pressure elevations in hypertension have been shown to be related to stress exposures, biofeedback blood pressure control procedures will only become effective treatments for hypertension if they facilitate blood pressure reductions under stressful conditions (Good et al., 1978).

The present study assesses the ability of subjects to self-regulate blood pressure with biofeedback under no-stress and stress conditions. A group that will receive systolic feedback is to be compared to groups that will receive diastolic feedback or no treatment. Blood pressure will be measured under both no-stress and stress conditions during pretreatment and posttreatment phases of the study.
Blood pressure reductions occurring from pre- to posttreatment phases would reflect the effects of the treatment in lowering blood pressure under the no-stress and stress conditions. The analogue stressor used to induce blood pressure increases in subjects will be the cold pressor. The cold pressor reliably increases blood pressure in both normotensive and hypertensive subjects and could, therefore, be uniformly applied to effect pressure increases under both pre- and posttreatment experimental phases (Lacey & Lacey, 1962, Lovallo, 1978). Consequently, the effectiveness of each treatment in mitigating against stress-induced, blood pressure elevations is compared. It is hypothesized that systolic biofeedback will more readily effect systolic pressure levels than diastolic feedback and that diastolic feedback will more effectively lower diastolic pressures. These differences for the two types of biofeedback are predicted to occur under both no-stress and stress conditions.

Biofeedback groups will receive instructions for the self-direction of their own treatments. These groups will utilize blood pressure monitoring and feedback apparatus that have been readily employed in outpatient clinical settings. All subjects are to measure their own blood pressures, and initiate their respective self-control treatments in a manner similar to those employable in an outpatient clinical setting.
Method

Subjects

The subjects were volunteers solicited from undergraduate psychology classes at North Texas State University. They were told that they would receive credit toward their final grades in return for participation in this study. Ninety-eight subjects volunteered and filled out a confidential questionnaire (Appendix A) designed to screen out subjects who were hypertensive, who had a previous history of cardiac disease, and who were taking medication that influences blood pressure. Eleven subjects were eliminated due to the presence of hypertension or cardiovascular disease. Forty-eight subjects declined participation due to scheduling conflicts.

Thirty-nine normotensive subjects remained and were randomly assigned to three groups, including a diastolic biofeedback group (DBF), a systolic biofeedback group (SBF), and a habituation control group (HC). Each group consisted of six males and seven females. Two of these subjects, one male and one female, were eliminated from the study because they evidenced hypertensive levels of blood pressure during the no-stress condition of the pretest. In addition, five subjects, three females and two males, did not complete the study. As a result of these seven drop-outs, SBF and HC consisted of five males and five females each, whereas
DBF was composed of seven females and five males. These subjects' age ranged from 18 to 28 years, with the average age of the females being 21.3 years and of the males being 20.7 years. The arm circumference of all subjects did not exceed twice that of the width of the standard blood pressure measurement apparatus utilized in this study. Informed consent was obtained from each subject during the pretraining sessions held for each group (Appendix B).

**Instruments**

The blood pressure monitoring apparatus used by the subjects throughout the study was an electronic sphygmomanometer, the Astropulse 10, designed for self-administration and manufactured by Marshall Electronics of Skokie, Illinois. Blood pressure measurements were recorded from the dial of each unit, and when the sensor detected the onset and termination of Korotkoff's sounds (K-sounds), a tone and a blinking light occurred or discontinued. The cold-pressor apparatus consisted of an insulated ice chest that held a liquid volume of 21 litres and was separated into two compartments by a plastic screen. In one compartment, 5.9 litres of ice were added and separated from the second compartment in which the subjects immersed their feet. Fifteen litres of water were also added to the apparatus. The "ice compartment" of the cold pressor was further insulated with a cover. An Atwood "Mimi King 300"
bilge pump was placed in the "ice compartment" of the cold pressor and circulated water at the rate of 1263 litres per hour. The water circulated 30 minutes prior to the coldpressor immersions, so that temperatures were maintained at ranges of 0° to 2° C. The subjects performed the pretest and posttest phases in rooms equipped with one-way mirrors. Room temperatures were maintained within a range of 17° to 20° C. Skin temperatures were recorded by a 32 X 105 mm skin thermometer attached with adhesive tape to index fingers. The apparatus was manufactured by the Conscious Lifting Foundation of Manhattan, Kansas. Subjects were seated next to tables that were 85 cm high, so that when they recorded their blood pressures or skin temperatures, their arms were extended on the table at the level of their hearts. All instructions to the subjects for the pretest, training, and posttest sessions were recorded and played to subjects on a Sears Solid State Model 799 cassette-tape recorder.

Procedure

All subjects attended a 2-hour pretraining meeting. During the first hour, subjects were taught to record their own blood pressures with the blood pressure cuff. Training was identical to that described by Bradley & Hughes (1979). During this session, the experimenter modeled the blood pressure recording procedure to be used, while cassette
recorded instructions for measuring blood pressure were played to each group of subjects (Appendix C). A written summary of the instructions for blood pressure recording were then provided to each subject (Appendix D). This was reviewed by the experimenter with the subjects. Each subject then practiced these procedures. The experimenter observed a minimum of 10 self-monitoring trials for each subject and made independent recordings of the obtained blood pressure readings. Subjects were considered competent in these procedures when the mean of five consecutive readings did not differ more than 2 mm Hg from those recorded by the experimenter. The subjects continued to practice this procedure, and at least an additional four co-readings by the experimenter and subjects were recorded.

The second hour consisted of a pretraining baseline in which subjects recorded their blood pressures, skin temperatures, and levels of experienced pain (only for cold pressor) during 57 minutes of self-directed relaxation. Subjects spent 15 minutes in the test room prior to both the pre- and posttest, to habituate to room temperatures. Each subject was exposed to 19 minutes of no-stress (NS) and then 19 minutes of stress (S) conditions. A 19-minute return to no-stress (RNS) period followed the stress condition. Instructions were given for self-directed relaxation during the pretest condition (see Appendix F).
The subjects in the two treatment groups attended five 66-minute sessions consisting of either SBF or DBF blood pressure control training. The initial sessions were conducted in groups wherein the experimenter provided recorded conceptualization training (Appendix B) and tape recorded procedural instructions (Appendices I and J) for the respective treatments. A credibility check was next administered to each treatment group (Appendix K). The remaining four treatment sessions were self-directed by each subject and included 45 minutes of blood pressure self-control training. The specific instructions for biofeedback were provided on cassette tapes that the subjects played during each training session (Appendices I and J). The subjects were also instructed to record their blood pressures during minutes 1, 2, 3, 13, 14, 15, 25, 26, 27, 28, 29, 30, 40, 41, 42, 52, 53, 54, 64, 65, and 66 of each session. The experimenters monitored the self-directed treatments of the subjects via one-way mirrors. This insured that the training procedures were performed correctly and alerted the experimenters to any equipment failures during training.

