CARDIOVASCULAR REACTIVITY TO SPEECH PROCESSING AND COLD PRESSOR STRESS: EVIDENCE FOR SEX DIFFERENCES IN DYNAMIC FUNCTIONAL CEREBRAL LATERALITY

by

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(ABSTRACT)

This experiment investigated sex differences in dynamic functional cerebral laterality effects on cardiovascular reactivity and dichotic listening in response to a stressor (a cold pressor). 120 right-handed undergraduate men (N = 60) and women (N = 60) underwent physiological measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) before and after exposure to the cold pressor and a phonemic dichotic listening task. Functional cerebral laterality was assessed through the administration of the phonemic dichotic listening task. Group differences in dynamic functional cerebral laterality were predicted.

Findings indicated a sex by focus interaction effect where men's, but not women's, systolic blood pressure increased significantly when focusing on sounds presented at the left ear during the dichotic listening task. Also, a compartmentalized, dynamic response in dichotic listening test performance was evidenced in both men and women (as both experienced increased accuracy at the right, but not left, ear), brought about as a function of the cold pressor. Men and women both evidenced increased cardiovascular reactivity, with men experiencing significantly more cardiovascular reactivity (SBP) than women in response to cold pressor pain. Women were also able to identify significantly more speech sounds presented to the left ear than men, and they were able to dynamically increase accuracy at the targeted ear identified within each focus group (left or right). Speech sounds processing (dichotic listening task) significantly decreased men's, but not women's, systolic blood pressure. These results contribute to the literature on sex differences in functional cerebral laterality.

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This project is dedicated to my loving wife, DeAnn. Her companionship is my treasure.

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CARDIOVASCULAR REACTIVITY TO SPEECH PROCESSING AND COLD PRESSOR STRESS: EVIDENCE FOR SEX DIFFERENCES IN DYNAMIC FUNCTIONAL CEREBRAL LATERALITY

Every thirty-three seconds, someone in America dies from cardiovascular disease (CVD). It is the No. 1 killer of men and women. Cardiovascular disease claimed a total of 959,227 lives in 1996 (41.4%, or 1 of every 2.4 deaths in America), compared to 544,728 lives lost to all types of cancer, and 93,874 lives lost to accidents (American Heart Association, 1999). Cardiovascular disease claims more lives each year than the next seven leading causes of death combined. The American Heart Association estimates that 58.8 million Americans (1 in 5) have one or more of the following forms of cardiovascular disease: high blood pressure, 50 million; coronary heart disease, 12 million; myocardial infarction (acute heart attack), 7 million; angina pectoris (chest pain), 6.2 million; stroke, 4.4 million; congestive heart failure, 4.6 million, and rheumatic heart disease, 1.8 million.

Coronary heart disease (CHD), a type of cardiovascular disease, is the single leading cause of death in America today, causing 476,124 deaths in 1996. The American Heart Association (AHA) reports that cardiovascular diseases and stroke cost America 287 billion dollars a year through medication costs, health professional services, and lost productivity from morbidity and mortality (stroke costs 45 billion dollars of this total; AHA, 1999). Furthermore, recent research suggests that the lifetime risk at age forty of developing coronary heart disease is 48.6% for men and 31.7% for women (Lloyd-Jones, Larson, Beiser, & Levy, 1999). Even at age seventy, the lifetime risk was still 34.9% for men and 24.2% for women.

Understanding the mechanisms contributing to heart disease risk can lead to lowering its incapacitating effect through more precisely tailored prevention programs. If all forms of CVD were eliminated, life expectancy would rise by 10 years (AHA, 1999). Sex differences contribute to the disparity of heart disease mortality rates among men and women. One in three men can expect to develop some major CVD before age 60, while one in ten women can expect the same. Each year men die of CVD 40% more often than women (505 vs. 361 deaths per 100,000, respectively). Furthermore, men die of coronary heart disease 53% more often than women (238 vs. 155 deaths per 100,000, respectively; AHA, 1999).

Notwithstanding, as men and women age, this epidemiological disparity diminishes, especially after menopause in women. In fact, in terms of total deaths (which is different than mortality rates), more women than men have died from CVD every year since 1984. Cardiovascular diseases claim the lives of more than half a million women every year, more lives than the next 16 causes of death combined (AHA, 1999).

Sex differences have always been an area of intrigue for very individual reasons. Every person associates with a member of the opposite sex, either through friendship or intimacy, and the idiosyncrasies of the other sex have produced both amazement and bewilderment, however, the fascination does not end there. For well beyond the intricate, connective threads of relationships lies the fabric of identity. With the identity of what it is to be a man or a woman comes a certain inherited biology which transcends exterior differences to a level representing more vital “internal” workings.

What is it that attenuates cardiovascular disease risk in women compared to men? The bodies of men and women have been studied and scientists have a fairly good understanding of the differences. However, the next frontier to be explored is the brain and its influence on health variables, with an emphasis on sex differences in dynamic functional cerebral laterality.

Why Neuropsychology?

The brain directs activity in bodily systems, and the cardiovascular system is one of the most important systems under its control. Cardiovascular disease can arise from cerebral dysfunction and it can be conceptualized as a brain disorder that contributes to a heart disorder.

Neuropsychology is a field which focuses on relationships among brain structures and behavior (Pribram, 1964). Neuropsychology has contributed enormously to the understanding of emotions and the underlying cardiovascular reactivity of emotional states. Through a neuropsychological perspective, emotions and cardiovascular reactivity can be understood as functions of relative cerebral activation patterns and corresponding cardiovascular responses. Differences in reactivity and dynamic functional cerebral laterality are just beginning to be explored. The journey begins with a description of developmental influences on the design of functional cerebral laterality.

Development of Cerebral Laterality and Functional Differentiation

The basis for the differential rates of neural development of the cerebral hemispheres should not be viewed as context-free (Turkewitz, 1993). There is evidence that neuroanatomical structures can be changed by experience, that structure and environment are coacting systems which give rise to brain functionality. Recent findings support the notion of dynamic cerebral development.

Turkewitz (1993) suggests that auditory experience helps guide brain laterality. This idea was first explained by Fred Previc (1991). He theorized that cerebral lateralization in humans is a result of the asymmetric prenatal development of the ear and labyrinth (vestibular organ). The aural asymmetry gives rise to a right ear advantage, especially for sound in the mid-frequency range (i.e., speech). This advantage is a result of the fetal position that has been found to exist among the majority of developing babies. Typically, the predominant position of the fetus during the final trimester of pregnancy is a cephalic (head-down) one, with its right ear facing out (against the mother’s anterior abdominal wall; Taylor, 1976). Thus, the bodily position of a developing fetus can be an important factor in the development of functional cerebral asymmetry, similar to the way a genetic program directs cerebral asymmetry.

Vestibular lateralization can also be traced to the asymmetric positioning of the fetus *in utero* during the final trimester. As the baby’s position combines with maternal locomotor patterns, a lateralized shearing effect favors the development of a left-otolithic advantage (Previc, 1991). This advantage gives rise to a reliance on the left side of the body for postural control and the right side for voluntary motor behavior. The right hemisphere also develops a specialization for most visuospatial operations.

In contrast, Walker (1994) concluded that alternative theories of lateralization of human brain function, such as the one proposed by Previc, find little support when considering the neural pathways involved in the process of asymmetric laryngeal innervation in language lateralization. He contends that the auditory system has much less contralateral and more ipsilateral neural projections than other sensory systems. It would be difficult to separate which pathways were responsible for specialized laterality. However, findings are still inconclusive; thus, this area deserves further research consideration.

In addition to auditory stimulus-directed cerebral *laterality*, researchers have begun to theorize that visual stimuli organize cerebral structural *functionality* during development, as well as the space-mapping within the structures (Knudsen, 1991; Knudsen & Brainard, 1991; Knudsen, Esterly, & Du Lac, 1991). New theories describe cerebral sensory and motor maps as dynamic, shaped by sensory experience (and by eye-head position signals) in developing animals. The superior colliculus (a small area at the "roof" of the brain stem and an integral part of the visual system) provides an ideal structure for examining the neural mechanisms underlying developmental and real-time modifications of structural cerebral functionality (information representation in the brain).

The superior colliculus integrates spatial information from various sensory systems and higher brain centers into a common oculocentric (relative to the eye) frame of reference (Knudsen, 1991). In barn owls raised with their eyelids sutured closed, the precision and topography of the auditory space map and the motor map are severely disrupted. These owls typically overestimate the origin of a sound and then turn toward/past it (Knudsen & Brainard, 1991). In a study where prisms were mounted in front of owls' eyes during development, the auditory space map shifted "according to the optical displacement induced by the prisms" (Knudsen, 1991; Knudsen, Esterly, & Du Lac, 1991). These results indicate that visual experience during development shapes the collicular auditory map in a site-specific manner and dictates its alignment with the visual map.

Consequently, research suggests that cerebral laterality is partly a function of (prenatal) auditory stimuli and that cerebral structural functionality is directed through visual stimuli. Péter Érdi (1993) has presented a Neurodynamic System Theory to begin to account for the changing conceptualizations of neural organization. He suggests that generalized causal dynamic models can describe the self-organizing mechanism of the nervous system, connecting structural and functional aspects of neural organization. The brain can be considered as consisting of hierarchically organized self-organizing structures. Self-organization is considered as a mechanism for generating emergent neural structures. The dynamic neural structures can be modified by environmental influences, both pre- and post-natally.

Specific cerebral systems differ in men and women, and the neurochemical influences that help shape the formation of these neural networks should not be underestimated. Hormones may influence the development of cerebral (a)symmetry during gestational development in men and women. Furthermore, differences in cerebral symmetry later impact sex differences in emotional regulation, cardiovascular reactivity (i.e., the development of cardiovascular disease), and, ultimately, differences in mortality rates in men and women. That is to say, as experience shapes brain structure and function, sex has an significant impact on brain development, influencing both cerebral lateralization and cerebral system functionality. Sex hormones have been found to influence lateralization of brain structure, when exposure has occurred during prenatal (Hines & Shipley, 1984; Joslyn, 1973) and neonatal (Holman & Hutchison, 1991) development.

Exposure to various levels of hormones during human gestation appears to play a primary role in the cytoarchitectural design of the central nervous system in men and women. These gestational hormones help determine whether the brain will have structural features characteristic of the male or female. During the initial phase of fetal development, the brain and physical character of the body are female in appearance. Around the seventh week following conception, the Y chromosome, signifying a male genetic pattern, is activated. At this point, sex differences in the design of the brain begin to be evident as testosterone, believed to be largely responsible for anatomical sex differences, is released (Ehrhardt & Meyer-Bahlburg, 1981; Fishbein, 1992; Valzelli, 1981).

As experience shapes brain structure and function, sex has an significant impact on brain development. Lateralization and cerebral system functionality are developed through influential sex effects, which have begun to be studied more closely. Differences in functional cerebral lateralization in men and women can be better appreciated when considering how it affects health, recovery, and prior research validity.

Sex differences in brain structure are of interest to neuropsychologists to the extent that they provide clues to functional differences in the brain. The considerable, recent interest generated by sex differences in brain anatomy is related to the fact that anatomical brain differences related to sex appear to be associated with some of the more substantial dimensions of human brain function: lateralization, verbal ability, spatial ability, and recovery from brain injury (Farace & Turkheimer, 1996). Recovery is directly related to the issue of asymmetry since more symmetrical brain functionality is not as vulnerable to focal, unilateral damage, such as that caused by a cerebrovascular accident (CVA) like a stroke.

Sex Differences in Functional Cerebral Laterality: Verbal and Spatial Abilities

Historically, sex differences have been found in verbal-linguistic processing, with women maintaining an advantage over men. Nevertheless, men usually outperform women on tasks requiring spatial processing (Benbow & Stanley, 1980; McGlone, 1980; Springer & Deutsch, 1989). Previous research has indicated different levels of cerebral laterality for each sex. Sex differences and cerebral asymmetry have been studied for some time. In 1880, Chrichton-Browne noted that the “tendency to symmetry in the two halves of the cerebrum is stronger in women than men” (p. 65). Though this difference in function due to cerebral asymmetry as related to sex has been well documented, it remains controversial (Turkheimer & Farace, 1992).

The most common way to assess lateralization of function is to present separate stimuli simultaneously to the left and right ears or to the left and right visual fields. Due to the lateralized organization of the auditory and visual perceptual systems, responses to lateralized stimuli may be related to lateralized organization of the brain. The large literature on sex differences in language that uses lateralized stimuli presentation in visual and auditory modality suggests that there is greater lateralization in men (Bryden, 1982; Beaumont, 1982; Crews and Harrison, 1994; Harrison & Gorelczenko, 1990; Hellige, 1990; Fairweather, 1982). Right-handed men traditionally show more extensive functional cerebral lateralization of language at the left hemisphere and spatial processing at the right hemisphere. However, women seem to have a more bilateral processing of language and spatial tasks compared to men. Thus, men may be more asymmetrically organized than women for both verbal and nonverbal processes (Beaumont, Mayes, & Rugg, 1978; Bradshaw & Nettleton, 1981; Bradshaw & Nettleton, 1983a; Bradshaw & Nettleton, 1983b; Flor-Henry & Koles, 1982; Kingsburg, LaBarba, and Bowers, 1987; McGlone, 1980; and Springer & Deutsch, 1989).

Sex differences in lateralization of language function have also been studied with functional imaging techniques, the most common being electroencephalography (EEG). This method can offer a glimpse of brain function while the subject performs various tasks, providing relatively direct information about brain activity. Notwithstanding the imprecision of EEG (low spatial resolution), it is an adequate means of testing hypotheses about the activation of large structures, such as the cerebral hemispheres. In EEG studies of sex differences in lateralization of function, measurements are taken at sites in the left and right hemispheres while subjects complete tasks designed to selectively activate one hemisphere. Comparisons of ratios of left to right activation during the two types of tasks are used as an indication of lateralization of function. Most studies have shown that men have greater differential activation of the hemispheres between verbal and nonverbal conditions (e.g., Glass, Butler, & Carter, 1984; Ray, Morell, Frediani, & Tucker, 1976; Trotman & Hammond, 1979). These studies are based on the power function of EEG spectra, which is related to the mean level of desynchronization during a task. When EEG data are analyzed for *coherence*, a measure of the correlation in desynchronization across frequencies at inter- or intrahemispheric sites, female subjects have been shown to have greater degrees of interhemispheric coherence on both verbal and nonverbal tasks (Beaumont, Mayes, & Rugg, 1978; Flor-Henry & Koles, 1982). This finding is consistent with the idea of greater interhemispheric cooperation in women, an indication of increased symmetry.

Interference tasks have also been used to demonstrate laterality related to sex. Wolff and Cohen (1980) asked right-handed subjects to perform simultaneous reading and finger-tapping tasks. Verbalizations disrupted right-handed performance in men but disrupted left-hand performance in women. A subsequent study used a unimanual force production task as interference for simultaneous verbalizations in right-handed men and women (Elliott, Weeks, Lindley, & Jones, 1986). These researchers also found that the speech task disrupted right-hand performance in men but left-hand performance in women. Kingsburg, LaBarba, and Bowers (1987) reported a study in which men and women solved a block design problem with one hand while either simultaneously finger tapping with the other hand or vocalizing words. Finger tapping had no differential effect on performance in either sex. However, vocalization disrupted women's performance using *either* hand, suggesting that verbal abilities are more bilateral in women.

In another imaging study, Wood, Flowers, and Naylor (1991) presented results from a study of regional cerebral blood flow (rCBF) in 60 normal subjects, 30 men and 30 women, using statistical comparisons analogous to the analysis of coherence in EEG spectra, described above. However, instead of examining hemispheric differences during verbal or spatial processing, correlations among the activation of eight left hemisphere and eight right hemisphere regions of interest obtained during a spelling task were analyzed. There was a positive relationship between Broca's area (language production) and Wernicke's area (language reception) in men but not in women. Instead, "bitemporal coupling" was found in women, in which left temporal regions were activated in parallel with right temporal regions. The linkage of intrahemispheric regions in men and interhemispheric regions in women suggests greater bilateral processing in women.

Some health issues related to the language laterality differential between the sexes has been explained by Sundet (1988), who stated that men and women are at unequal risk for stroke, have different recovery profiles, and that there are sex differences in the effects of aging on stroke. Also, Kelly (1991) noted that language functions appear to transfer more readily to the right hemisphere in girls than boys when children sustain damage to the left hemisphere. Other researchers have also found better recovery profiles for women from aphasia, suggesting more distributed bilateral interhemispheric organization of speech function in women, compared to men (Basso, Capitani, & Moraschini, 1982; Pizzamiglio, Mammucari, Razzano, 1985). When Inglis and Lawson (1981) studied neurological patients, they found a strong association between the side of the brain that was injured and the type of cognitive deficits produced. In men, verbal functions were disturbed by left hemisphere lesions while nonverbal functions were disturbed by right-hemisphere lesions. However, in women, this association was much weaker, again suggesting less functional asymmetry in women.

It is important to note sex differences in the relationship between lateralization and ability. That is to say, women show more functional cerebral symmetry than men for lingual tasks, and they (women) perform better on these tasks. Nevertheless, men perform better on visuospatial tasks than women, notwithstanding the evidence for increased asymmetry (in men) of these abilities. Thus, symmetry of verbal abilities in women gives rise to an advantage over men, while asymmetry of visuospatial abilities gives rise to augmented performance in men, relative to women. Therefore, functional cerebral (a)symmetry differentially affects each sex, with symmetry aiding women in language and asymmetry aiding men in visuospatial performance.

The Neuropsychology of Emotions

Overall, the right hemisphere has been demonstrated to be superior in interpreting nonverbal emotional expression in the face and speech, which can be seen as a type of visuospatial task (Campbell, 1978; Gainotti, 1984; Ley & Bryden, 1979; Rinn, 1984;

Rothbart, Taylor, & Tucker, 1989; Weber & Sackeim, 1984). Studies have consistently revealed a left visual field superiority in processing facial affective stimuli (Dimond, Farrington, & Johnson, 1976; Gainotti, 1972; McKeever, 1986; McKeever & Dixon, 1981; Schwartz, Davidson, & Maer, 1975; Wechsler, 1973; Wedding & Cyrus, 1986). These studies suggest that both positive and negative emotion are regulated more by the right hemisphere than the left hemisphere (Harrison & Gorelczenko, 1990). However, further research indicates that the although the right hemisphere has been shown to regulate both positive and negative emotions, the left hemisphere has been shown to aid in the regulation of positive affect (Davidson & Fox, 1982; Harrison & Gorelczenko, 1990; Sackeim & Gur, 1978; Schwartz, Ahern, & Brown, 1979; Tucker, 1981).

The right hemisphere is thought to regulate negative emotional perception and expression and the left hemisphere is thought to regulate positive emotional perception and expression. This idea was introduced by Schwartz, Ahern, and Brown (1979), who measured lateralized facial muscle response in response to positive and negative emotional stimuli, using voluntary facial expressions. Positive emotions elicited more right muscle activity, while negative emotions elicited more left muscle activity. Electroencephalographic research has also supported this idea, as Davidson, Ekman, Saron, Senulis, and Friesen (1990) recorded bilateral EEG activity while showing "happy" and "disgusting" film clips to college students. They noted individual differences in affective style and EEG patterning. Findings indicated that during negative films, relative right hemispheric activation was recorded and was associated with negative affect, or "withdrawal" behaviors. Further, more left hemispheric activation was associated with positive affect, or "approach" behaviors. Differences were largest when analyzing in the left frontal and right frontal regions.

Research using electroencephalography (EEG) has demonstrated that right hemisphere EEG activation in the frontal region has been shown to elicit negative emotional experience, expression, and perception, while left hemisphere EEG activation in the frontal region has been shown to elicit positive emotional experience, expression, and perception. However, positive emotions can be perceived by the right hemisphere as well, while negative emotions cannot be perceived by the left hemisphere (Tucker, Stenslie, Roth, & Shearer, 1981). These differences seem to appear as early as during the first year of life (Davidson & Fox, 1982; Fox & Davidson, 1988).

When considering emotional regulation and possible asymmetrical aspects of emotional processing, Heilman, Bowers and Valenstein (1993) have postulated that the right orbitofrontal region and the right anterior temporal region interact, resulting in emotional regulation and expression, which gives rise to *emotional learning*. A stable interaction yields more appropriate emotional regulation. However, if the interaction affords relative activation of either the orbital-frontal cortex or the anterior temporal area then emotional disregulation is likely (verbal capacity is more thought to be more prominent in the left hemisphere, whereas emotions and arousal are more prominent in the right hemisphere; Heilman & Bowers, 1990).

Tucker has proposed more of a “balance” model of cerebral activation (1981), where reciprocal inhibition takes place between homologous brain tissue of the right and left cerebral hemispheres. That is to say, left hemisphere deactivation may correspond with homologous right hemisphere activation. Further, behaviors associated with the relatively more active area would become more salient (Tucker, 1981; Tucker & Williamson, 1984). Greater right than left cerebral hemisphere activation during a stress condition with emotional arousal was found prior to the publication of this hypothesis (Tucker, Roth, Arneson, & Buckingham, 1977), which may have contributed to the formulation of the "cerebral balance" theory. However, when considering possible neuropsychological mechanisms of emotion and cardiovascular regulation, it is worth noting that Liotti and Tucker (1995) have proposed it is more important to study dorsal versus ventral divisions of corticolimbic architecture, rather than left versus right divisions.

Negative Emotions and Increased Reactivity to Stress

Many of the measures that have been used in studies of emotion have been physiological measurements of cardiovascular reactivity, skin conductance, and skin temperature. From the beginning, research on emotion has noted profound changes in cardiovascular reactivity during fight or flight responses in animals (Cannon, 1929; Malmo, 1959).

The idea of stimulus specificity of emotions, specifically cardiovascular specificity, is illustrated through a classic experiment (Ekman, Levenson & Friesen, 1983). The design included two emotion-eliciting situations, posed emotional faces and emotional imagery. Facial poses influenced heart rate and skin temperature changes, which could be analyzed and used to delineate three emotion subgroups: 1) during posed facial expressions, heart rate distinguished anger/fear/sadness from happy/disgust/surprise; 2) finger temperature further distinguished anger from fear/sadness; 3) during imagery, skin conductance distinguished sadness from fear/anger/disgust.

Substantial empirical work has directly examined central nervous system (CNS) activity associated with emotion and there is a growing literature on the CNS substrates of emotion. The increased attention to the central substrates of emotion in adults has been catalyzed by observations of the affective consequences of localized brain damage and also the studies performed during the past three decades on the effects of experimentally produced lesions in animals on affective behavior (Panksepp, 1992). These studies have emphasized that different brain systems regulate different emotions and they highlight the specific role that different neurotransmitters play in the production and modulation of a range of emotional behavior.

Thayer (1989) suggests that there are multiple cerebral systems and that the neural processes are complex; thus, researchers still rely on behavioral evidence to better understand these distinctive systems. For this reason, emotions can be better understood when seen from a neuropsychological perspective. The history of neuropsychological research into emotional regulation and expression is significant. In 1937, Klüver and Bucy described a pattern of behaviors that resulted from the bilateral removal of the temporal area in monkeys. After the operation, the monkeys showed changes in visual perception, behavior (sudden attacks of rage), and memory disturbances (Klüver & Bucy, 1937, 1938). Papez (1937) suggested that the medial zones of the temporal region are related to the primary mechanisms of emotion. The prefrontal cortex has extensive connections with the limbic system (Luria, 1962). Pribram (1969a; 1969b) described the medial and orbital surfaces of the frontal lobes as part of a single “frontal-limbic” system. Nauta (1971) also described this area of the prefrontal cortex as the “cortical modulator of the limbic system.” Therefore, the frontal lobes seem to regulate limbic system activity (Pribram & Luria, 1973).

Research conducted on electrical stimulation of different brain areas and corresponding behavioral patterns has been reviewed by Kalat (1995). Stimulation of the hypothalamus, amygdala, and brain stem was found to elicit an affective attack in the cat. As a result of such stimulation, the cat hissed, growled, arched its back, and bared its teeth. Often the cat would direct its attack toward a close target, but sometimes electrical stimulation elicited only the facial expressions without the remainder of the attack sequence (see Delgado, 1981; Siegel & Pott, 1988). Electrical stimulation of the amygdala has been found to lead to vigorous attacks, while lesioning the amygdala in previously aggressive monkeys has lead to pacification and placidity (Rosvold, Mirsky, & Pribram, 1954). Rage behavior in the cat has also been facilitated through stimulation of the right amygdaloid area (Shaikh, Schubert, & Siegel, 1994; Shaikh, Steinberg, & Siegel, 1993).

Similarly, damage to the right orbitofrontal region has yielded aggressive behavior, whereas stimulation of the right orbitofrontal region has produced passive responses, often accompanied by flat affect expression. Activation of the frontal lobe, particularly the orbital frontal cortex, has been found to lower or inhibit the expression of hostility (Butter, Snyder, & McDonald, 1970). The right orbital-frontal cortex has extensive interconnections with the right anterior temporal area, especially the amygdala. Using electroencephalographic techniques, Everhart and Harrison (1995) found decreased orbital-frontal activation with corresponding increased right temporal beta activation in a homicidal patient. These studies demonstrate negative affect regulation by the right cerebrum. More specifically, negative, hostile emotions were expressed following deactivation of the right orbital-frontal region with concurrent increased activation of the right temporal region (Everhart & Harrison, 1995).

Sex Differences in the Functional Cerebral Laterality of Emotions

Men and women differ in the degree to which language functions and spatial abilities are lateralized. Men also appear to have more pronounced cerebral lateral specialization in the right hemisphere for emotional recognition, expression, and regulation, as compared to women, who appear to have more bilateral emotion regulation control (Bryden, 1982; Beaumont, 1982; Crews and Harrison, 1994; Fairweather, 1982; Harrison & Gorelczenko, 1990; Hellige, 1990; Pardo, Pardo, & Raichle, 1993; Stalans & Wedding, 1985; Wedding & Cyrus, 1986). These findings support the research of Ekman, Levenson and Friesen (1983), which proposed that the right cerebrum has a larger involvement in processing emotion in men.

The relationship between the right hemisphere’s specialization for visuospatial processing and emotional regulation has been interpreted by Flor-Henry (1983) as indicating that males (referred to as "specialized females") have acquired a more lateralized and efficient right-hemisphere than females. The specialized functions include more efficient visuospatial processing, greater musicogenic ability (music composition), and better emotional stability. However, the paradox is that women, having more bilateral cognitive systems, have a more robust verbal ability than men.

Sex differences in cerebral asymmetry for emotional processing were also found by Harrison, Gorelczenko, and Cook (1990). They used a facial affect recognition task with forced-choice response requirements (angry or happy), with stimuli presented in the left or the right visual fields. Results supported the hypothesis that men show heightened functional cerebral laterality when processing emotional faces, although, relative symmetry was found for positive affect. Men evidenced heightened functional cerebral laterality across valences, because they processed affective facial information significantly faster than women when it was presented in the left visual field. Thus, it is possible that women may process negative emotion across diverse cerebral regions within the left and right hemispheres. In contrast, men have a significant advantage when processing negative emotion presented to the right cerebral hemisphere, whereas the capacity to allocate left cerebral systems to the processing of negative affect may be diminished. The idea of laterality effects when studying emotion in men have been replicated by research conducted at Virginia Tech (see Demaree & Harrison, 1997; Herridge, Harrison, & Demaree, 1997).

While men and women appear to differ in the degree to which language functions, spatial abilities, and emotional regulation are lateralized, the present, emerging evidence extends these differences in cerebral symmetry to cardiovascular disease differences for each sex. This study purports to examine sex differences in the lateralization of cardiovascular factors as well.

Different functional lateralization in men and women is better appreciated when considering how it can affect health, recovery, and research validity. Although this difference in function due to cerebral asymmetry (related to sex) has been well documented, it remains controversial (Turkheimer & Farace, 1992). It is possible that enhanced functional cerebral symmetry in women has also contributed to decreased cardiovascular disease incidence. Further, it is interesting to note that many sex differences in brain anatomy and functionality are found in the temporo-parietal regions of the brain, which are related to linguistic and spatial functions (Witelson, 1991).

Investigating Dynamic Functional Cerebral Laterality

The right and left cerebral hemispheres seem to have a dynamic relationship with one another, each can influence the other's activity. Some studies have attempted to understand this relationship, with regard to emotion and cardiac control. These studies often employ a procedure known as the WADA test, in which sodium amytal is injected into the carotid artery. This is also done during neurosurgical procedures in order to aid the physician in identifying (and sparing) the language area in the brain. The sodium amytal temporarily arrests most functioning in the hemisphere of the brain to which the vascular supply travels.

Early studies of unilateral injection of sodium amytal into the left carotid artery (which supplies blood to the left hemisphere) produced severe emotional reactions (crying, pessimism, indignity or despair, fear, negative thoughts), often with the patient simultaneously reporting no apparent *reason* for such feelings (Fox, 1994). Unilateral injection into the right artery (to right hemisphere) elicited quite a different response (euphoria, smiling, optimism, an overall sense of well-being). Dynamic functional cerebral laterality is evidenced when considering the processes underlying these positive or negative emotional reactions. This research suggests that emotional changes are the result of the release of one cerebral hemisphere from the "contralateral inhibitory influences of the other." Thus, when not counterbalanced, the right cerebral hemisphere would produce dysphoria (negative mood) and the left cerebral hemisphere would produce euphoria (positive mood; Fox, 1994). Viewed as such, emotions are not a result of the independent functioning or activity of one hemisphere, but rather arise from the dynamic interplay of distinct cerebral systems.

This experiment explored whether the distinct cerebral systems responsible for regulating cardiovascular reactivity are as dynamically functional and if men and women differ in the lateralization of cardiac regulation. Dynamic influences should be considered in order to appreciate sex differences in the neural networks and corresponding, differing rates of behaviorally-mediated cardiovascular diseases.

Cardiovascular Reactivity, Sex Differences, and Cerebral Dynamics

Dynamic laterality has also been proposed through sex hormones, acting as neurochemical mediators on cardiovascular variables. Khaw and Barrett-Connor (1988) investigated blood pressure and endogenous testosterone levels in men. They found that men with hypertension had significantly lower testosterone levels than non-hypertensives. This association was present throughout the range of blood pressures and testosterone levels, with a stepwise decrease in mean systolic blood pressure and diastolic blood pressure "per increasing quartile of testosterone." Just as significant was the finding that no other hormone nor sex hormone-binding globulin showed a consistent relationship with blood pressure.

Changes in neurochemistry can also influence proprioception, the ability to accurately perceive one's position in space. McCourt, Mark, Radonovich, Willison, and Freeman (1997) investigated hormonally-mediated changes in interhemispheric dynamics. They found that women showed menstrual phase-related cognitive changes that suggested altered hemispheric activation for specific tasks. Women, during a space bisection task, were more likely to have asymmetric hemispheric activation (similar to men) during the luteal phase than during the menstrual phase. Similarly, Mead and Hampson (1996) found that during the midluteal phase, left visual field accuracy (right hemisphere functioning) was significantly lower for both verbal and nonverbal tasks than during the menstrual phase. Further, right ear performance on nonverbal dichotic test was significantly reduced at the midluteal phase. Usually, both men and women show a pronounced right ear advantage, as most language is stored in the left hemisphere. Thus, there was evidence for suppression of right hemisphere processing, as well as possible reductions in corpus callosum transfers, usually a strength in women.

Further, significant interhemispheric asymmetry of binding sites associated with serotonergic mechanisms was found in the orbital frontal cortex of 6 women and 6 men (who died of natural causes). Arató, Frecska, Tekes, and MacCrimmon (1991) found that women had significantly more binding sites in the right orbital cortex than men. However, there was not a significant sex difference at the left orbitocortical areas. Many of the serotonin-related psychological disorders have different incidence rates in each sex. This study begins to offer a possible explanation for these observed differences. Of course, frontolimbic pathways associated with both positive and negative emotion reactivity are implicated by this research finding.

Overall, sex differences in aggression have remained remarkably stable, when changes in methodology are controlled (Knight, Fabes & Higgins, 1996). Men evidence more aggression than women, and these differences in aggression may be a manifestation of different underlying functional emotional cerebral networks in men and women that contribute to differential rates of coronary heart disease and other types of cardiac risk. Through a neuropsychological conceptualization, different emotional regulatory patterns seen in men and women can be better appreciated, along with the corresponding health consequences of the distinct cardiovascular reactivity patterns attributable to sex.

Wittling (1990) proposed that physiological arousal indicates heightened anterior right cerebral activation. As the right cerebrum has been differentially implicated in the regulation of negative affect perception and expression, synthesis of the research suggests a relationship between negative emotional reactivity and increased cardiovascular reactivity (one of the primary risk factors for cardiovascular disease, specifically, coronary heart disease). Recent research has investigated the laterality of cardiovascular regulation.

Lateralized Cardiovascular Response

The anterior right cerebrum has been found to be involved in the regulation of autonomic functioning in numerous studies (Caltagirone, Zoccolotti, Originale, Daniele, & Mammucari, 1989; Hachinski, Oppenheimer, Wilson, Guiraudon, & Cechetto, 1992; Lane, Novelly, Cornell, Zeitlin, & Schwartz, 1988; Lane & Schwartz, 1990; Rosen, Gur, Sussman, Gur, & Hurtig, 1982; Walker & Sandman, 1979; Walker & Sandman, 1982; Wittling, 1990; Wittling, 1995; Yoon, Morillo, Cechetto, & Hachinski, 1997; Zamrini et al., 1990; & Zoccolotti, Caltagirone, Benedetti, & Gainotti, 1986).