During systolic biofeedback-control training, the subjects were seated and erect with the left arm extended and supported at the level of the heart. They received feedback in the following manner. They were told to inflate
the cuff to a level above their systolic pressure and then gradually reduce the pressure at a rate of 2 to 4 mm Hg per second until the tone sounded and the light appeared (systolic blood pressure). Subjects were then instructed to close their eyes and make the light and tone go away. They were informed that a decrease in frequency or cessation of these signals provided feedback of lowered blood pressure. No instructions were given as to how they were to accomplish this. These training procedures have been used by Bradley and Hughes (1979) and were similar to those employed by Kristt and Engel (1975) for the use of the apparatus described above.

Each subject completed 30 biofeedback trials. Each trial was 90 seconds in duration, and biofeedback procedures were initiated by three verbal commands. The first command of "pump up" marked the onset of this period, at which time each subject pumped up the cuff to over each subject's estimated systolic blood pressure (200 mm Hg or greater). Then the subjects reduced cuff pressure until the systolic level was indicated by K-sounds and attempted to make the tone and light go away. A second command of "perform biofeedback" occurred after 30 seconds had elapsed, and subjects continued blood pressure biofeedback. When a third command of "deflate and rest" marked 60 seconds, they rapidly deflated. Subjects rested for 30 seconds,
until another command stated that they "pump up" again. This signaled the start of a new cycle.

The diastolic feedback groups received similar feedback treatments. Subjects pumped up identically to the systolic group and deflated their cuffs at a rate of 2 to 4 mm Hg per second past the tone and light onset indicating systolic blood pressures. They continued deflating to just past the point where the tones and lights were terminated indicating diastolic blood pressures. This group was instructed to make the lights and tones reappear. They were told that the recurring onset of the tones and lights provided feedback of lowered diastolic blood pressures. The initiation of diastolic feedback trials was also controlled by three commands. The beginning of feedback trials received by this group was also signaled by the command "pump up." Upon hearing the first command, the subjects were instructed to pump up past their estimated systolic pressures and then to pump down to just below their diastolic pressures. A second and third command again, respectively, marked the passing of 30 seconds and the time to end feedback and deflate after 10 seconds. Subjects had 30 seconds to rest before another command was sounded to commence a new cycle.

The procedure for the posttraining of blood pressure control under no-stress and stress conditions was identical
to the pretraining baseline, except that the subjects from each treatment group were instructed to utilize their biofeedback procedures to lower their blood pressure during the assessment periods. Instructions for performing biofeedback were recorded on tapes that also provided the subjects with directions to record their blood pressures, skin temperatures, and pain experiences. During this period, the HC group received the instructions for self-directed relaxation. Finally, after the posttest, an involvement questionnaire was given to the subjects to assess the degree to which they had carried out the treatment instructions appropriately (Appendix L).

**Results**

**Reliability between Experimenters' and Subjects' Recordings of Blood Pressure**

The experimenters co-observed with each subject a minimum of 4 blood pressure recordings before the pretest and 4 before the posttest. There was a total of 259 co-readings between the experimenters and subjects. A Pearson product moment correlation coefficient is calculated to determine the degree or reliability between the experimenters' and subjects' readings for both systolic and diastolic blood pressure levels. The correlation coefficient for systolic pressure is 0.98 and for diastolic pressure is 0.91.
Comparison of Biofeedback and Control Groups

Three dependent measures of systolic blood pressure, diastolic blood pressure, and skin temperature were utilized to evaluate differences among the three groups of SBF, DBF, and HC. A three-way analysis of variance (ANOVA) with repeated measures on two factors (conditions and phases) is computed separately for each variable. These ANOVAs compare the three groups of SBF, DBF, and HC during the three conditions of no-stress, stress, and return-to-no-stress from the pretest and posttest phases.

**Systolic and diastolic blood pressures.** The analysis indicates that there are no significant three-way interactions for either the systolic or diastolic blood pressures (see Tables 1 & 2, Appendices M & N). Likewise, there are no significant two-way interactions for either of these variables. Condition main effects for both systolic and diastolic blood pressure levels are shown to be significant ($F = 79.86$, $p \leq .000001$ and $F = 30.95$, $p \leq .000001$ for systolic and diastolic blood pressure levels respectively). This demonstrates that the cold pressor significantly elevated systolic and diastolic blood pressure levels during stress conditions and that these pressure levels returned to their approximate no-stress levels during the return-to-no-stress condition for both the pretest and posttest phases (see Tables 3 & 4,
Appendices 0 & P). No significant main effects are found for either the group or the phase factors.

**Skin temperature.** A three-way ANOVA with repeated skin-temperature measures for the phase and condition factors reveals that neither the three-way nor the two-way interactions are significant (see Table 5, Appendix Q). Significant main effects are evidenced across conditions ($F = 13.08, p \leq .00002$) and from the pretest to the posttest phases ($F = 34.17, p \leq .000001$). This significant main effect for conditions shows that skin temperature significantly dropped during stress and did not recover to no-stress levels during the return-to-no-stress condition for all treatment groups in both the pre- and posttest phases (see Table 6, Appendix R). The phase-factor main effect shows that uniform skin temperature increases occurred from the pre- to posttest for all treatment groups across all conditions. Main effects for the group factor are not significant.

**Subjective Ratings of Pain**

Pain data were collected only during the stress condition. To compare the effects of treatments upon pain ratings across the group factor for the pre-post phases of the study, a two-way ANOVA (groups X phases) is performed (see Table 7, Appendix S). There are no significant two-way interactions and only a significant phase-factor main
effect is demonstrated, \( F = 13.27, p < .0010 \). This significant phase main effect shows that the required level of pain by subjects was decreased for all groups from the pre- to the posttest (see Table 8, Appendix T).