Heart rate has been found to change more in response to emotional and nonemotional stimuli presented to the right hemisphere than the same stimuli presented to the left hemisphere (Hugdahl, Franzon, Andersson, & Walldebo, 1983), suggesting right hemisphere regulation of heart rate. For example, Hachinski et al. (1992) studied cardiac effects associated with each cerebral hemisphere at the level of the cortex. These effects were measured following experimental stroke induced by left or right middle cerebral artery occlusion, involving the insula and portions of the perirhinal, frontolateral, motor, and sensory cortex. Effects upon mean arterial pressure and the QT interval of the ECG were greater if the right brain as opposed to the left brain was involved.

Most studies examining the cardiac effects of unilateral brain damage in human subjects have been interested in investigating heart rate changes. Two influential studies were conducted by Caltagirone et al. (1989) and Zoccolotti et al. (1986). Caltagirone et al. (1989) found that left-brain damaged patients and control subjects experienced significantly greater cardiac decelerative responses to an emotionally negative film than a neutral film. However, right brain-damaged patients did not differ in their cardiac responses to the negative- or neutral-valenced films and experienced a smaller cardiac decelerative response to the emotional film than both the left-brain damaged patients and the control subjects. The researchers theorized that parasympathetic control of heart rate was impaired in right brain-damaged patients.

Newer research has implicated both the right and left hemisphere in cardiac control. Research examining right and left hemisphere involvement in heart rate control has been conducted using techniques for unilateral hemispheric inactivation through intracarotid amobarbital injection. Rosen et al. (1982) found heart rate increases to be higher "following left hemisphere inactivation than following right hemisphere inactivation." Lane et al. (1988) found that heart rate increased during left hemisphere inactivation, "favoring patients with left hemisphere as opposed to right hemisphere damage" (Lane & Schwartz, 1990; Wittling, 1995). Further, Zamrini et al. (1990) studied 25 patients undergoing unilateral cerebral inactivation prior to epilepsy surgery. Heart rate was measured preceding amobarbital injection (1 minute) and after the injection (3 minutes). The researchers found a significant difference in heart rate changes following left vs. right intracarotid injection. "Mean heart rate increased up to 4 beats per minute (bpm) during left hemisphere inactivation and decreased up to 2.4 bpm during right hemisphere inactivation" (Wittling, 1995). Oppenheimer, Gelb, Girvin, and Hachinski (1992) found that stimulation of the left-insular region corresponded with decreased heart rate, while stimulation of the right-insular region produced increases in heart rate.

Walker and Sandman (1979) found that spontaneous changes in heart rate were related to visual evoked potentials. Flashes of light were presented to subjects during fast, midrange, and slow heart beats. However, when looking at the visual evoked responses recorded over the left and right occipital lobes related to heart rate changes, the data were different for the two hemispheres. "Potentials recorded during high vs. slow heart rate could be differentiated from one another by waveform if recording was done over the right hemisphere. In contrast, potentials were not related to heart rate if recorded from the left hemisphere." Walker and Sandman (1982) then explored if the differences in the waveforms of visual evoked potentials could be found during periods of systolic vs. diastolic carotid pressure. They again found that "sensory evoked activity recorded from the right hemisphere differed significantly between systolic and diastolic pressure phases" (Wittling, 1995).

Wittling, Block, Genzel, and Schweiger (1998) used lateralized film presentation for stimulation of the left and right hemispheres. They found that sympathetic activity seemed to be mainly controlled by the right hemisphere and parasympathetic activity by the left hemisphere (see also Wittling, 1997; Wittling, Block, Schweiger, & Genzel, 1998).

Given these indications of the contribution of sex differences to emotional regulation and corresponding differential cardiovascular reactivity, several recent theories have proposed that functional cerebral asymmetry contributes to differences in emotional regulation (including aggression) in men and women, and that these differences may contribute to corresponding cardiovascular disease risks.

Emotions, Cardiovascular Reactivity, and Health: A Systematic Examination

In an array of related studies conducted at Virginia Polytechnic Institute and State University, possible neuroanatomical mechanisms of emotion and cardiovascular reactivity have been assessed through various sensory modalities. The effects of hostility and its interconnections with different systems throughout the brain have been studied, with an emphasis on possible health consequences and/or intervention strategies. Other emotions have also been studied from a neuropsychological perspective, in order to better understand possible functional neuroanatomical systems. The research has supported previous theories, discussed above, and has been instrumental in furthering the understanding of the possible functional neuroanatomical bases of emotional reactivity and cardiovascular regulation.

In assessing differences between low and high-hostile men, Herridge (1996) found that high-hostile men were less accurate than low-hostile men in the assessment of happy, angry, and neutral faces presented tachistoscopically to their left visual field (right hemisphere). However, high-hostile men were more accurate than low-hostile men when assessing happy and angry facial configurations presented tachistoscopically to their right visual field (left hemisphere). Thus, high-hostile men show more pronounced laterality effects than low-hostile men. It is unclear whether this same pattern would be found between "normal" men and "normal" women, respectively, as women have traditionally shown less lateralized function than men.

Using dichotic listening tasks, Demaree and Harrison (1997) found "greater right cerebral activation to stress among high-hostile men, as indicated by their enhanced intention to the left ear," with corresponding physiological reactivity as measured by systolic blood pressure, diastolic blood pressure, and heart rate. Furthermore, they found dramatic effects with low-hostile individuals who had significantly more left temporal cerebral activation to stress and evidenced minimal cardiovascular reactivity to the cold pressor stressor.

Men traditionally show pronounced laterality effects when researching emotion. For instance, Herridge, Harrison, and Demaree (1997) investigated skin conductance between low and high-hostile groups and found significant left hand skin conductance increases in men in reaction to making angry facial configurations. Making angry faces yielded slow habituation of skin conductance at the left hand in hostiles and slow habituation at the right hand in low hostiles. When making faces portraying happy affect, increased conductance at the right hand was noted.

Traditionally, men have shown more cardiovascular reactivity than women, with a higher incidence of coronary heart disease (CHD) in men. However, Emerson and Harrison (1990) found that women with scores placing them in a high-denial category (measured by the Marlowe-Crowne Social Desirability Scale) *and low anger* (measured by the State-Trait Anger Expression Inventory) exhibited the most elevated cardiovascular reactivity in response to a stressor. Thus, it is possible that this is a group of highly reactive women that has not been previously identified (who also deny their emotions).

Follow-up research has extended previous research findings from a level of secondary implication of brain activation (skin response, heart rate, blood pressure, auditory processing, and visual processing) to a level of primary visualization of brain activation through the use of real-time, quantitative electroencephalography (topographical brain-mapping). Demaree (1997) found that low hostile men show decreased left frontal activation and increased left anterior temporal activation. He hypothesized that the left anterior temporal region of the brain may regulate parasympathetic nervous system activation as the right anterior temporal region regulates sympathetic nervous system activation. Furthermore, just as the right orbito-frontal area inhibits the right anterior temporal area (sympathetic), it is possible that the left orbito-frontal area inhibits the left anterior temporal area (parasympathetic). Thus, low-hostile men may have under-inhibited parasympathetic nervous system activation (i.e., increased parasympathetic activation), which would decrease cardiovascular reactivity and CHD risk. This pattern (in low-hostile men) may be similar to women, who normally show decreased cardiovascular reactivity, increased emotional regulation, and decreased CHD risk.

Rationale for this Experiment: The Brain, Reactivity, and Cardiovascular Disease

Research has shown that emotional reactivity due to individual stressors leads to higher rates of coronary heart disease (CHD). For example, people in lower socioeconomic divisions and the elderly exhibit patterns of higher CHD incidence rates (Manuck & Krantz, 1986; Matthews et al., 1992; Rosenman et al., 1975; U.S. Department of Health and Human Services, 1988). In studying the etiology of emotional reactivity and its relationship to cardiovascular disease, several mechanisms have been proposed. One possible mechanism is that repeated excessive cardiovascular reactions to behavioral stressors promote arterial “injury” through “hemodynamic forces such as turbulence and sheer stress” (Manuck, Kaplan, & Clarkson, 1983). The behavioral factors influencing the development of CHD act through the “cardiovascular or endocrine correlates of sympathetic-adrenal-medullary and pituitary-adrenal-cortical activation (Manuck & Krantz, 1986), causing blood vessel sheer stress. Recent evidence supports the concept that individual differences in “behaviorally induced autonomic and neuroendocrine reactivity” corresponds with a higher incidence of CHD (Manuck & Krantz, 1986). Emotional reactivity has been linked to cardiovascular disease in numerous studies (Kubany, Gino, Denny, & Torigoe, 1994; Lee & Cameron, 1987; Treiber, Musante, Riley, & Mabe, 1989). Biochemical forces also damage the coronary arteries, through the increased release of certain endocrine substances (such as the catecholamines and corticosteroids) to damaging levels. If these physiologic mechanisms are partly responsible for CHD, then the greatest damage would be incurred among highly reactive individuals, those who show the greatest psychophysiologic responsivity (Manuck &

Krantz, 1986). Recent research results lend support to the idea that certain cardiovascular reactive patterns are more likely with individuals who have particular neural networks *and* concurring circumstances. That is to say, a reactive individual may differ in the cerebral systems involved, either in the activation or inhibition of cardiovascular reactivity. Therefore, given a specific circumstance (e.g., confrontation or harassment), individuals will react according to the functioning of their emotional regulatory system, both through behavior and cardiovascular reactivity patterns.

One study evaluating the reactivity-CHD relationship found that the magnitude of the participants' diastolic blood pressure reactivity to the cold pressor test was associated significantly with development of CHD when a follow-up test was conducted 23 years later. Prediction conducted with the participants' diastolic responsivity data transcended prediction based upon more traditional risk factors. The cold pressor test "had major predictive power, especially for CHD death or infarction" (Keys, Taylor, Blackburn, Brozek, Anderson, & Simonson, 1971). Sherwood et al. (1997) found that when using the cold pressor to induce cardiovascular responses, the magnitude and pattern of cardiovascular responses remained relatively unchanged over the course of 10 years, specifically, test-retest correlations of SBP and HR responses were significant.

Cardiovascular reactivity is one of the primary risk factors for cardiovascular disease and the right cerebrum has been differentially implicated in the manifestation of negative emotions and cardiovascular reactivity. It is difficult to say how improved regulation over the right cerebrum would become possible. However, improved regulation over these neural systems would likely result in decreased cardiovascular-related diseases. Thus, this area of research warrants careful attention. The risk of CHD in men is significantly greater than in women and cardiovascular responsivity patterns (greater heart rate and SBP responses) have been found by Harbin (1989) in men but not women. However, as stated previously, following menopause women's CHD risk increases considerably.

The mechanisms that produce differential rates of CHD in men and women were investigated in this study. In order to assess brain activation, a dichotic listening test was used. Dichotic listening tasks have been used to assess language lateralization in the brain (Kimura, 1961 & 1967; Kimura & Harshman, 1984). Furthermore, right ear advantages have been found using dichotic listening protocols similar to the one used in this experiment (Shankweiler & Studdert-Kennedy, 1967; Studdert-Kennedy & Shankweiler, 1970).

Dichotic listening accuracy scores were also compared to cardiovascular response measures. Sex differences were analyzed, with an emphasis on asymmetric patterns in dichotic listening test scores and cardiovascular measures. How cold pressor pain differentially affects men and women was assessed, with likely health consequences of each cardiovascular reactivity pattern explained. This research followed similar research conducted with men; thus, findings from the present study should allow a more complete understanding of reactivity across sex, using an auditory dependent measure. The effects of stress on language may be different for men and women, according to differential interference with access to language areas of the brain. Men may have more difficulty with language processing during pain or a stressful situation, as they are more laterally specialized, while women may have less difficulty with language processing, as they seem to have bilateral access (to both emotion and language). Furthermore, there is evidence that women have better connectivity between the two hemispheres, via a more dense corpus callosum (Johnson, Pinkston, Bigler, & Blatter, 1996). These sex differences were also assessed according to focus group. Men and women were asked to focus on speech sounds in their left ear (FL), right ear (FR), or no ear (NO) in particular. This design allowed for analysis not only by sex and stress condition, but by focus also.

Thus, for this study, increased relative functional activation of the right cerebrum was predicted among the men whereas increased relative functional activation of the left hemisphere was predicted among the women in response to exposure to cold pressor pain.

Variables

The independent variables were sex and focus group. The dependent variables were the physiological measures (SBP, DBP, HR), the dichotic listening scores from the left ear and the right ear, POC scores, and the stress and pain scores obtained from self reports.

Hypotheses

Hypothesis 1: There will be an initial, overall right ear advantage across sex and focus group (NO, FL, and FR) on the dichotic listening test (using word sounds).

Hypothesis 2: Prior to the stressor (a cold pressor), men and women will differ in the perception of dichotically presented phonemic speech sounds, with men showing a stronger relative right ear advantage.

Hypothesis 3: Both men and women in each focus group will be able to achieve different dichotic listening accuracy scores at each ear, according to the requested focus condition (NO, FL, or FR). NO and FR groups are expected to show greater accuracy at the right ear than the FL group, while the FL group is expected to show greater accuracy at the left ear than the NO and FR groups.

Hypothesis 4: Both men and women will evidence physiological (SBP, DBP, and HR) reactivity to the stressor (a cold pressor).

Hypothesis 5: Men will show greater physiological (SBP, DBP, and HR) reactivity to the stressor (a cold pressor) than women. A sex by focus by experimental condition interaction is expected, as lateralized cerebral activation (in this experiment, a focused, dichotic listening test) has been shown to affect blood pressure and heart rate indices in previous research and sex differences in cardiovascular reactivity have been well-documented. Thus, both sex and focus are expected to interact with cardiovascular measures.

Hypothesis 6: Men in each focus group (NO, FL, and FR) will show increased accuracy at the left ear in response to the stressor (a cold pressor), compared to women in similar focus groups, indicating heightened right cerebral arousal in men. Women in similar focus groups will not be as affected by lateralized stimulation and/or activity. Thus, a sex by focus interaction is expected for dichotic listening scores.

Hypothesis 7: Women in each focus group (NO, FL, and FR) will show increased right ear perception of speech sounds on a phonemic dichotic listening task following stress, compared to men in similar focus groups, indicating heightened left cerebral arousal as well as more bilateral speech processing ability in women.

Method

Participant Selection

Sixty men and sixty women were recruited from the Introductory Psychology course and other psychology courses at Virginia Polytechnic Institute and State University through the offering of extra credit for the course. Only right-handed participants were used in the study. This was done to ensure maximum homogeneity within the experiment and so that any observed differences were more likely due to sex differences than handedness.

Classification / Measures Used

All participants were required to sign a consent form prior to participation in the research (Appendix A). Participants were assessed using the Head Injury / Medical History Inventory (HIMHI; Appendix B). Those with a history of a past traumatic head injury, other neurological damage, serious illness, Reynaud's Syndrome, extreme sensitivity to cold temperatures, Asthma, Arthritis, or Psoriasis were excluded from the study. Three men and one woman were excluded from the experiment due to past traumatic head injuries and other medical concerns.

Participants were then given the Coren, Porac, and Duncan Laterality Questionnaire (1979; Appendix C) to determine lateral hemibody preference (i.e., "handedness," for the purposes of this experiment). This self-report assesses right (+1) and left (-1) hemibody preference based on reported preferred use of either eye, ear, arm, and leg. Scores range from (-13) to (+13), indicating extreme left and right "handedness," respectively. A score of 7 or greater was required for inclusion in the experiment. Ten men and five women were excluded from further participation in the study due to scores below the cut-off (a score of 7).

All participants were also given the Cook-Medley Hostility Inventory (CMHO; Cook & Medley, 1954; Appendix D). The CMHO is an increasingly important measure in studies examining health consequences of hostility. It has been shown to be significantly associated with coronary heart disease and hostile personality type (Type A; Barefoot, Dahlstrom, & Williams, 1983; Williams, Barefoot, & Shekelle, 1985; Williams et al., 1980) as well as increased mortality rates (Shekelle, Gale, Ostfeld, & Oglesby, 1983). Williams, Barefoot, and Shekelle (1985) have contended that high-scoring individuals on the CMHO experience anger more frequently and intensively than other, low-hostile individuals (see also Harrison & Gorelczenko, 1990). The Cook-Medley is the most frequently utilized measure of hostility, and it exhibits validity as a predictor of medical, psychological, and interpersonal outcomes (Contrada & Jussim, 1992). The heuristic value of hostility and emotional reactivity can be measured in terms of predictable risks to the individual's health, with evidence for increased morbidity and mortality rates.

The construct validity of the CMHO has been supported by research conducted by Pope, Smith and Rhodewalt (1990), who found that high Ho scores were associated with a greater level of aroused anger, suspicious thoughts, and the tendency to attribute hostile intent to others. Further, individuals scoring high on the CMHO have shown significantly elevated cardiovascular responses when harassed, compared to low-hostiles who were harassed (Suarez & Williams, 1989). The discoveries from these and other investigations have been consonant with previous conceptual descriptions of cognitive, behavioral, and affective correlates of hostility (Pope, Smith & Rhodewalt, 1990), supporting the idea that the CMHO scale can be interpreted as reflecting future, potential health consequences of hostility.

All participants were also asked to complete the Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960; Appendix E). This scale is purported to identify individuals who depict themselves in a very favorable way. They can be understood as wanting to be seen in socially-desirable terms. Using the Kuder-Richardson formula 20 for this scale, the internal consistency coefficient is .88. Further, a test-retest correlation of .88 was obtained, indicating satisfactory reliability (Crowne & Marlowe, 1964).

Results from these questionnaires were used to further explore subject variables related to cardiovascular reactivity and disease. Participants were asked to sign a second consent form (Appendix F) before entering the testing chamber. Once there, they were requested to continue with physiological testing after the initial screening period.

Apparatus

In a sound-attenuated testing room were a black chair and the cold pressor equipment. The participant faced a flat white wall and sat in a chair surrounded by a flat white vinyl curtain. Dichotic listening equipment and physiological assessment equipment were located outside the testing chamber in an adjacent laboratory equipment room. The dichotic listening equipment and physiological assessment equipment were connected by cables to the corresponding headphones and physiological sensors.

Cold Pressor

For the cold pressor task, ice water temperature was maintained at 0° C in an ice cooler (Coleman Corporation, model 5274), measured using a standard mercury thermometer (Fisher Scientific, model 14-985E).

Dichotic Listening

A computer-synthesized audio compact disc created by the Kresge Hearing Research Laboratory was used. It consists of thirty pairs of concurrently voiced consonant vowels (C-Vs; BA, DA, GA, KA, PA, TA), which were played for each participant. This particular recording has been used extensively as a dichotic listening device. Stimuli were presented at about 75 dB by a Sony High Density Linear Converter compact disc player (model CDP-211) using Koss Digital Ready Stereo Headphones (Pro Model 4X Plus). A Metrosonics dB 307 Noise Dosimeter was used to calibrate sound levels. The inter-stimulus interval was 6 seconds. The six possible C-V pairs were presented as the stimulus sheet and were laser-printed as 1 cm bold, black upper-case letters on 21.5 cm by 28 cm white paper displayed approximately 50 cm in front of the participant (Appendix G).

Hearing Assessment

A brief training phase introduced the participant to dichotic listening procedures. The experimenter read aloud and pointed to each of the six phonemes on the stimulus sheet and asked the participant to repeat each phoneme. An auditory acuity assessment was then conducted using 10 total C-V pairs presented (5 individually at each ear) via the compact disc and equipment listed above. For continued participation, each participant had to correctly identify ten of ten C-V sounds presented individually (5) to each ear. If the participant did not identify all ten of the phonemes then he or she was dismissed from further participation in the research experiment. Eight women and seven men were excluded from the study after misidentifying one or more of the phonemes during this test.

Physiological

Physiological measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured using a Korotkoff measuring device. American National Standard Institute (ANSI) and Association for the Advancement of Medical Instrumentation (AAMI) standards and recommendations were followed during Blood Pressure and Heart Rate measurement (see Harrison & Edwards, 1988; Harrison, Gorelczenko, & Kelly, 1988). The accuracy of heart rate readings was reported to be within 2% of those gauged (approx. 1 beat / min.). The accuracy of the BP measurement was reported to be ± 3 mm Hg of those auscultated. Auditory validation of blood pressure measures was obtained, as the Korotkoff device's volume was adjusted accordingly.

Procedure

The experiment consisted of three phases: Pre-Stress, Stressor, and Post-Stress. Cardiovascular and dichotic listening variables were measured prior to the stressor and following the stressor (during the Pre-Stress phase and the Post-Stress phase; Figure 1).

Testing was done with one participant at a time. As each participant began the second phase of the experiment (after being screened for medical conditions, hearing ability, and cerebral dominance), he or she was assigned to one of three different groups: the no focus group (NO), the focus left group (FL), or the focus right group (FR). Participants were assigned to these groups in a rotational fashion (i.e., NO, FL, FR, NO, FL, FR, etc.) within each sex. This was done until a total of 20 men and 20 women were tested in each focus group.

Pre-Stress Period

Each participant had approximately 20 minutes after arriving to adjust to the test room. The participant was next fitted with the BP and HR apparatus for the assessment. The blood pressure monitor was attached to each participant's right upper-arm. The researcher then said the following, "Please make yourself comfortable, try to relax, and sit still in the chair." Headphones for the dichotic listening task were then placed over the participant's ears.

SBP, DBP, and HR data were collected after a 1 minute baseline period (Condition 1 = Baseline). Following this measurement, the researcher played the digital recording (compact disc). The participant was asked to point at the phonemes on the stimulus sheet as they heard them. Headphone position was counterbalanced between participants.

The researcher then exited the testing chamber. No focus (NO) participants heard the following pre-recorded instructions (instruction sets for all three focus conditions were pre-recorded on the compact disc, and words in italics were emphasized):

"Now you are going to hear thirty trials of these syllables. You will hear a syllable in one ear and a different syllable in the opposite ear. It will be somewhat confusing. You need to listen very carefully and point to the syllable on the chart that you hear *most* clearly."

The recording then continued with presentation of thirty C-V trials. The experimenter recorded the participant's response to each trial (Appendix H).

The focus left (FL) participants heard the following pre-recorded instructions:

> "Now you are going to hear thirty trials of these syllables. You will hear a syllable in one ear and a different syllable in the opposite ear. It will be somewhat confusing. You need to listen very carefully and point to the syllable on the chart that you hear most clearly in your *left* ear."

The experimenter allowed the recording to continue with presentation of thirty C-V trials and recorded the participant's response to each trial.

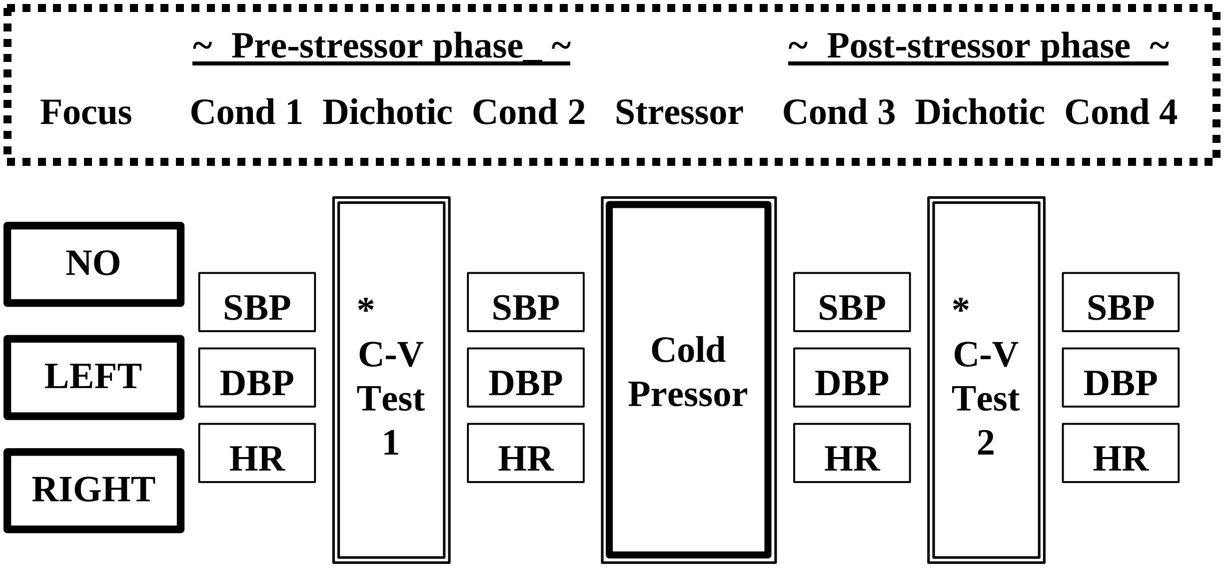
The focus right (FR) participants heard the following pre-recorded instructions:

> "Now you are going to hear thirty trials of these syllables. You will hear a syllable in one ear and a different syllable in the opposite ear. It will be somewhat confusing. You need to listen very carefully and point to the syllable on the chart that you hear most clearly in your *right* ear."

The experimenter allowed the recording to continue with presentation of thirty C-V trials and recorded the participant's response to each trial.

Verbal directions for the "no focus," "focus left," and "focus right" conditions were counterbalanced between participants and sex; however, this order was maintained within each participant's instruction set according to his or her condition.

Figure 1. Experimental Design.



* Headphone placement was counterbalanced across participants

Next, the researcher said the following, “Please make yourself comfortable, try to relax, and sit still in the chair.” SBP, DBP, and HR data were again collected (Condition 2 = Post Dichotic 1).

During Stressor

The point at which each participant should immerse his or her hand (1” above wrist) was marked on his or her wrist with a black wax pencil. The researcher entered the sound-attenuated room and gave the following instructions,

> “Please keep your eyes closed. When instructed, place your left hand in the ice water on your left to this wax line (the ice was exposed at this point). You will be asked to keep your hand in the water for 45 seconds. Although this may be difficult and possibly painful, please try to keep your hand in the water until instructed to take it out. However, you can take your hand out of the water at any time without any penalty. This test has been used often as a research tool, and many research participants have been able to keep their hand in the water for up to 15 minutes without any problems. Do you have any questions? Okay, begin."

After forty-five seconds, the participant was asked to remove his or her hand from the ice water. One woman was excluded from the experiment when she withdrew her hand early from the ice water (and also withdrew from the experiment).

Post-Stress Period

The researcher then said, “Please make yourself comfortable, try to relax, and sit still in the chair for a few more minutes.” SBP, DBP, and HR data were collected for a period of 1 minute after the participant pulled his or her left hand from the ice water (Condition 3 = Post Cold Pressor) and attempted to relax after the researcher had exited the room.

The dichotic listening procedure was again performed as described in the Pre-Stress Period, with the three separate conditions (no focus, focus left, focus right). Verbal directions for the “no focus,” “focus left,” and “focus right” conditions were again counterbalanced between participant and sex, while this order was again maintained within each participant’s instruction set according to his or her condition.

Next, the researcher said the following, “Please make yourself comfortable, try to relax, and sit still in the chair.” Again, SBP, DBP, and HR data were collected (Condition 4 = Post Dichotic 2).

Following the experiment, participants were thoroughly debriefed and asked about their feelings of the experiment. Participants were also asked to answer a very brief questionnaire about their experience in the study (Appendix I). If the participants exhibited negative verbal or nonverbal behavior then extra time was spent to help them resolve these feelings.

Before analyzing the data from the 3 focus groups (NO, FL, & FR), it became clear that these three groups were not similar. The Focus Left (FL) and Focus Right (FR) groups were both asked to intend to a specific ear and then identify the speech sound heard in that specific ear, thus, they were directed by the examiner focus at this ear. However, the No Focus groups (NO) were not directed to focus either to the right or to the left, but rather, they were only asked to identify the speech sound heard, irrespective of the ear in which they heard the phonemic sound. In this way, the No Focus (NO) groups should be considered control groups (without focus effects).

Data Analyses

The data analyses included several independent analysis of variance (ANOVA) procedures using data from all focus groups (NO, FL, FR), which were followed by several refined analyses of variance for each group (ANOVAs), explained below. Post hoc comparisons were performed on all means with Tukey's Honestly Significant Difference procedure (HSD; $\alpha = .05$). Significant differences are indicated by dissimilar letters on the bars within the ensuing figures / graphs.

Self Report Scales

A t-test was conducted to assess differences between men and women on the Cook-Medley Hostility Inventory, used as a descriptive measure in this study to further explore subject variables related to cardiovascular reactivity and disease. T-tests were also conducted on CPD scores, MCSDS scores, and age of participant for each sex to discover if any significant differences existed between men and women on any of these descriptive measures.

Physiological Measures

Independent analyses of variance (ANOVA) were performed on the physiological variables (HR, SBP, and DBP) to measure cardiovascular reactivity to the cold pressor. There were three statistical designs analyzing: A) overall group effects (using all focus groups), B) focus effects on cardiovascular reactivity (using focus left and focus right groups), and C) sex differences in cardiovascular reactivity among the no focus (control) groups.

Statistical analysis design A was: Sex (2 levels) x Focus (3 levels) x Condition (4 levels). Thus, data were analyzed with a three-factor mixed design, analysis of variance (ANOVA), with fixed factors of Sex (men and women) and Focus (NO, FL, FR), and a repeated measure of Condition (baseline, post dichotic 1, post cold pressor, and post dichotic 2; see Figure 1). In addition, more refined ANOVAs were performed for each sex. Post hoc comparisons were performed with Tukey's HSD and significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design B was: Sex (2 levels) x Focus (2 levels) x Condition (4 levels) . Thus, data were analyzed with a three-factor mixed design, analysis of variance (ANOVA), with fixed factors of Sex (men and women) and Focus (FL and FR), and a repeated measure of Condition (baseline, post dichotic 1, post cold pressor, and post dichotic 2). In addition, refined ANOVAS were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design C used only NO focus participants and was: Sex (2 levels) x Condition (4 levels). Thus, data were analyzed with a two-factor mixed design, analysis of variance (ANOVA), with a fixed factor of Sex (men and women), and a repeated measure of Condition (baseline, post dichotic 1, post cold pressor, and post dichotic 2). In addition, refined ANOVAS were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Again, significant differences are indicated by dissimilar letters on graphs.

Dichotic Listening Scores: POC

From the dichotic listening scores a percentage of correct responses (POC) index was calculated to assess the percent of correctly identified speech sounds by each participant. This was computed according to the following formula:

$$POC = (pR - pL) / (pR + pL)$$

where: pR = proportion of correctly identified right-ear stimuli
pL = proportion of correctly identified left-ear stimuli

POC scores fall within a range of +1 (right ear advantage, a perfect score) to -1 (left ear advantage, a perfect score). An independent analysis of variance (ANOVA) was performed on the dependent variable obtained through the dichotic listening task- percent of correct responses (POC) score. Again, there were three statistical designs analyzing: A) overall group effects (using all focus groups), B) focus effects on POC scores (using focus left and focus right groups), and C) sex differences in POC scores among the no focus (control) groups.

Statistical analysis design A was: Sex (2 levels) x Focus (3 levels) x Trial (2 levels). Thus, data were analyzed with a three-factor mixed design analysis of variance (ANOVA), with fixed factors of Sex (men and women) and Focus (NO, FL, FR), and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAS were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design B was: Sex (2 levels) x Focus (2 levels) x Trial (2 levels). Thus, data were analyzed with a three-factor mixed design analysis of variance (ANOVA), with fixed factors of Sex (men and women) and Focus (FL and FR), and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAS were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design C used only NO focus participants and was: Sex (2 levels) x Trial (2 levels). Thus, data were analyzed with a two-factor mixed design analysis of variance (ANOVA), with a fixed factor of Sex (men and women), and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAS were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Again, significant differences are indicated by dissimilar letters on graphs.

Dichotic Listening Scores: Dichotic Left and Dichotic Right

Independent analyses of variance (ANOVAs) were performed on dichotic listening task variables (number of correctly identified stimuli presented to the left ear and to the right ear). There were three statistical designs analyzing: A) overall group effects (using all focus groups); B) focus effects on dichotic listening scores (using focus left and focus right groups); and C) sex differences in dichotic listening scores reactivity among the no focus (control) groups.

Statistical analysis design A was: Sex (2 levels) x Focus (3 levels) x Trial (2 levels). Thus, data were analyzed with a three-factor mixed design, analysis of variance (ANOVA) with fixed factors of Sex (men and women) and Focus (NO, FL, FR), and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAs were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design B was: Sex (2 levels) x Focus (2 levels) x Trial (2 levels). Thus, data were analyzed with a three-factor mixed design, analysis of variance (ANOVA) with fixed factors of Sex (men and women) and Focus (FL and FR), and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAs were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Significant differences are indicated by dissimilar letters on graphs.

Statistical analysis design C used only NO focus participants and was: Sex (2 levels) x Trial (2 levels). Thus, data were analyzed with a two-factor mixed design, analysis of variance (ANOVA) with a fixed factor of Sex (men and women) and a repeated measure of Trial (dichotic 1 pre-stressor vs. dichotic 2 post-stressor). In addition, more refined ANOVAs were performed for each sex. Post hoc comparisons were performed with Tukey's HSD. Again, significant differences are indicated by dissimilar letters on graphs.