**Credibility and Involvement Questionnaires**

A credibility scale was administered after the conceptualization training period to the SBF and DBF groups to evaluate the subjects' expectancies for blood pressure change from their respective treatments. A t test reveals no significant differences in expectancies for the two groups. An involvement scale was given to subjects in the two treatment groups after the completion of the posttest, to assess the degree to which the subjects were emotionally committed to the success of the treatment and the degree to which they performed the self-control procedures correctly. A t test reveals that there are no significant differences between the two groups on the involvement measure.

**Discussion**

It was hypothesized that the systolic biofeedback group would decrease systolic blood pressure more than the diastolic biofeedback group and that diastolic feedback would have a greater impact in reducing diastolic pressures than systolic feedback. There hypotheses are applicable for the three experimental conditions of no-stress, stress, and return-to-no-stress. However, as significant reduction
in blood pressure from pretest to posttest are not found, a meaningful comparison of the two types of biofeedback is not possible.

On the basis of these results, the conclusion could be drawn that systolic and diastolic feedback are equally ineffective in influencing systolic and diastolic blood pressures. This finding is in contrast to the many other studies that have used both systolic and diastolic biofeedback with normotensives under no-stress conditions to reduce blood pressure levels. By examining how the procedures employed in this study diverged from those of past research, some important methodological considerations for future research may be highlighted.

Several of the studies that used normotensives and found blood pressure reductions under no-stress conditions employed an increase-blood-pressure biofeedback condition, in addition to the decrease-blood-pressure biofeedback condition. Both Shapiro et al. (1969) and Fey and Lindholm (1975) provided systolic biofeedback to subjects to increase their pressures, whereas Shapiro et al. (1972) provided diastolic feedback to a group of subjects to increase their pressure. Several differences in evaluating blood pressure changes contrast these studies from the present one. This study evaluates the effects of decrease blood pressure biofeedback groups by comparing pretest and
posttest levels of blood pressure for each biofeedback group. In the other studies, differences between the increase and decrease biofeedback groups were compared. It is possible that if the blood pressure levels of the decrease biofeedback groups had been evaluated independently from the increase biofeedback groups that no differences would have been found. This interpretation is congruent with the present findings.

Other studies have reduced both systolic and diastolic blood pressure with normotensives under no-stress conditions using either systolic or diastolic feedback without the use of increase blood pressure biofeedback groups (Elder et al., 1974; Shannon et al., 1978). During the test sessions of these studies, pressure biofeedback was provided for 40 minutes before the effects of the biofeedback on blood pressure were assessed. In the present study, only 5 minutes of biofeedback were provided before blood pressure changes were measured during the posttest. The 15 minutes of biofeedback were interrupted by two blood pressure measurement periods of 3 minutes each. No biofeedback was provided during these measurement periods. In effect, blood pressure reductions resulting from biofeedback were assessed after three different periods of 5 minutes of biofeedback, compared to being evaluated after 40 minutes of biofeedback in previous studies.
Possibly, if longer periods of uninterrupted biofeedback had been provided to subjects, blood pressure reductions comparable to those of the other studies could have been observed.

Surwit et al. (1978) reported difficulties replicating blood pressure reductions reported in experiments utilizing systolic pressure feedback for severe hypertensives. Their subjects were borderline hypertensives. They hypothesized that their failure to replicate past results was partly due to their subjects' initial blood pressure values being lower than the initial values of the severe hypertensives. They reasoned that "the law of initial values" was applicable in explaining some of the differences between the studies. That is, the higher the initial baseline range of blood pressure values evidenced, the more readily treatment effects can be demonstrated. Surwit's borderline hypertensives showed a narrower range of initial blood pressures, in contrast to the severe hypertensives of the other studies. Thus, treatment effects need to be more powerful in the borderline populations in order for blood pressure changes to be detected. By using normotensives in this study, the low initial blood pressure values limited the magnitude of blood pressure reductions possible. Consequently, biofeedback treatment effects became more difficult to observe with normotensive subjects because of their narrower range of possible blood pressures.
Surwit et al. (1978) speculated the replication of past research might be more readily achieved if the number of training sessions provided to their subjects had been extended or if more severe hypertensives had been used. The same suggestions of extending treatment sessions or including subjects with more elevated blood pressures are also suggested by the findings of this study.

A second method for increasing the sensitivity of the experimental design to offset the limiting effect of "the law of initial values" for detecting blood pressure changes in normotensives would be to increase the number of subjects assigned to each of the experimental conditions. The systolic feedback group consistently reduced both systolic and diastolic pressure means more greatly than the diastolic feedback treatments. Although these differences are not significant, perhaps a larger number of subjects would enable these variations between groups to attain statistical significance, even if treatment effects were being limited by the "law of initial values."

The results also indicate that no changes of blood pressure occurred from the pre- to the posttest under the stress conditions. In effect, no treatment effects upon blood pressure elevations resulting from cold pressor are observed. Accordingly, differences between the systolic and diastolic treatments in effecting blood pressures
during stress are undetected. Although no other studies were found that used the cold pressor to evaluate the effects of biofeedback treatments in lowering blood pressure, Victor et al. (1978) utilized the cold pressor to evaluate the effects of heart-rate biofeedback upon heart rate increases that occur from stress. Some of the findings of the Victor et al. (1978) study are compared to those of this study.

The present study provided three cold pressors during the pretest and three with the posttest. The cold-pressor treatments were shown to significantly elevate systolic and diastolic blood pressure from the no-stress levels. The elevated blood pressures returned to the no-stress levels during the return-to-no-stress conditions. Thus, the cold-pressor procedure was effective in elevating blood pressure levels reliably during the pre- and posttests. Victor et al. (1978) used two cold pressors that elevated heart rates and provided subjects with 30 minutes of heart rate biofeedback after the first cold-pressor exposure. Following biofeedback, the subjects underwent a second cold-pressor experience. The heart rates were elevated less during the second cold pressor for the biofeedback group. If more time had been provided for biofeedback in the present study, then the blood pressure biofeedback treatment might have had a similar effect as heart-rate
feedback in diminishing physiological arousal resulting from cold pressor. The amount of stress utilized in this study may have been too great for the treatment regimen to overcome it.