Results

Descriptive Measures

In order to assess possible sex differences on the descriptive measures, t-tests were performed. There was no significant difference between the mean age of men ($\underline{M}$ = 19.47 years, $\underline{SD}$ = 1.29) and women ($\underline{M}$ = 19.45 years, $\underline{SD}$ = 1.20), $\underline{t}(118) = 0.10$, $\underline{p} < .92$.

There was no significant difference between men's and women's mean score on the Coren, Porac, and Duncan Laterality Questionnaire, ($\underline{M}$ = 10.3, $\underline{SD}$ = 2.0) and ($\underline{M}$ =

11.0, $SD = 2.3$), respectively, $t(118) = -1.73$, $p < .09$. There was a nonsignificant trend for women to be more strongly right handed than men.

On the Marlowe-Crowne Social Desirability Scale men ($M = 14.7$, $SD = 4.7$), and women ($M = 16.3$, $SD = 5.7$) were not significantly different, $t(118) = -1.66$, $p < .10$.

However, scores obtained from the Cook-Medley Hostility Inventory (CMHO) indicate that men, as a group, were more hostile than women. Men scored significantly higher ($M = 20.4$, $SD = 7.2$) than women ($M = 17.3$, $SD = 6.9$), $T(118) = 2.38$, $p < .02$. This scale was included as a descriptive measure in this study to further explore subject variables related to cardiovascular reactivity and disease. It has been used extensively for this purpose (Williams & Anderson, 1987). Inclusion of this measure was useful in the preparation for a follow-up study that will investigate sex differences in the effects of hostility on cardiovascular reactivity.

Cardiovascular Reactivity

In order to assess cardiovascular reactivity, independent analyses of variance (ANOVAs) were performed on the following dependent variables of cardiovascular reactivity: systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR). Recall that data were analyzed in the following three design sequences: A) overall group effects (using all focus groups); B) focus effects on cardiovascular reactivity (using focus left and focus right groups only); and C) cardiovascular reactivity in the no focus (control) groups. Further, in each design, refined ANOVAs were performed for each sex. The following results are from statistical analysis design sequence A.

Group means and standard deviations of SBP, DBP, and HR measures are presented in Tables 1, 2 and 3, respectively. Independent ANOVA results of these cardiovascular measures are presented in Table 4.

A main effect of sex was found for both systolic blood pressure and diastolic blood pressure. Overall, men evidenced significantly higher SBP than women ($M = 126.32$ vs. 113.56, $F\ (1,114) = 46.04$, $p < 0.0001$). However, women evidenced significantly higher DBP than men ($M = 75.91$ vs. 68.26, $F\ (1,114) = 27.74$, $p < 0.0001$). A main effect of sex was not found for HR.

A main effect of focus was found only for DBP, $F\ (2,114) = 3.73$, $p < 0.0271$, where the Focus Right (FR) groups evidenced the lowest DBP (see Figure 2). Nevertheless, the Focus Left groups were significantly different from the No Focus groups, whereas, the Focus Right groups did not differ significantly from the No Focus groups in DBP.

A main effect of Condition was found for SBP ($F\ (3,342) = 75.85$, $p < 0.0001$), DBP ($F\ (3,342) = 14.54$, $p < 0.0001$), and HR ($F\ (3,342) = 6.76$, $p < 0.0002$), with significant changes occurring between experimental conditions. Therefore, all cardiovascular measurements during various conditions were significantly different from one another. These significant changes are detailed below.

Overall, across all focus groups, systolic blood pressure (SBP) decreased significantly between Condition 1 (baseline) and Condition 2 (post dichotic 1). A significant increase in SBP occurred across groups at Condition 3 (post cold pressor), followed by another significant decrease in SBP at Condition 4 (post dichotic 2), indicating systolic recovery from the cold pressor (see Figure 3)

Diastolic blood pressure (DBP) did not show a significant change between Condition 1 (baseline) and Condition 2 (post dichotic 1). A significant increase in DBP did occur across groups at Condition 3 (post cold pressor), followed by a significant decrease in DBP at Condition 4 (post dichotic 2), indicating diastolic recovery from the cold pressor (see Figure 4).

Heart rate (HR) did not change significantly between Condition 1 (baseline) and Condition 2 (post dichotic 1), in the three focus groups analyzed together. However, a significant decrease in HR occurred across groups at Condition 3 (post cold pressor), followed by a significant increase at Condition 4 (post dichotic 2; see Figure 5). This might suggest a healthy cardiovascular reactivity response across participants. Heart rate and blood pressure are inversely related through the baroreceptor reflex (Rushmer, 1976). That is to say, as blood pressure increased as a function of the cold pressor (SBP and DBP), heart rate decreased, compensating for some of the extra pressure effects in the vasculature.

Refined independent analyses of variance (ANOVAs) were then performed for each sex and are presented in Table 5. For men, a focus main effect on SBP was found, $\underline{F}$ (2,57) = 4.39, $\underline{p} < 0.0169$, where the focus right participants experienced significantly lower SBP than the focus left participants (see Figure 6). Thus, the men showed a cardiovascular response which suggests more lateralized SBP control. This effect also lends support to theories on greater functional cerebral laterality in men, as focusing on speech sounds heard in the right or the left ear (a selective attentional task) produced different effects on systolic blood pressure. These focus effects were different for each sex, as women did not evidence a focus main effect on SBP.

The first dichotic listening test occurred between Conditions 1 and 2 (baseline vs. post dichotic 1), which corresponded with a significant decrease in men's systolic blood pressure at Condition 2 (see Figure 7). However, women did not evidence a similar decrease at Condition 2 as a function of the dichotic listening test (see Figure 8). This difference in main effects for each sex supports the idea that language and/or parasympathetic cardiovascular regulation is more lateralized to the left hemisphere in men, since the left hemisphere was likely activated by the language task and then systolic blood pressure evidenced a drop in men between Conditions 1 and 2. Overall, for men and for women, a main effect of Condition was found for SBP (for men, $\underline{F}$ (3,171) = 52.25, $\underline{p} < 0.0001$; and for women, $\underline{F}$ (3,171) = 26.44, $\underline{p} < 0.0001$).

The main effect of Condition found for DBP was also significant for men and for women, $\underline{F}$ (3,171) = 5.69, $\underline{p} < 0.0010$, and $\underline{F}$ (3,171) = 9.12, $\underline{p} < 0.0001$, respectively.

For women, a main effect of Condition on HR was found, $\underline{F}$ (3,171) = 6.46, $\underline{p} < 0.0004$, where HR decreased significantly following the cold-pressor (at Condition 3). However, men did not evidence a main effect of Condition on HR. As stated previously, a drop in HR as SBP increases is a healthy response pattern. Therefore, it is interesting that men did not evidence this (arguably) healthy cardiovascular response pattern.

Table 1

Means and Standard Deviations of Systolic BP by Sex, Focus Group, and Condition

	Men		Women	
	Mean	SD	Mean	SD
No Focus Group				
Baseline (Cond 1)	125.1	14.3	110.5	12.0
Post Dichotic 1 (Cond 2)	120.8	11.8	109.7	12.5
Post Cold Pressor (Cond 3)	134.4	13.1	119.9	12.5
Post Dichotic 2 (Cond 4)	121.8	11.2	109.8	10.8
Focus Left Group				
Baseline (Cond 1)	132.0	10.5	113.8	10.2
Post Dichotic 1 (Cond 2)	127.0	8.7	112.3	8.5
Post Cold Pressor (Cond 3)	140.4	12.8	117.8	9.8
Post Dichotic 2 (Cond 4)	127.2	10.0	111.9	8.9
Focus Right Group				
Baseline (Cond 1)	121.3	11.9	114.2	14.1
Post Dichotic 1 (Cond 2)	117.6	10.5	110.0	10.6
Post Cold Pressor (Cond 3)	128.7	14.7	121.6	14.9
Post Dichotic 2 (Cond 4)	119.7	11.2	111.6	10.4

Table 2

Means and Standard Deviations of Diastolic BP by Sex, Focus Group, and Condition

	Men		**Women**	
	Mean	SD	Mean	SD
No Focus Group				
Baseline (Cond 1)	70.2	8.0	77.0	9.3
Post Dichotic 1 (Cond 2)	68.7	6.9	76.6	9.3
Post Cold Pressor (Cond 3)	75.3	11.4	80.3	6.6
Post Dichotic 2 (Cond 4)	70.5	7.4	79.5	7.5
Focus Left Group				
Baseline (Cond 1)	67.7	11.6	75.3	8.6
Post Dichotic 1 (Cond 2)	67.6	9.9	75.0	7.4
Post Cold Pressor (Cond 3)	67.2	13.4	80.7	9.2
Post Dichotic 2 (Cond 4)	66.1	11.5	72.9	9.7
Focus Right Group				
Baseline (Cond 1)	64.4	12.1	71.7	6.8
Post Dichotic 1 (Cond 2)	63.9	9.7	71.3	7.8
Post Cold Pressor (Cond 3)	70.3	10.9	77.0	12.1
Post Dichotic 2 (Cond 4)	67.6	8.0	73.9	7.7

Table 3

Means and Standard Deviations of Heart Rate by Sex, Focus Group, and Condition

	Men		**Women**	
	Mean	SD	Mean	SD
No Focus Group				
Baseline (Cond 1)	65.9	13.9	68.3	9.9
Post Dichotic 1 (Cond 2)	66.0	8.6	69.1	11.1
Post Cold Pressor (Cond 3)	63.1	8.7	67.1	9.8
Post Dichotic 2 (Cond 4)	66.1	8.1	68.7	10.9
Focus Left Group				
Baseline (Cond 1)	62.1	7.5	66.1	13.8
Post Dichotic 1 (Cond 2)	62.6	8.7	66.6	12.4
Post Cold Pressor (Cond 3)	60.7	11.1	61.0	12.8
Post Dichotic 2 (Cond 4)	60.6	8.3	64.5	11.7
Focus Right Group				
Baseline (Cond 1)	63.8	10.2	65.0	14.6
Post Dichotic 1 (Cond 2)	67.7	12.5	64.7	13.7
Post Cold Pressor (Cond 3)	63.4	10.1	60.8	12.8
Post Dichotic 2 (Cond 4)	65.0	9.6	64.7	15.1

Table 4

Independent ANOVA Results for Systolic BP, Diastolic BP, and Heart Rate for All Groups (No Focus (Control), Focus Left, and Focus Right)

Source	DF	SS	MS	F Value	p
Systolic BP					
Sex	(1,114)	19533.01	19533.01	46.04	<0.0001**
Focus	(2,114)	1987.55	993.78	2.34	<0.1007
Sex*Focus	(2,114)	2091.45	1045.73	2.46	<0.0896
Condition	(3,342)	8896.35	2965.45	75.85	<0.0001**
Sex*Cond	(3,342)	228.98	76.33	1.95	<0.1209
Focus*Cond	(6,342)	150.76	25.13	0.64	<0.6960
Sex*Foc*Cond	(6,342)	261.56	43.59	1.12	<0.3530
Diastolic BP					
Sex	(1,114)	7015.05	7015.05	27.74	<0.0001**
Focus	(2,114)	1884.93	942.46	3.73	<0.0271*
Sex*Focus	(2,114)	89.83	44.91	0.18	<0.8375
Condition	(3,342)	1556.51	518.84	14.54	<0.0001**
Sex*Cond	(3,342)	23.42	7.81	0.22	<0.8833
Focus*Cond	(6,342)	392.54	65.42	1.83	<0.0917
Sex*Foc*Cond	(6,342)	363.67	60.61	1.70	<0.1204
Heart Rate					
Sex	(1,114)	315.25	315.25	0.80	<0.3741
Focus	(2,114)	1165.33	582.66	1.47	<0.2338
Sex*Focus	(2,114)	469.00	234.50	0.59	<0.5547
Condition	(3,342)	766.64	255.55	6.76	<0.0002**
Sex*Cond	(3,342)	68.31	22.77	0.60	<0.6137
Focus*Cond	(6,342)	86.40	14.40	0.38	<0.8909
Sex*Foc*Cond	(6,342)	162.16	27.03	0.72	<0.6375

* $p < .05$

** $p < .01$

Table 5

Refined Independent ANOVA Results for Each Sex for Systolic BP, Diastolic BP, and Heart Rate for All Groups (No Focus (Control), Focus Left, and Focus Right)

Source	DF	SS	MS	F Value	p
MEN					
Systolic BP					
Focus	(2,57)	3927.41	1963.70	4.39	<0.0169*
Condition	(3,171)	5918.65	1972.88	52.25	<0.0001**
Focus*Cond	(6,171)	122.39	20.40	0.54	<0.7771
Diastolic BP					
Focus	(2,57)	1023.60	511.80	1.63	<0.2045
Condition	(3,171)	616.95	205.65	5.69	<0.0010**
Focus*Cond	(6,171)	442.27	73.71	2.04	<0.0631
Heart Rate					
Focus	(2,57)	702.33	351.16	1.38	<0.2602
Condition	(3,171)	279.10	93.03	1.98	<0.1182
Focus*Cond	(6,171)	136.78	22.80	0.49	<0.8181
WOMEN					
Systolic BP					
Focus	(2,57)	151.60	75.80	0.19	<0.8283
Condition	(3,171)	3206.68	1068.89	26.44	<0.0001**
Focus*Cond	(6,171)	289.93	48.32	1.20	<0.3112
Diastolic BP					
Focus	(2,57)	951.16	475.58	2.47	<0.0933
Condition	(3,171)	962.98	320.99	9.12	<0.0001**
Focus*Cond	(6,171)	313.94	52.32	1.49	<0.1852
Heart Rate					
Focus	(2,57)	932.01	466.00	0.87	<0.4253
Condition	(3,171)	555.85	185.28	6.46	<0.0004**
Focus*Cond	(6,171)	111.79	18.63	0.65	<0.6904

* $p < .05$, ** $p < .01$

Figure 2. Main Effect of Focus on Diastolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

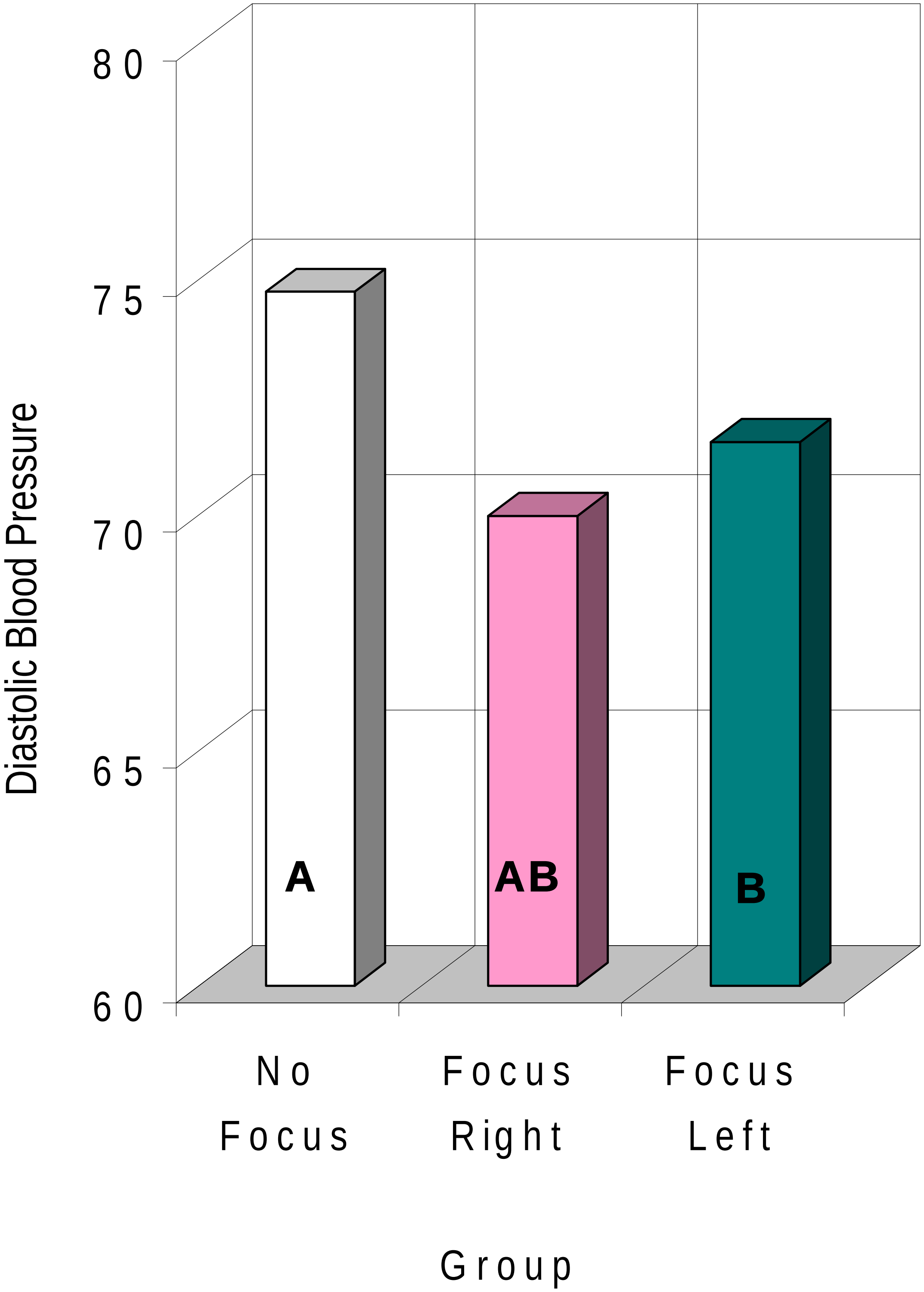


Figure 3. Main Effect of Condition on Systolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