The effects of blood pressure biofeedback upon pain perception and skin temperature during stress are also examined in this study. Reported pain intensity was greatly reduced from the pre- to posttest for all three groups. This reduction of pain is hypothesized to be the result of subjects' habituating to the sensation of the cold pressor, since the diminished pain for the biofeedback groups was comparable to those of the habituation-control group. These results differ from those of Victor et al. (1978). They found that a reduction in pain perception in their biofeedback group was related to a concommitant reduction in their physiological variable of heart rate. Those reductions significantly differed from those of their habituation-control group in which the reported pain and measured heart-rate increases altered little from the pretest cold-pressor conditions.

In the current study, the reductions in pain perception are not accompanied by physiological changes of blood pressure. This may indicate that while reductions of heart-rate acceleration during cold pressor accompany diminished pain perception, changes of blood pressure from
stress do not occur with pain perception. However, the
pain reduction of the habituation-control group suggests
that the findings of the Victor et al. (1978) (in which
pain perception and heart-rate acceleration covary) may be
an artifact of their limited use of stress. If they had
utilized a greater number of cold-pressor administrations,
their habituation-control subjects may have evidenced a
reduction of pain perception independently of physiological
changes in heart rate. A possible explanation for the
different physiological effects for blood pressure and
heart rate that occurred with reduced pain perception
relates to the different amounts of stress and treatment
provided for in the studies. When two cold pressors were
presented, subjects failed to habituate to the cold
sensation. Pain perception was not attenuated. But with
six presentations, habituation occurred and the subjects
reported less pain. The likelihood of subjects habituating
to the cold sensation in this study is further enhanced
by the duration of the cold pressor. This study used
cold pressors of 60-seconds duration, compared to a
duration of 30 seconds in the Victor et al. (1978) study.

The results also indicate that skin temperatures were
significantly increased from the pre- to posttest for all
groups. This increase in skin temperatures across groups
is accompanied by a decrease in pain perception.
These increases in skin temperature may also be an habituation effect that results from repeated exposures to the cold pressor. However, two other factors must be weighted against this conclusion. First, significant decreases in skin temperature from the no-stress to stress conditions occurred in both the pre- and posttests. Skin temperatures also failed to recover to no-stress levels during the return-to-no-stress condition at the time of both pre- and posttests. Thus, even though skin temperatures were consistently elevated during the posttest as compared to the pretest, the same physiological pattern of skin temperature reductions during the stress conditions occurred for both the pre- and posttests. The alternative conclusion is drawn that skin temperature decrements during the stress conditions of both the pretest and the posttest are identical patterns of physiological responses to the cold pressor in which no habituation effect is observed. This conclusion is further supported by the increase in outdoor temperatures that was observed from the pre- to posttest that paralleled the increases of skin temperature during the test conditions (Appendix U). This finding suggests that the use of skin temperatures as a dependent measure would require longer periods of subject habituation to a constant test-room temperature than the 15 minutes provided for in this study, so that outdoor temperature conditions
would not influence the levels of this variable.

In summary, several conclusions can be drawn concerning the findings of this study. First, the use of systolic and diastolic feedback under no-stress and stress conditions appear to have equivalent effects upon the blood pressure levels of normotensives. However, a more extensive test of the relative efficacy of these two forms of feedback would be possible if a number of methodological changes were implemented in future research. First, the biofeedback treatments could be improved by increasing the number of training sessions provided to subjects. In addition, the periods of biofeedback provided to subjects prior to assessing blood pressure reductions could be extended. In evaluating the effects of the two forms of biofeedback treatment, it would be optimal to either utilize subjects that are hypertensives with blood pressure elevations that are as severe as possible, or to increase the number of subjects included if normotensives are used in a study. When using stress, the amount of treatment should be matched to the quantity and intensity of stressors utilized. If a large amount of stress would be applied in future studies, training that has usually been shown to be effective with less stress would have to be extended. If skin temperatures were used as a dependent measure, a period of habituation to test-room temperatures
should greatly exceed the 15 minutes provided for in this study. Skin temperature reductions consistently resulted after exposure to cold pressor. Finally, pain perception and physiological changes that resulted from cold pressor do not appear to be related. Pain perception from cold pressor diminished as repeated stressors were administered. In contrast, change in levels of blood pressure and skin temperature persisted. Past studies that have demonstrated a relationship between pain perception and physiological changes provided too little stress for pain to diminish (from habituation to cold sensation) independently of continued physiological responses to the stress.
Appendix A

Confidential Questionnaire
Autonomic Self-Control Research

Name ___________________________ Age __ Sex ___
Address _________________________ City _____ Zip ___
If student, state major ________ Telephone __________
Marital Status _________ Height ___ Weight __________
Education ________________ Occupation __________________

Are you currently taking any form of medications or drugs? Please describe.

Have you ever been diagnosed as hypertensive or had any cardiovascular health problem? If yes, explain.

In general, I would describe my present health status as:
__ Very Healthy __ Healthy __ Average __ Ill __ Very Ill
Appendix B

Informed Consent Agreement

I, ______________________ hereby give consent to Roger E. Dafter and associates to perform or supervise the following investigational procedure and treatment: recording of blood pressure, utilizing electronic instruments; biofeedback training, utilizing electronic instruments to monitor blood pressure; and training in psychophysiological therapy techniques for the self-control of blood pressure. I understand that the use of the above described procedures to control blood pressure is experimental, but if they are successful, I may expect to develop some degree of control over my blood pressure. I further understand that this investigation does not involve either medical diagnosis or medical treatment and is not intended to substitute for consultation with a physician or medical treatment for any present symptoms that I possess.

I have (seen, heard) a clear explanation and understand the nature and purpose of the procedure or treatment, the attendant discomforts or risks involved, and the possibility of complications which might arise. If hypertensive, a clear explanation of alternative procedures for my condition and the experimental procedures have been
clearly explained to me and understood by me. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my participation. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in the paragraph above.

DATED

SIGNED: _______________  SIGNED: _______________
Witness  Subject

or

SIGNED: _______________  SIGNED: _______________
Witness  Person Responsible

Relationship

Instructions to persons authorized to sign:

If the subject is not competent, the person responsible shall be the legal guardian or legally authorized representative. If the subject is a minor under 18 years of age, the person responsible is the mother or father or legally appointed guardian. If the subject is unable to write his name, the following is legally acceptable: John H. Doe (his X mark) and two (2) witnesses.
Appendix C

Instructions for Blood Pressure Monitoring

Introduction: The following instructions are a standardized procedure for measuring your own blood pressure. For research purposes and for your own efforts to control your blood pressure, it is important that these factors be held constant. In this way, you and the researchers will know that any changes in the blood pressure readings obtained are the result of real changes in your blood pressure and are not due simply to differences in the procedures for measuring your blood pressure. Therefore, the procedure outlined here should be followed exactly throughout the duration of your participation in this research project.

Throughout your participation in this project you will be asked to take your blood pressure to obtain readings of both your systolic and diastolic pressures. The systolic pressure is the higher number, and the diastolic the lower number in a pressure reading. During the pre- and post-treatment sessions you will take 18 blood pressure readings during a 57-minute period. During the five treatment sessions you will take blood pressure up to 21 times over a 66-minute period. You will be provided with cassette recordings that will instruct you as to when your blood pressure should be taken. You are requested to record all
of your blood pressure readings as accurately and as neatly as you can on the data sheets provided to you. Now take the blood pressure recording units out of their cases and perform the procedures as I talk to you about them. The experimenters are there to assist you with learning the procedure.

**Preparation for Recording Blood Pressure:** When you are ready to begin measuring your blood pressure, sit still and assume a position where you can rest your nondominant arm at about the same level as your heart. It is important that you position your arm with the palm turned upward and the arm extended so that it will rest perfectly still while blood pressure readings are being taken. Movements of the arm may cause false readings. It is also important that you assume exactly the same position every time you take your blood pressure. The position you assume must, therefore, be comfortable. During this presentation, you need not worry about your arm position while you are becoming familiar with the blood pressure monitoring unit and procedure for blood pressure recording. However, throughout the rest of the experiment, every time you take your blood pressure in your assigned therapy room, it is essential that your arm is always in the same position at the level of your heart, if the readings are to be accurate.

**Fitting the Equipment:** At the beginning of each session,
remove the blood pressure cuff from its carrying case. Slide the cuff up your nondominant arm, making sure that no clothing is between the cuff and your arm. The hoses and inflation gauge should be on the side of the cuff toward your hand. Wrap the loose end of the cuff back under and around your arm, and press together the velcro tape to secure the cuff around your arm.

Rotate the cuff and slide it either up or down until the dot on the cuff (just above where the rubber hoses go into the cuff) is on the inside of your arm over the large artery near the hollow of your elbow where your arm bends. This artery can be found by feeling for the pulse of the artery. Straighten your arm completely and use the index finger of the other hand. The artery is located with the arm outstretched and palm up, about 1/2 inch to the body side of the center of the arm, just above the hollow of the elbow. Once you have placed the dot over your artery, you may want to adjust the cuff to fit snugly around your arm. Next, place the pressure gauge in a convenient location where the sphygmomanometer dial can be easily read.

**Taking Your Blood Pressure:** Be sure the power switch is turned **off** before you begin to take your blood pressure. Rotate the air flow valve screw on the bulb clockwise in order to close the air valve. Begin taking your blood pressure by squeezing the bulb with your dominant hand. Always inflate as quickly as you can. This point about
inflating quickly cannot be emphasized enough as it will make it easier for you to collect your data.

After inflating rapidly, move the sphygmomanometer power switch to the "on" position. You will generally get an immediate beep sound and the light on the gauge will flash. If the unit continues to "beep" and the light continues to flash for more than 5 seconds and you feel sure that your arm is not moving, deflate the cuff by turning the air valve screw in a counterclockwise direction, and turn off the power switch.

When the cuff is completely deflated, repeat the procedure again raising the cuff pressure 30 mm Hg over your last systolic pressure reading. After the cuff becomes deflated to this level, turn the unit on, and if the unit is not continuously "beeping" and "flashing," begin decreasing the pressure in the cuff by turning the air flow valve so that the needle of the sphygmomanometer is falling at the rate of about 2 to 4 mm per second or one to two marks per second. Continue decreasing the pressure in the cuff, keeping your arm as stationary as possible until the unit "beeps" and "flashes." Immediately close the air flow valve by turning the screw clockwise. The unit should continue "beeping" and "flashing" in a regular manner corresponding to your pulse rate. If this is indeed occurring, record your systolic blood pressure on the forms provided at the point that the continuous beeping
Appendix C—Continued

and flashing started. Be sure to record only the level that was indicated just at the point where the continuous beeping and flashing started.

If the unit does not continue to "beep" and "flash" regularly, you probably have a flash reading and should continue to decrease the pressure in the cuff as before until you get another "beep" and "flash." Shut the air flow valve immediately as before, and notice if you are getting regular beeps and flashes. If so, this is your systolic blood pressure. Record the reading from the sphygmomanometer dial at the point where the "beeps" and "flashes" first started. If the unit is still not "beeping" and "flashing" in a regular manner, continue decreasing the pressure following the same procedure until regular spaced "beeps" and "flashes" occur. If after these three efforts regularly spaced "beeps" and "flashes" are not obtained, deflate the cuff completely, turn off the power, and begin the procedure again.

After your systolic pressure has been obtained and recorded according to the above instructions, again begin to reduce the cuff pressure to take your diastolic reading. Continue decreasing the cuff at the same rate of 1 to 2 marks per second until this time the unit stops beeping and flashing. Close the air flow valve immediately by turning the screw in a clockwise direction. The unit should at this point not be "beeping" and "flashing" or at
least should beep only infrequently. Again, record the sphygmomanometer reading at the very point where the beeping and flashing stopped. If the unit begins "beeping" and "flashing" at regular intervals within a few seconds, again reduce the cuff pressure until the regular "beeping" and "flashing" ceases while the cuff pressure is held stable for 5 seconds. After completing your diastolic reading, decrease the cuff pressure to zero.
Appendix D

Pointers on Taking Accurate Blood Pressure Readings

SETTING UP

1. Slide the cuff onto your nondominant arm and find the brachial artery. Make sure the dot on the cuff is over it.
2. Then tighten the cuff to fit snugly around your arm.
3. Place the gauge near you so that you can easily read it.

PUMPING UP

1. Be sure the unit is turned off before you pump up.
2. Turn the air valve clockwise to close it (not too tight).
3. Inflate the cuff as quickly as you can to about 30 mm Hg over your last systolic reading or to 180 mm Hg during cold pressor readings.