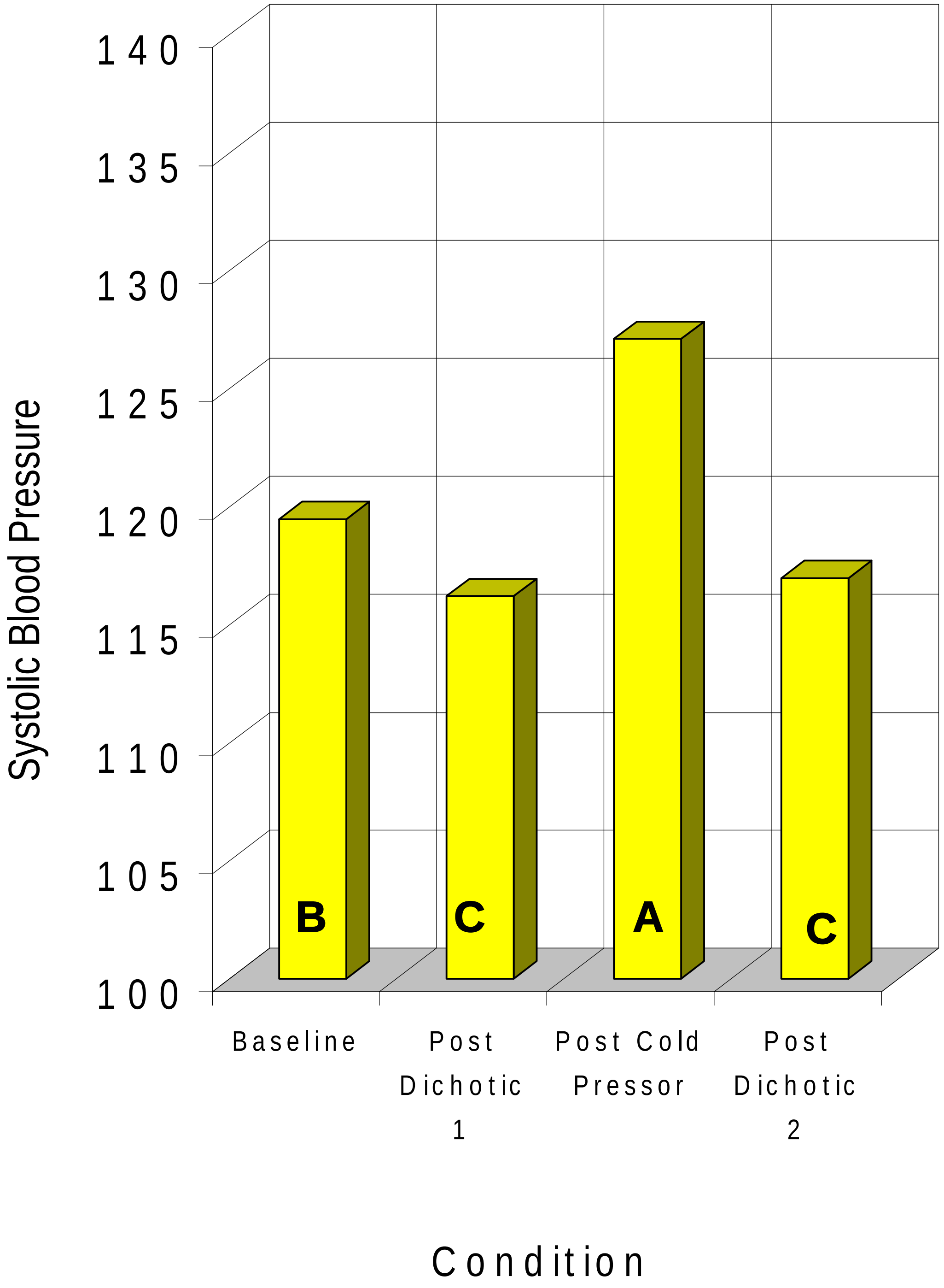


Figure 4. Main Effect of Condition on Diastolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

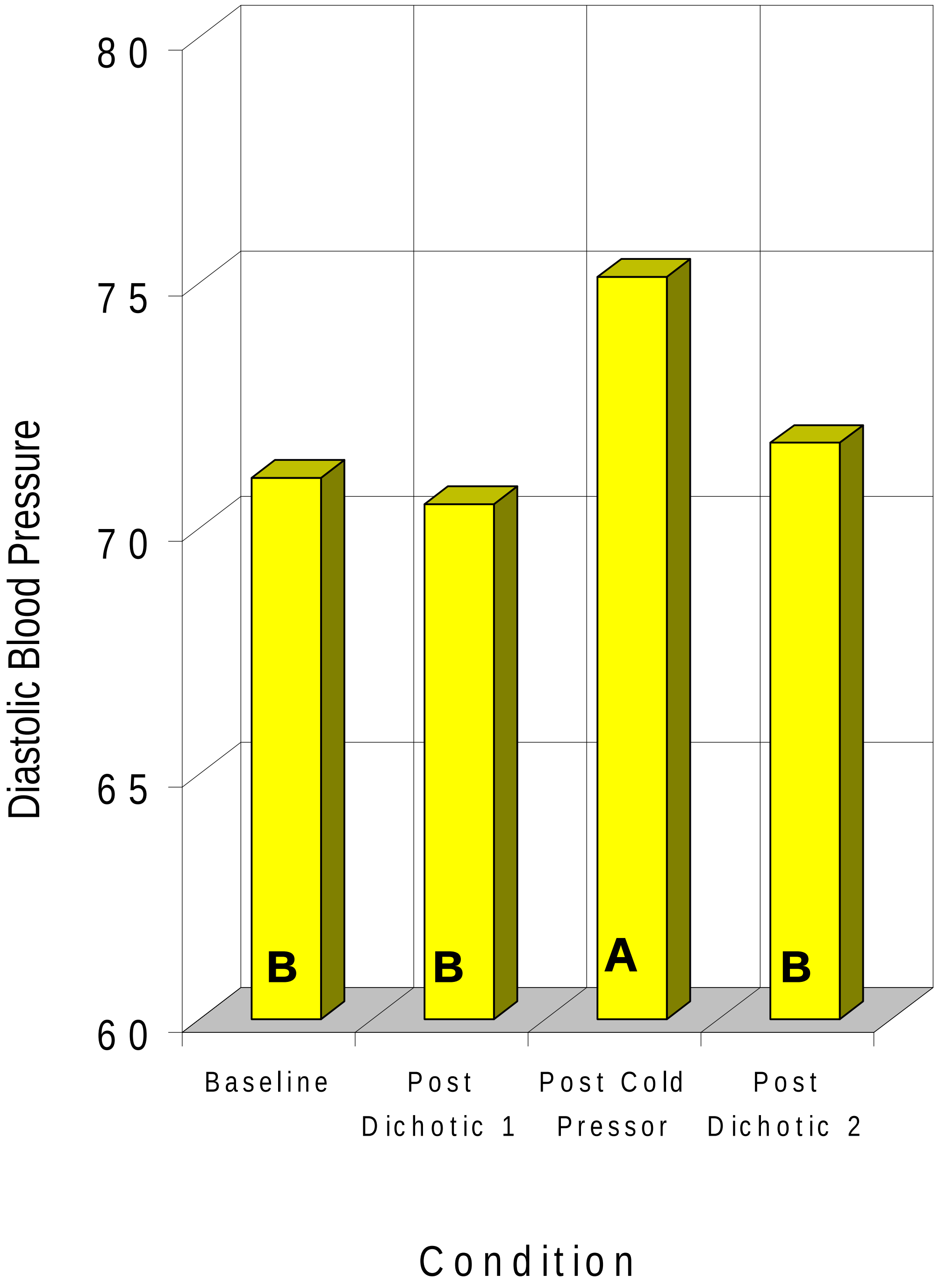


Figure 5. Main Effect of Condition on Heart Rate, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

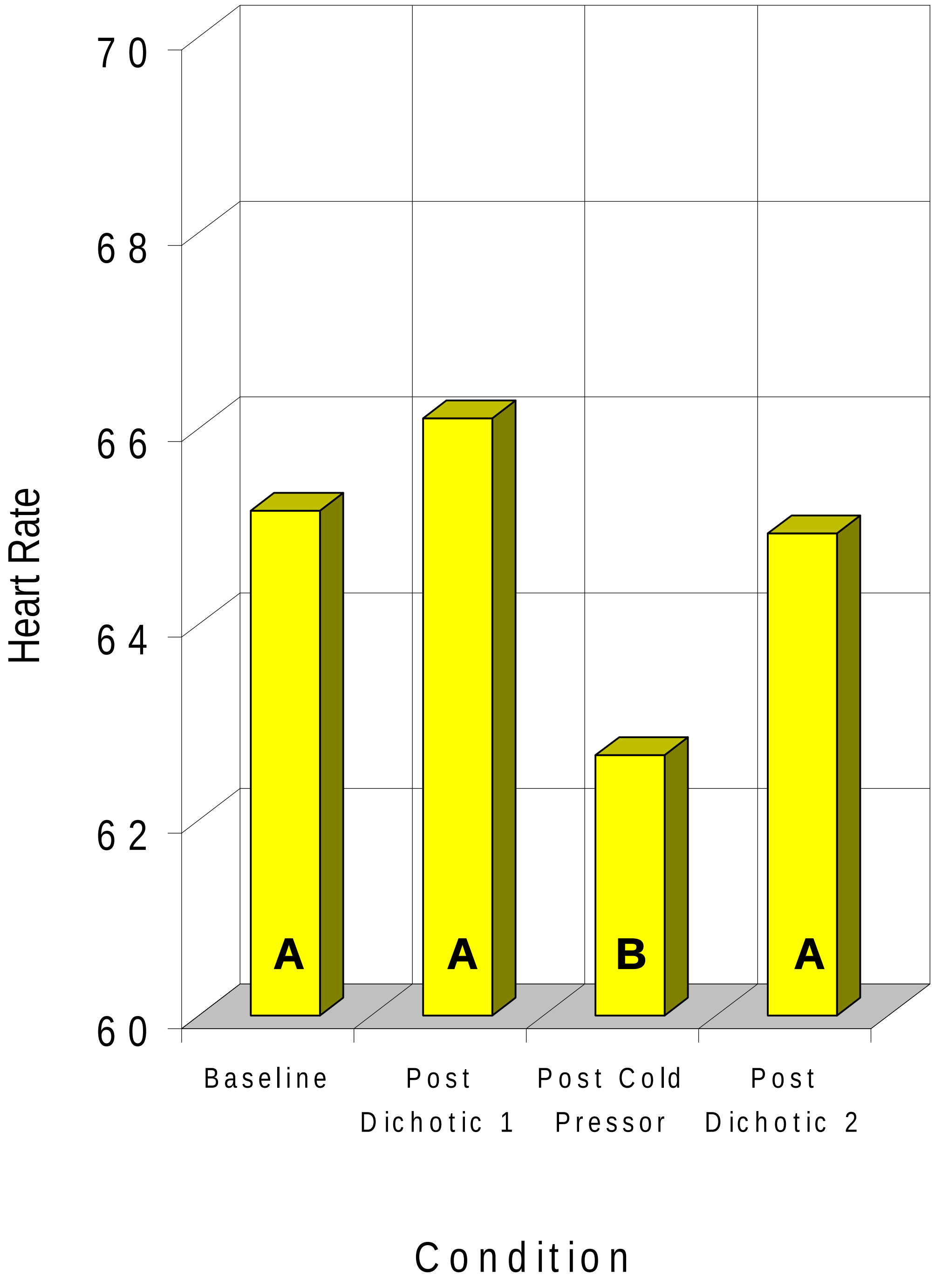


Figure 6. Main Effect of Focus for Men on Systolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

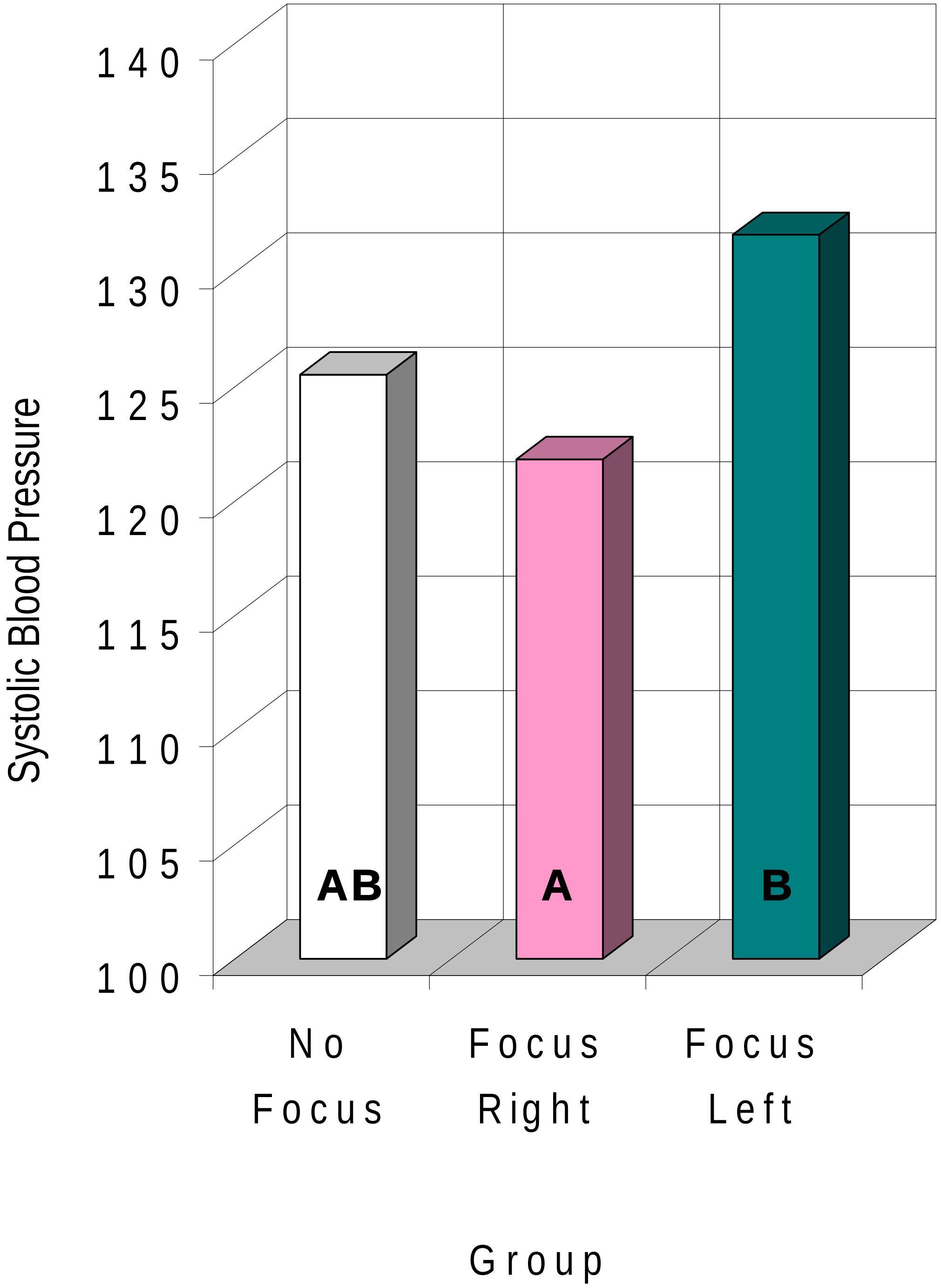


Figure 7. Main Effect of Condition for Men on Systolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