RECORDING BLOOD PRESSURE

1. Turn the switch on.
2. Slowly release the air pressure by turning the air valve counter-clockwise.
3. The needle should fall at about a rate of 2-4 mm per second (1 to 2 marks per second).
4. Watch the light, not the gauge needle.
5. When the light comes on, close the air valve immediately (the unit should be beeping and flashing regularly).
6. Record the level that was indicated at the exact point where the light first started to flash in your data notebook.
7. Release air pressure again and watch the light.
8. When the light goes out and the beeping stops, close the air valve immediately (the unit should not beep and flash regularly).
9. Record the level that was indicated just when the light and beeping stopped in your data notebook.

10. Open the valve completely by turning it counterclockwise.

11. Turn the unit off and rest until you receive further instructions.

EQUIPMENT CARE

1. When putting equipment away be sure the unit is turned off and that the cuff is completely deflated.

2. Avoid getting the cuff or gauge wet.
### Appendix E

Taped Instructions for Pretest and Posttest

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Recorded Instructions Given to Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>2</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>3</td>
<td>Record Skin Temperature</td>
</tr>
<tr>
<td>9</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>10</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>11</td>
<td>Record Skin Temperature</td>
</tr>
<tr>
<td>17</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>18</td>
<td>Record Blood Pressure</td>
</tr>
<tr>
<td>19</td>
<td>a) Record Skin Temperature b) Prepare to Submerge</td>
</tr>
<tr>
<td>20</td>
<td>a) Submerge Now b) Record Blood Pressure</td>
</tr>
<tr>
<td>21</td>
<td>a) Withdraw Your Foot b) Record Blood Pressure c) Rate the Cold Pressor Experiment</td>
</tr>
<tr>
<td>22</td>
<td>a) Record Skin Temperature b) Prepare to Submerge</td>
</tr>
</tbody>
</table>

(Five minutes of self-directed relaxation or initiation of treatment skills)
Appendix E—Continued

Minutes

28

29

30

(Five minutes of self-directed relaxation or initiation of treatment skills)

36

37

38

39

40

41

(Five minutes of self-directed relaxation or initiation of treatment skills)

47

48

49

Recorded Instructions Given to Subject

a) Submerge Now
b) Record Blood Pressure

a) Withdraw Your Foot
b) Record Blood Pressure
c) Rate the Cold Pressor Experiment

a) Record Skin Temperature
b) Prepare to Submerge
Record Blood Pressure

Record Blood Pressure

Record Skin Temperature
Appendix F

Instructions for Self-Directed Relaxation

You are about to begin the pretest phases of the study to assess your ability to lower your blood pressure under stress and no-stress conditions. Some people have been shown to have the ability to lower their blood pressure prior to undergoing any specific training for this skill. Decreasing your blood pressure is possible if you concentrate on calming yourself and relaxing the muscles in your body.

During this session you will be recording your own blood pressure or skin temperature and reporting your reactions to the cold pressor on the sheets provided to you. Be sure to pump up quickly and to make all your readings as accurate as you can. Remember to keep your arm in the same position for every blood pressure recording. I will turn on this cassette recorder with taped directions which will indicate when you are to actually take these readings and record your reactions. Sometime during the sessions after completing all of your cold pressors you will have to turn this tape over. (This is demonstrated.) If you are not finished completing one reading before further directions are given for taking a second reading, then just finish taking the first reading and proceed with completing the second one as soon as you can.
As you immerse your foot in the cold water, an experimenter will observe you through a one-way mirror to insure that you place your foot in the cold pressor for the exact amount of time that you are instructed to by the tape. The cold pressor can be a very painful and shocking experience. Do not let the shock of the cold pressor interfere with the accuracy of your blood pressure recordings. Be sure to take good blood pressure readings even when you experience upset from the cold pressor.

Now for the next 57 minutes you are to use any skills that you have to relax and lower your blood pressure under both stress and no-stress conditions.
Appendix G

Data Sheets

BLOOD PRESSURE: ________

BLOOD PRESSURE: ________

SKIN TEMPERATURE: ________

BLOOD PRESSURE: ________

BLOOD PRESSURE: ________

SKIN TEMPERATURE: ________

BLOOD PRESSURE: ________

BLOOD PRESSURE: ________

SKIN TEMPERATURE: ________

BLOOD PRESSURE: ________

BLOOD PRESSURE: ________
NO PAIN—PAIN AS BAD AS IT COULD BE
SKIN TEMPERATURE: 

BLOOD PRESSURE: 

BLOOD PRESSURE: 

---
NO PAIN — PAIN AS BAD AS IT COULD BE
SKIN TEMPERATURE: ________

BLOOD PRESSURE: ________

BLOOD PRESSURE: ________
NO PAIN—PAIN AS BAD AS IT COULD BE
SKIN TEMPERATURE: 

BLOOD PRESSURE: 

BLOOD PRESSURE: 

SKIN TEMPERATURE: 

BLOOD PRESSURE: 

BLOOD PRESSURE: 

SKIN TEMPERATURE: 

BLOOD PRESSURE: 

BLOOD PRESSURE: 

SKIN TEMPERATURE:
Appendix H

Introduction to Biofeedback Training

Internal physiological processes, such as brain waves, body temperature, heart rate, and blood pressure, are normally controlled by the autonomic nervous system rather than by our conscious efforts. Since the development of biofeedback devices, which provide a record of the body's internal processes, researchers have developed ways for individuals to voluntarily control their physiological processes. People who are given visual or auditory feedback of their physiological responses have been shown to gain the ability to consciously control these responses.

Over the past 10 years, biofeedback has received a great deal of attention and scrutiny from researchers around the world. Early research on blood pressure control, for example, demonstrated that people with normal blood pressure could learn with the help of feedback to raise and lower their blood pressures when asked to do so. Physicians, psychologists, and medical researchers have applied this new technology to the treatment of hypertensives, enabling them to reduce their pathological blood pressure elevations. These results have been replicated many times in the clinic, as well as in the laboratory. Furthermore, the ability to initiate blood pressure reductions acquired from biofeedback training has been reported to last for a year or more.
Researchers have shown that blood pressure elevations naturally occur in times of stress. You have observed your own blood pressure elevate while you were exposed to the cold pressor, a laboratory analog stressor. Studies have demonstrated that such elevations resulting from stressful conditions can be minimized or eliminated with the help of biofeedback training. In this study, you will learn to control, or lower, your blood pressure under stress and no-stress conditions, using blood pressure biofeedback.