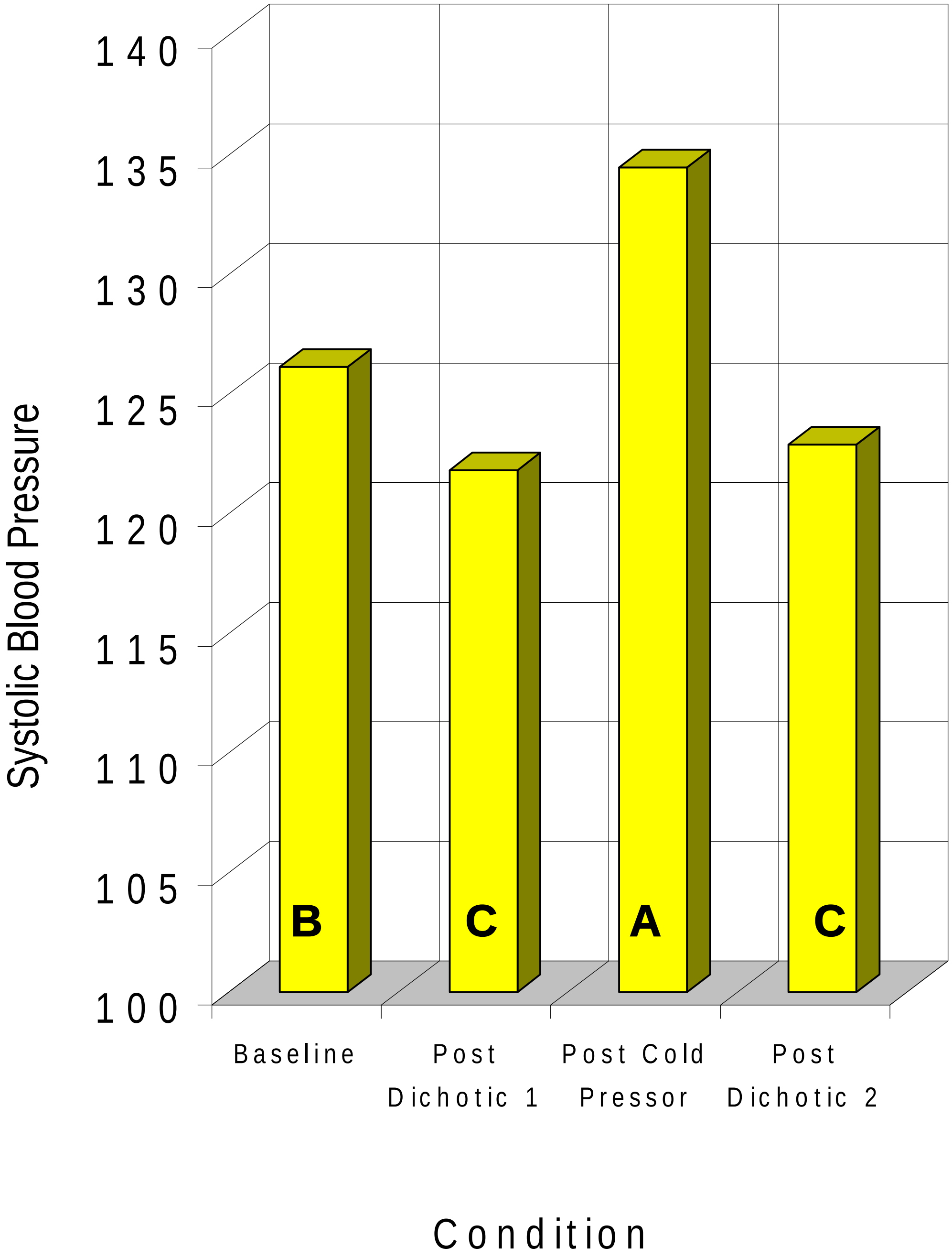
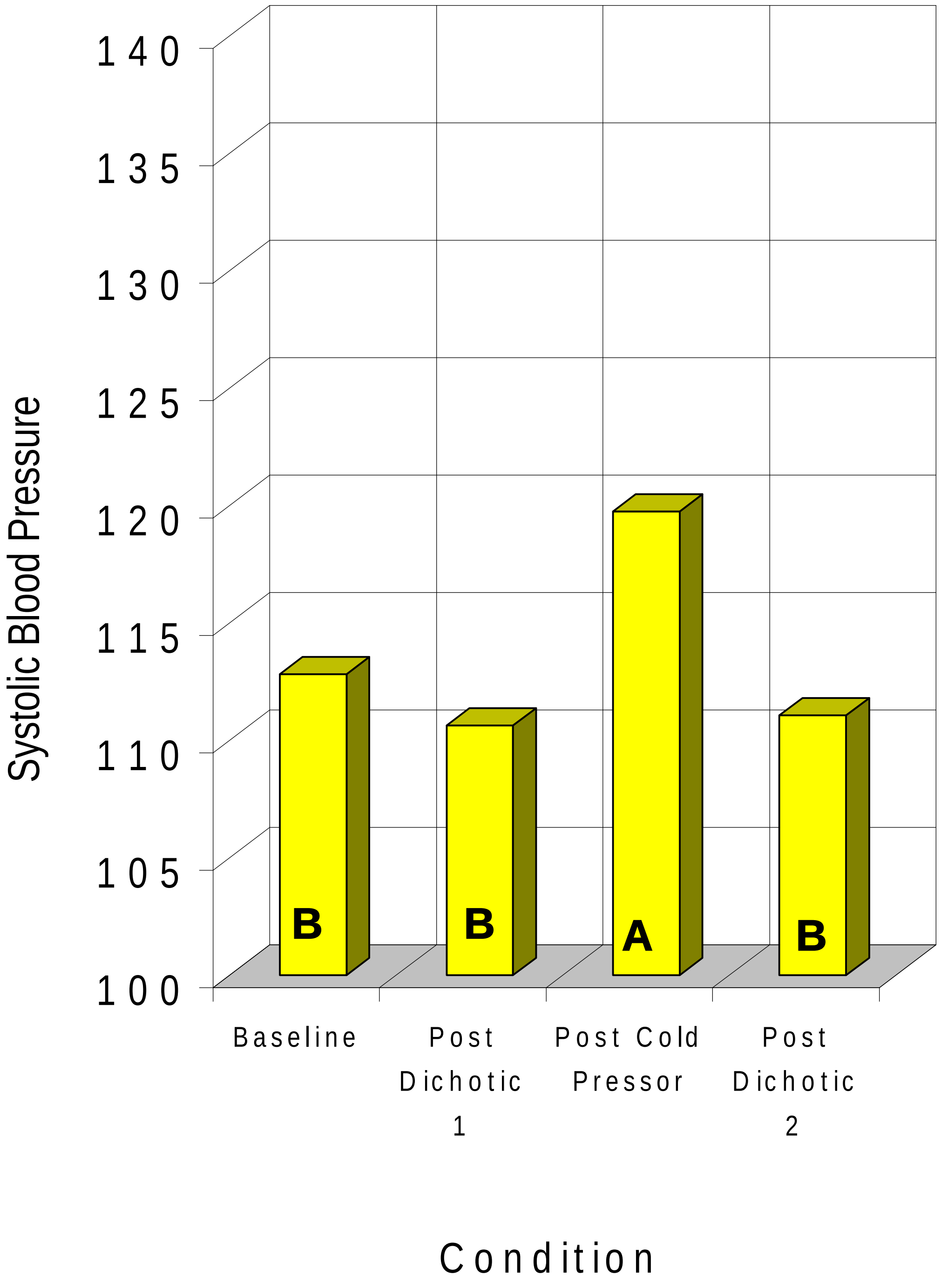


Figure 8. Main Effect of Condition for Women on Systolic Blood Pressure, Using All Groups: No Focus (Control), Focus Left, and Focus Right.



The following results flow from the statistical analysis described previously as design sequence B. Again, these analyses are refined independent ANOVAs of the cardiovascular measures for Focus Left and Focus Right groups only (presented in Table 6). This was done to provide a more accurate comparison of the groups who were asked to focus to the left ear or the right ear.

A Sex by Focus Interaction effect was found for systolic blood pressure levels, F (1,76) = 5.37, p < 0.0232 (see Figure 9). For a comparison, a figure was created with the No Focus group included (control group; see Appendix J). It is interesting to note that in men SBP responses varied when focusing right or left, while in women there were no significant changes according to focus instructions. Women's relatively stable SBP responses across focus groups suggests more functional cerebral symmetry, while men's changing SBP according to focus group suggests more functional cerebral asymmetry.

A main effect of sex was found for both systolic blood pressure and diastolic blood pressure. Overall, Focus Left and Focus Right men evidenced significantly higher SBP than women, F (1,76) = 32.74, p < 0.0001. However, Focus Left and Focus Right women evidenced significantly higher DBP than men, F (1,76) = 17.36, p < 0.0001). A main effect of sex was not found for HR.

A main effect of focus was found only for SBP, F (1,76) = 4.56, p < 0.0359, where the focus right (FR) groups evidenced the lowest SBP (see Figure 10). This contrasts the 3 focus group comparison of men and women, where DBP was the only cardiovascular measure affected by different focus conditions. However, it is similar to the finding among men, where focus affected SBP measures only.

A Focus by Condition Interaction effect was found for diastolic blood pressure, F (6,228) = 3.21, p < 0.0240. This can be seen on Figure 11. Focus Left groups had increased diastolic blood pressure levels compared to Focus Right groups. However, men contributed to this difference significantly more than women (see below).

A main effect of Condition was found for SBP (F (3,228) = 43.80, p < 0.0001), DBP (F (3,228) = 9.0, p < 0.0001), and HR (F (3,228) = 5.79, p < 0.0008), with significant changes occurring between each Condition . These cardiovascular changes were similar to those seen in the analysis of all three groups (detailed above).

Refined independent analyses of variance (ANOVAs) were performed on the Focus Left and Focus Right groups of each sex and are presented in Table 7.

A main effect of Focus on SBP was found in men, F (1,38) = 9.37, p < 0.0040, where the focus right men experienced significantly lower SBP than the focus left men (see Figure 12). Women did not evidence a focus main effect on SBP.

Also, in men, a Focus by Condition interaction was evidenced for DBP, F (3,114) = 3.42, p < 0.0197. Thus, as discussed above, men seem to have contributed to this interaction effect differently than women (see Figure 13).

A main effect of Condition was found for SBP (for men, F (3,114) = 33.00, p < 0.0001; and for women, F (3,114) = 13.80, p < 0.0001). A main effect of Condition for DBP was significant for women only, F (3,114) = 7.60, p < 0.0001. Likewise, for women, a main effect of Condition on HR was found, F (3,114) = 9.40, p < 0.0001, where HR decreased significantly following the cold-pressor, unlike men.

Table 6

Refined Independent ANOVA Results for Systolic BP, Diastolic BP, and Heart Rate of Focus Left and Focus Right Groups

Source	DF	SS	MS	F Value	p
Systolic BP					
Sex	(1,76)	12713.40	12713.40	32.74	<0.0001**
Focus	(1,76)	1771.90	1771.90	4.56	<0.0359*
Sex*Focus	(1,76)	2085.90	2085.90	5.37	<0.0232*
Condition	(3,228)	5296.91	1765.64	43.80	<0.0001**
Sex*Cond	(3,228)	157.28	52.43	1.30	<0.2750
Focus*Cond	(6,228)	56.08	18.69	0.46	<0.7079
Sex*Foc*Cond	(6,228)	241.08	80.36	1.99	<0.1157
Diastolic BP					
Sex	(1,76)	4984.90	4984.90	17.36	<0.0001**
Focus	(1,76)	196.88	196.88	0.69	<0.4103
Sex*Focus	(1,76)	75.08	75.08	0.26	<0.6107
Condition	(3,228)	988.28	329.43	9.00	<0.0001**
Sex*Cond	(3,228)	139.21	46.40	1.27	<0.2864
Focus*Cond	(6,228)	352.13	117.38	3.21	<0.0240*
Sex*Foc*Cond	(6,228)	158.03	52.68	1.44	<0.2323
Heart Rate					
Sex	(1,76)	68.45	68.45	0.16	<0.6945
Focus	(1,76)	148.51	148.51	0.34	<0.5632
Sex*Focus	(1,76)	352.80	352.80	0.80	<0.3736
Condition	(3,228)	652.71	217.57	5.79	<0.0008**
Sex*Cond	(3,228)	160.73	53.58	1.43	<0.2360
Focus*Cond	(6,228)	43.01	14.34	0.38	<0.7664
Sex*Foc*Cond	(6,228)	56.08	18.69	0.50	<0.6844

* $p < .05$; ** $p < .01$

Table 7

Refined Independent ANOVA Results for Systolic BP, Diastolic BP, and Heart Rate For Each Sex of Focus Left and Focus Right Groups

Source	DF	SS	MS	F Value	p
MEN					
Systolic BP					
Focus	(1,38)	3851.41	3851.41	9.37	<0.0040**
Condition	(3,114)	3637.07	1212.36	33.00	<0.0001**
Focus*Cond	(3,114)	101.02	33.67	0.92	<0.4354
Diastolic BP					
Focus	(1,38)	14.40	14.40	0.04	<0.8474
Condition	(3,114)	220.03	73.34	2.19	<0.0928
Focus*Cond	(3,114)	343.25	114.42	3.42	<0.0197*
Heart Rate					
Focus	(1,38)	479.56	479.56	2.11	<0.1547
Condition	(3,114)	217.27	72.42	1.34	<0.2646
Focus*Cond	(3,114)	73.27	24.42	0.45	<0.7162
WOMEN					
Systolic BP					
Focus	(1,38)	6.40	6.40	0.02	<0.8955
Condition	(3,114)	1817.13	605.71	13.80	<0.0001**
Focus*Cond	(3,114)	196.15	65.38	1.49	<0.2210
Diastolic BP					
Focus	(1,38)	257.56	257.56	1.35	<0.2526
Condition	(3,114)	907.47	302.49	7.60	<0.0001**
Focus*Cond	(3,114)	166.92	55.64	1.40	<0.2468
Heart Rate					
Focus	(1,38)	21.76	21.76	0.03	<0.8562
Condition	(3,114)	596.17	198.72	9.40	<0.0001**
Focus*Cond	(3,114)	25.82	8.61	0.41	<0.7483

* $p < .05$, ** $p < .01$

Figure 9. Refined Analysis of Focus Left and Focus Right Groups. A Sex by Focus Interaction Effect on Systolic Blood Pressure was found.

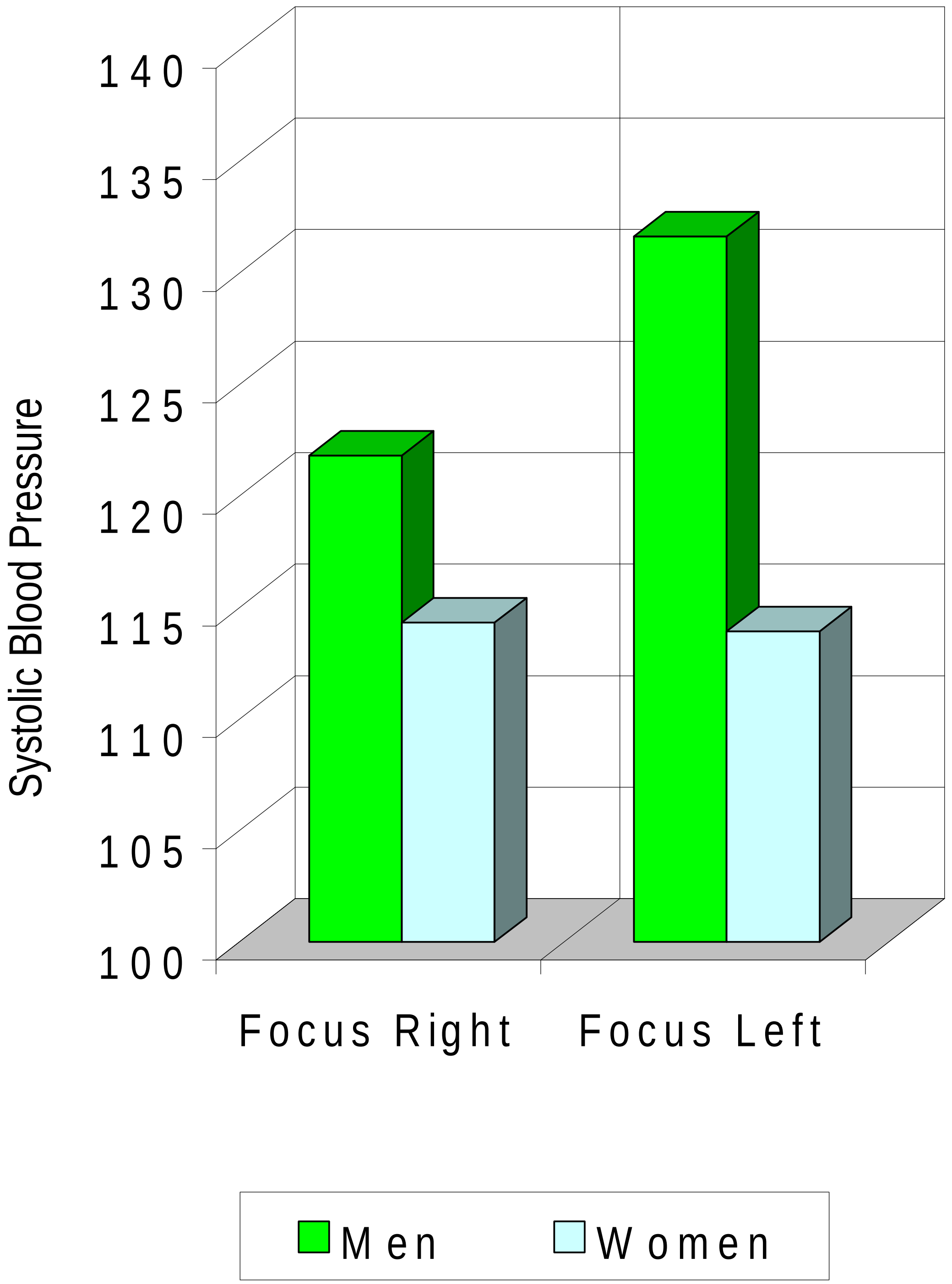


Figure 10. Refined Analysis of Focus Left and Focus Right Groups. Focus Main Effect on Systolic Blood Pressure.