Acquiring the skill to gain control over one's physiological activity to influence blood pressure is a similar learning process to refining one's muscle movements when throwing darts to hit a bull's-eye. These two learning situations require that feedback about one's success in acquiring these skills be provided so that improvement occurs. For example, if you are learning the response of throwing a dart accurately, and you are blindfolded during this process, your brain receives no information about your performance. As a result, you will show little improvement in throwing darts no matter how long you practice or how hard you try to do well. With the blindfold removed, you receive visual feedback about the success of your efforts. This feedback is necessary for refining your motor skills to achieve the goal of hitting the bull's-eye. In the same way, you cannot learn the skill of controlling physiological processes without information about how your conscious
efforts influence your physiological responding. Biofeedback gives information through visual or auditory signals about your successes in affecting physiological processes. This enables individuals with practice to consciously influence and voluntarily regulate some of their body's physiological responses. You will be learning to alter your body's physiological responses to achieve the goal of lowering your blood pressure.

The mechanisms by which you will learn to control and lower your blood pressure reside within your nervous system. The neocortex, the part of your brain that mediates conscious awareness, has direct connections to the hypothalamus. The hypothalamus is a part of the brain that regulates autonomic processes that control blood pressure. Brain researchers have shown that neural activities of the neocortex associated with conscious activity are continuously influencing blood pressure levels through these connections to the hypothalamus. These processes of the neocortex also influence the magnitude of blood pressure elevations resulting from the cold pressor.

Biofeedback training will provide you with information about your physiological responses enabling you to identify those conscious thoughts and feelings (i.e., states of peace or calm) that normally lower your blood pressure. As training proceeds, you will begin to let these conscious states occur, so that blood pressure reductions will take
place under the no-stress conditions. When you are exposed to the cold pressor again, you will initiate these same states to eliminate or minimize the blood pressure elevations that occur during the cold pressor experience.

The remaining time you spend in training will involve specific instructions to undergo biofeedback training. You will receive information about changes in your blood pressure in the form of visual and auditory feedback to gain voluntary control over the processes that affect your pressure levels. You will be assisted by a doctoral student in clinical psychology during training. Be sure to follow all instructions and training procedures exactly, as these methods have been shown to work for many people who have undergone this training before you. In doing this, you will maximize your learning of skills to influence your blood pressure. Good Luck. Be sure to do your best.
Appendix I

Systolic Biofeedback Training Instructions

You have recorded your blood pressure and should be completely familiar with the blood pressure monitoring procedure. You are now ready to begin the biofeedback training period of this study in which you will learn to lower your systolic blood pressure and minimize blood pressure elevations resulting from cold pressor immersions.

To a large extent, this is a trial and error process. Even people who have learned to control their blood pressure very effectively cannot satisfactorily explain how they do it. It seems to be similar to trying to tell someone how to wiggle their ears. The learning is very individualized, and it is difficult to put into words how one learns the skill. What works for one person will not necessarily work for someone else, so you will need to find the way that works for you. Whatever strategy you choose to try for learning to reduce your blood pressure, it is particularly important to assume a passive attitude. That is, be attentive, but just let it happen without trying to make anything happen. Don’t try to force yourself to make your blood pressure go down; instead, let it go down. While you are learning to control blood pressure, try to avoid becoming discouraged if you don’t succeed right away.

Learning to control bodily processes frequently seems slow,
but if you continue to practice during the sessions, reductions will eventually occur.

The blood pressure instrument you have been using to record your blood pressure can be used as a biofeedback device to provide you with information regarding your systolic blood pressure. Begin biofeedback practice by preparing as if you were going to record your blood pressure, but during this period, you will hold the cuff pressure constant at the level of systolic blood pressure by turning the air flow valve off. Then, close your eyes and let the "beeping" and "flashing" go away. When these signals stop or decrease in frequency, you have reduced your blood pressure below the level indicated on the gauge. Decreases in systolic pressure are almost always accompanied by proportional decreases in diastolic pressure. Whether or not the signals go away, at the end of the trial, release the cuff pressure and rest.

Each training trial will last approximately 60 seconds, and there will be a 30-second break between trials. A cassette tape with recorded instructions will signal the beginning and end of biofeedback trials. Before beginning a practice session, be sure the tape is completely rewound. The first taped instruction you will hear will be "inflate" your blood pressure cuff. Begin the biofeedback procedure when the instruction "perform biofeedback" is given you from the tape. End these trials when you receive the instruction to "deflate and rest."
The following checklist summarizes the procedure to be followed:

1. Prior to carrying out the procedure, set up the tape recorder so that the cassette is rewound, nearby where you can turn it on and off without getting up.

2. Turn on the tape recorder.

3. When the instruction "inflate" is given, inflate the cuff to about 30 mm above your last self-monitored systolic reading.

4. When the instruction to "perform biofeedback" is given, turn the gauge unit power switch to "on" and reduce the pressure in the cuff until the unit just begins "beeping" and "flashing" at regular intervals. This is around the point of your last systolic reading. Stop reducing the pressure in the cuff at this point.

5. Close your eyes and begin practicing whatever strategy you have chosen to employ to let the "beeping" and "flashing" go away. If it does, simply continue with whatever strategy you are employing until the next tone occurs.

6. Stop biofeedback immediately when the instruction to "deflate and rest" is given by opening the air flow valve and letting the pressure in the cuff drop to zero. Completely deflate the cuff.

7. After you rest for 30 seconds, the cycle will repeat itself.

Thank you for your continuing efforts. Good luck during the training.
Appendix J

Diastolic Biofeedback Training Instructions

You have recorded your blood pressure and should be completely familiar with the blood pressure monitoring procedure. You are now ready to begin the biofeedback training period of this study in which you will learn to lower your systolic blood pressure and minimize blood pressure elevations resulting from cold pressor immersions.

To a large extent, this is a trial and error process. Even people who have learned to control their blood pressure very effectively cannot satisfactorily explain how they do it. It seems to be similar to trying to tell someone how to wiggle their ears. The learning is very individualized, and it is difficult to put into words how one learns the skill. What works for one person will not necessarily work for someone else, so you will need to find the way that works for you. Whatever strategy you choose to try for learning to reduce your blood pressure, it is particularly important to assume a passive attitude. That is, be attentive, but just let it happen without trying to make anything happen. Don't try to force yourself to make your blood pressure go down; instead, let it go down. While you are learning to control blood pressure, try to avoid becoming discouraged if you don't succeed right away. Learning to control bodily processes frequently seems slow, but if you
continue to practice during the sessions, reductions will eventually occur.

The blood pressure instrument you have been using to record your blood pressure can be used as a biofeedback device to provide you with information regarding your diastolic blood pressure. Begin biofeedback practice by preparing as if you were going to record your blood pressure, but during this period, you will hold the cuff pressure constant at the level of diastolic blood pressure by turning the air flow valve off. Pass the point of systolic pressure and continue deflating until just past the point where the light and tone reappear. Then, close your eyes and make the light and tone reappear. When these signals reappear or increase in frequency, you have reduced your blood pressure to the level indicated on the gauge. Decreases in diastolic pressure are almost always accompanied by proportional decreases in systolic pressure. Whether or not the signals come back, at the end of the trial, release the cuff pressure and rest.

Each training trial will last approximately 60 seconds, and there will be a 30-second break between trials. A cassette tape with recorded instructions will signal the beginning and end of biofeedback trials. Before beginning a practice session, be sure the tape is completely rewound. The first taped instruction you will hear will be to "inflate" your blood pressure cuff. Begin the biofeedback
procedure when the instruction "perform biofeedback" is given to you from the tape. End these trials when you receive the instruction to "deflate and rest."

The following checklist summarizes the procedure to be followed:

1. Prior to carrying out the procedure, set up the tape recorder, so that the cassette is rewound, nearby where you can turn it on and off without getting up.
2. Turn on the tape recorder.
3. When the instruction "inflate" is given, inflate the cuff to about 30 mm above your last self-monitored systolic reading.
4. When the instruction to "perform biofeedback" is given, turn the gauge unit power switch to "on" and reduce the pressure in the cuff until the unit just passes the diastolic pressure point. This is around the point of your last diastolic reading. Stop reducing the pressure in the cuff at this point.
5. Close your eyes and begin practicing whatever strategy you have chosen to employ to let the "beeping" and "flashing" come back. If it does, simply continue with whatever strategy you are employing until the next tone occurs.
6. Stop biofeedback immediately when the instruction to "deflate and rest" is given by opening the air flow valve
and letting the pressure in the cuff drop to zero so that the cuff is completely deflated.

7. After you rest for 30 seconds, the cycle will repeat itself.

Thank you for your continuing efforts. Good luck during the training.
Appendix K

Credibility Chart

Please read the following questions and circle the number which best describes your present beliefs about the blood pressure control instructions that you just received.

1. How logical does this treatment seem to you?
   
   not logical somewhat very logical
   1 2 3 4 5 6 7

2. How confident are you that this treatment will help you control your blood pressure when your foot is in the ice water?
   
   not confident somewhat very confident
   1 2 3 4 5 6 7

3. How confident are you that this treatment will help you control your blood pressure under non-stress conditions?
   
   not confident somewhat very confident
   1 2 3 4 5 6 7

4. How confident would you be in recommending this treatment to a friend who was to participate in an experiment in which he or she was asked to place his/her foot in ice water and control their blood pressure response?
   
   not confident somewhat very confident
   1 2 3 4 5 6 7

5. How confident would you be in recommending this treatment to a friend who was to participate in an experiment in which he or she was asked to lower his/her blood pressure under non-stress conditions?
   
   not confident somewhat very confident
   1 2 3 4 5 6 7
6. How willing are you to use this treatment for lowering your blood pressure while your foot is in the ice water?

not willing 2 3 somewhat 4 very willing 6 7
Appendix L

Posttest Questionnaire

1. To what extent did you follow your instructions for lowering your blood pressure?

<table>
<thead>
<tr>
<th>not at all</th>
<th>somewhat</th>
<th>completely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

2. How involved personally do you think that you were in performing biofeedback during the posttest?

<table>
<thead>
<tr>
<th>not at all</th>
<th>somewhat</th>
<th>very involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

3. Do you think your efforts to lower your blood pressure during the posttest were as strong as your efforts during the training period?

<table>
<thead>
<tr>
<th>not as strong</th>
<th>just as strong</th>
<th>much stronger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

4. While your foot was in the ice water, do you think that the biofeedback helped you to control your responses during the immersion?

<table>
<thead>
<tr>
<th>not at all</th>
<th>somewhat</th>
<th>very much so</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 1

Three-Way Analysis of Variance--
Systolic Blood Pressure

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
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<tbody>
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* P ≤ .000001
Table 2

Three-Way Analysis of Variance—
Diasystolic Blood Pressure

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* p ≤ .000001
Table 3

Summary of Systolic Blood Pressure
Means and Standard Deviations
across Three Conditions

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<thead>
<tr>
<th>Treatment groups</th>
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<td>$\bar{x}$  SD</td>
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<td>105.9  12.7</td>
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<td>105.7  14.0</td>
<td>106.5  9.0</td>
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<td>Habituation Control</td>
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<td>124.0  17.0</td>
<td>111.3  12.1</td>
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Appendix 0
Table 4

Summary of Diastolic Blood Pressure
Means and Standard Deviations
across Three Conditions

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<td>Stress</td>
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<td>( \bar{x} ) SD</td>
<td>( \bar{x} ) SD</td>
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<td>82.7 7.2</td>
<td>76.4 8.2</td>
<td>69.0 7.3</td>
<td>78.5 10.0</td>
<td>69.4 9.5</td>
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<td>74.7 8.0</td>
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Table 5

Three-Way Analysis of Variance—
Skin Temperature

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* * \( P \leq 0.00001 

** \( P \leq 0.00002 \)
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<td>Systolic Biofeedback</td>
<td>19.8</td>
<td>8.7</td>
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<td>Habituation Control</td>
<td>22.9</td>
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Appendix S

Table 7

Two-Way Analysis of Variance—Pain Ratings

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<td>61.92</td>
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* p ≤ .001
### Appendix T

#### Table 8

**Summary of Pain Rating Means and Standard Deviations across Phases**

<table>
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<tr>
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Appendix U

Outdoor Temperatures During The Pretest and Posttest

The temperature for the following dates were reported in the *Denton Record Chronicle*.

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<td>31.7</td>
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Fey, S. G., & Lindholm, E. Systolic blood pressure and heart rate changes during three sessions involving biofeedback or no feedback. Psychophysiology, 1975, 12, 513-519.


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Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effects of treatment on morbidity in hypertension: Results in patients with diastolic blood pressure averaging 115 through 129 mm Hg. *Journal of the American Medical Association*, 1976, 202(21), 1028-1034.