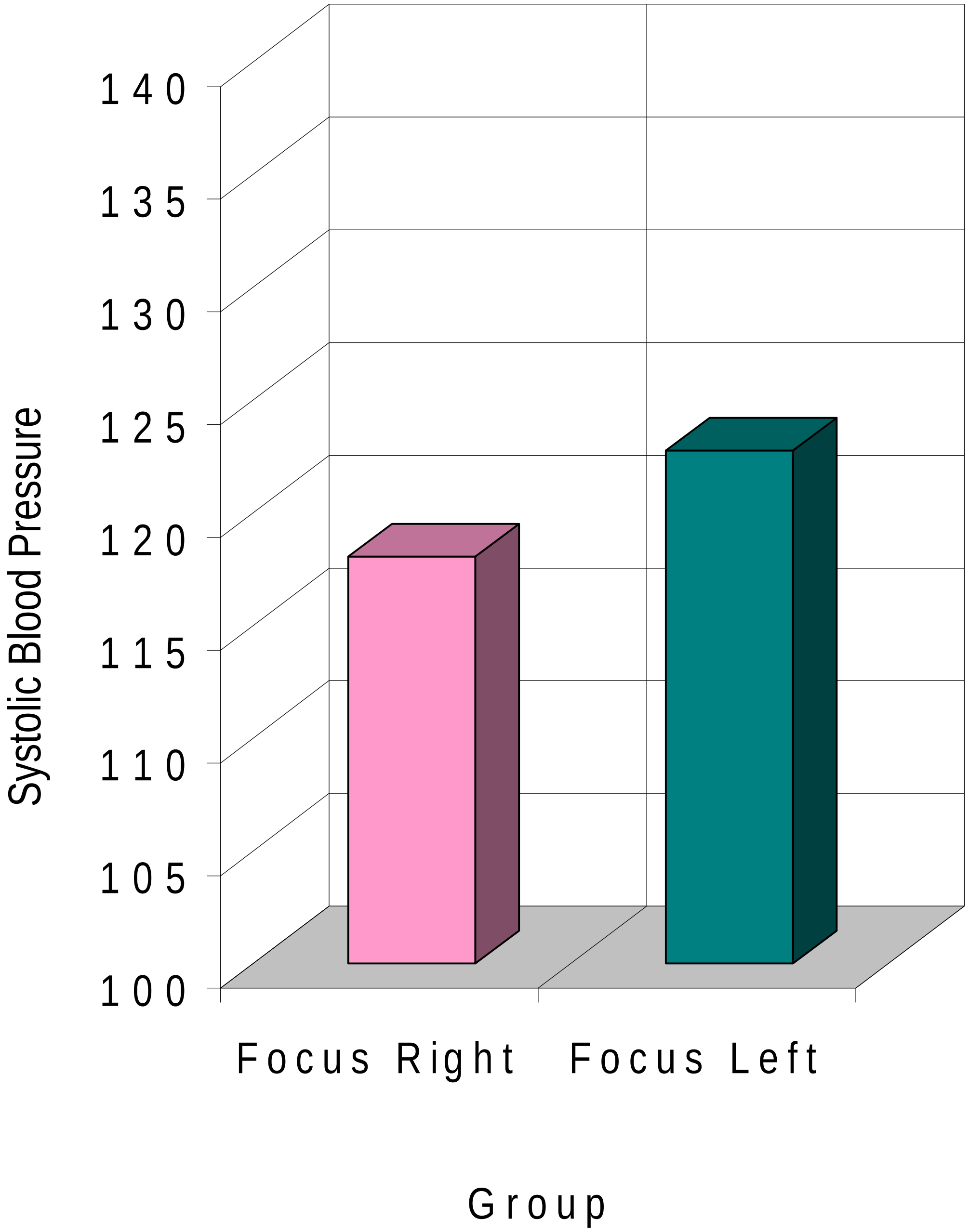


Figure 11. Refined Analysis of Focus Left and Focus Right Groups. Focus by Condition Interaction Effect on Diastolic Blood Pressure.

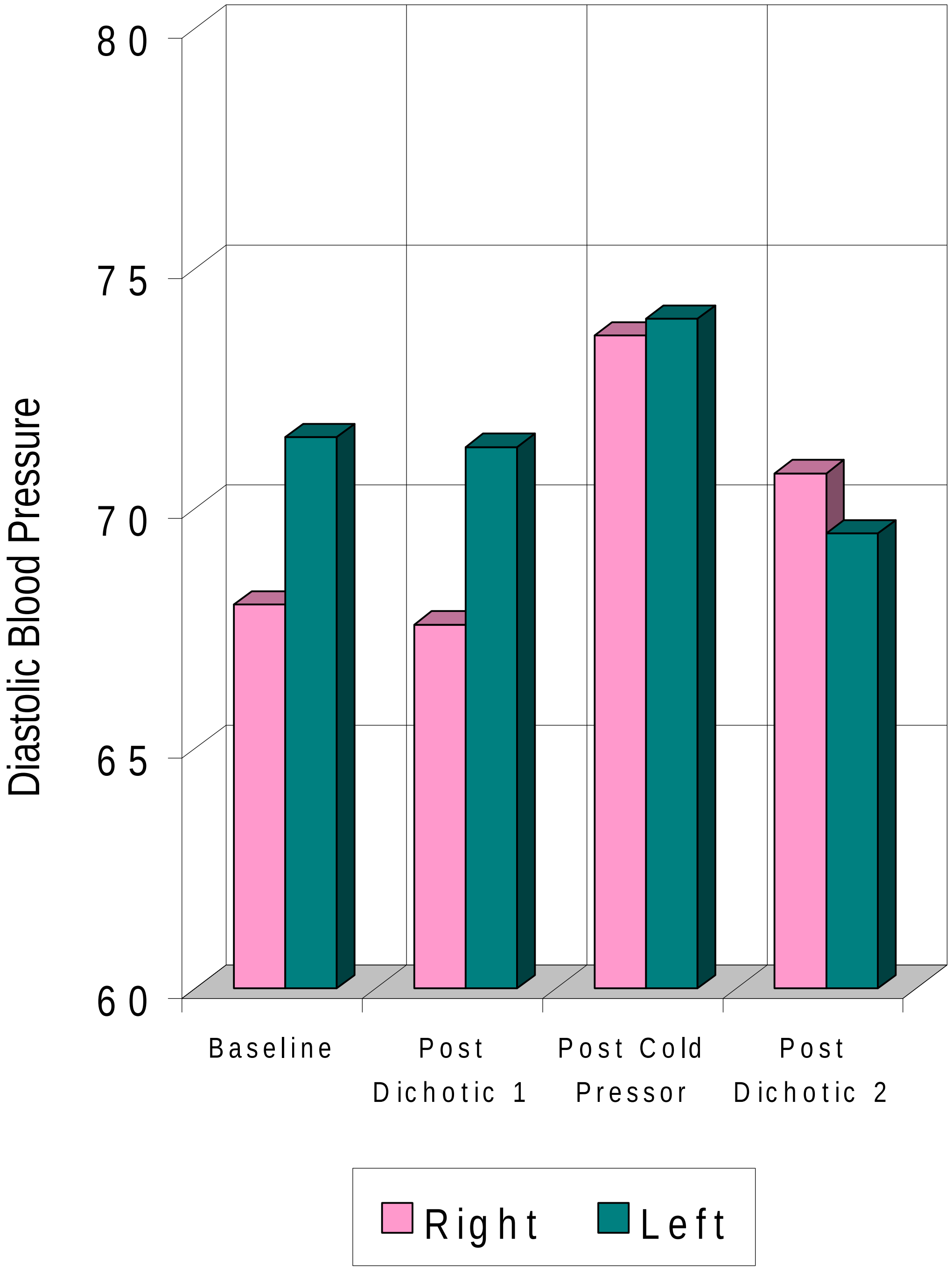
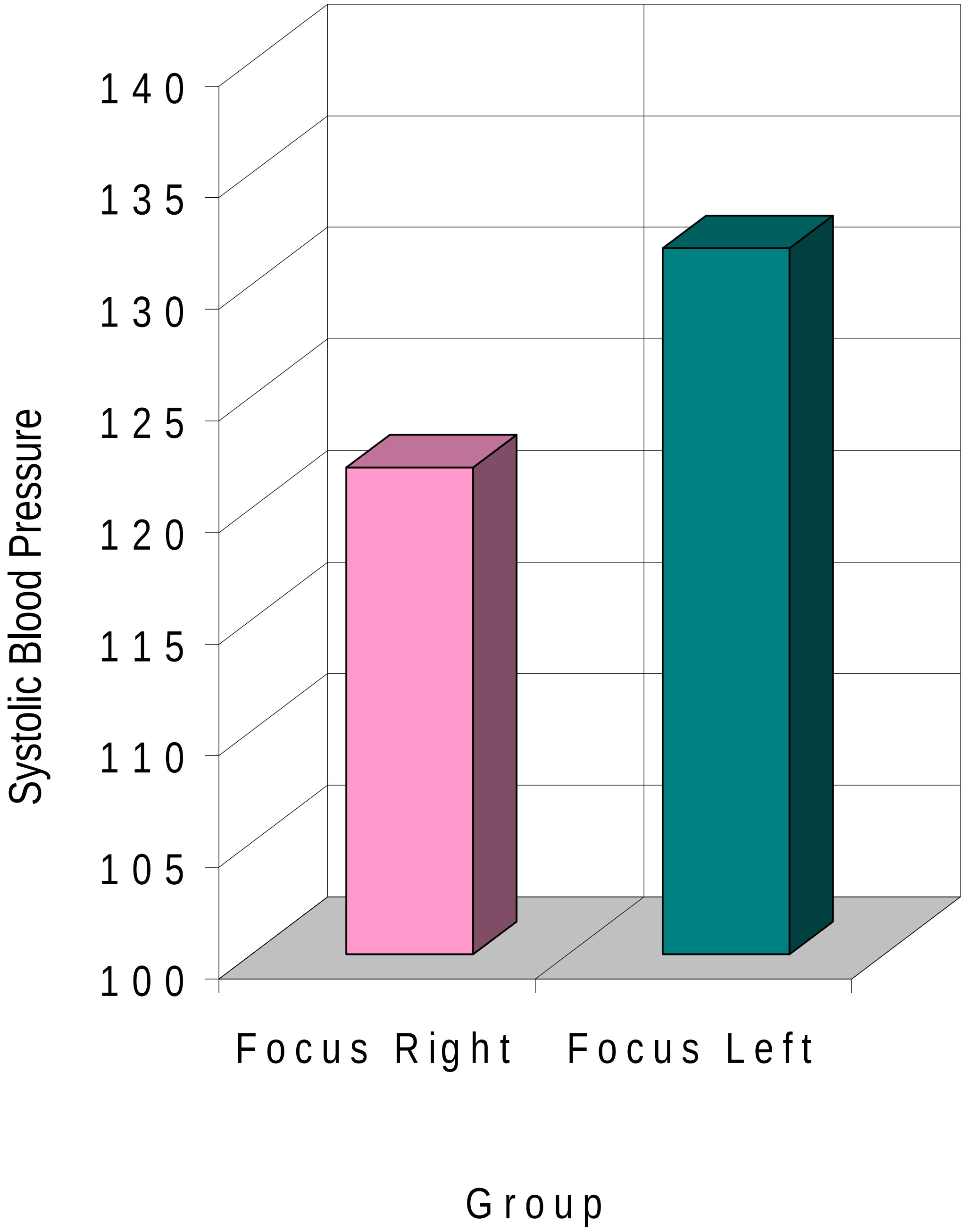
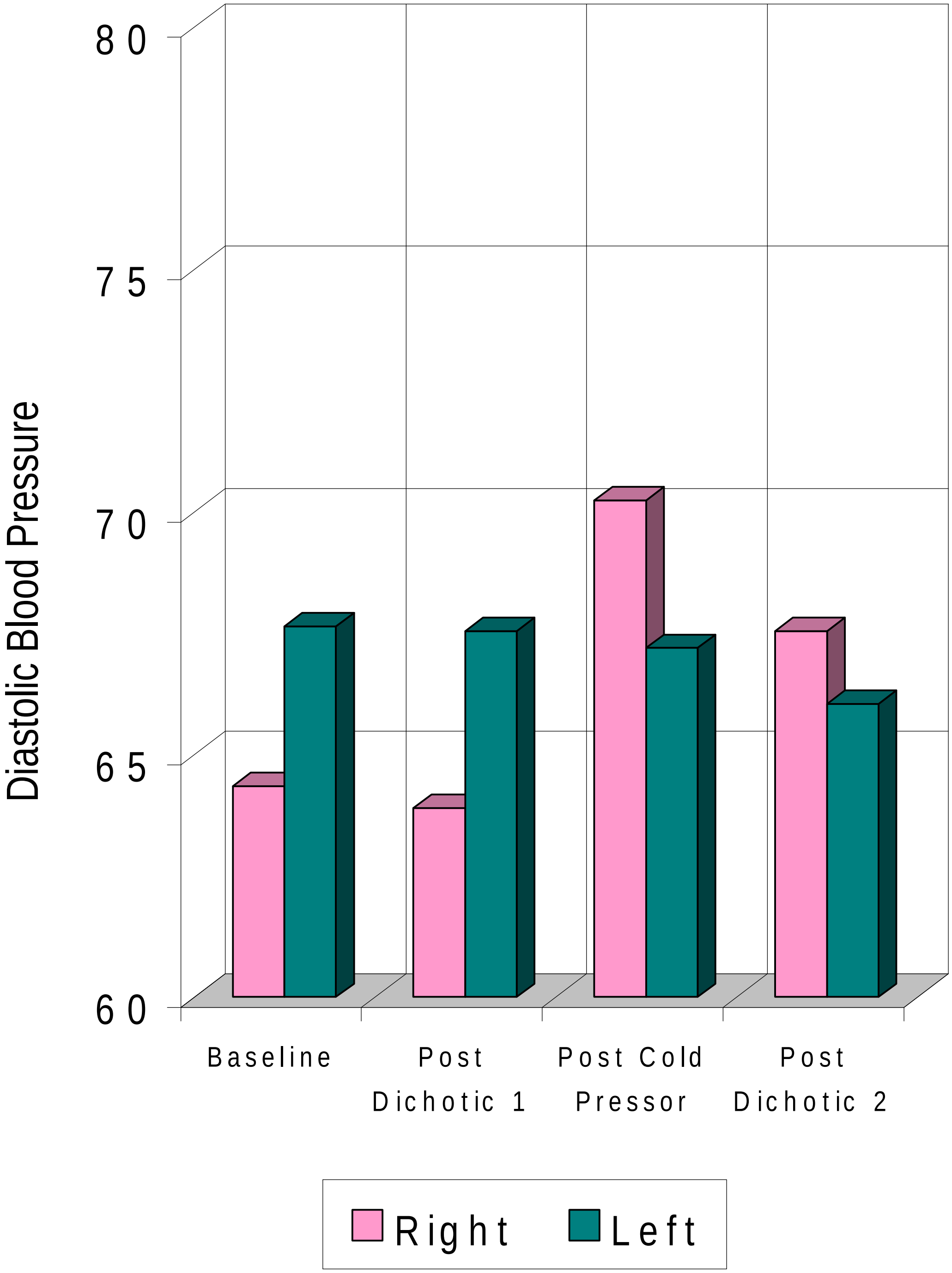


Figure 12. Refined Analysis of Focus Left and Focus Right Men Only. Focus Main Effect on Systolic Blood Pressure.



<u>Figure 13</u>. Refined Analysis of Focus Left and Focus Right Men Only. Focus by Condition Interaction Effect on Diastolic Blood Pressure.



The following results come from statistical analysis design sequence C, described previously. Again, these analyses are refined independent ANOVAs of cardiovascular measures for No Focus groups only (presented in Table 8). This was done to provide a control group comparison to the active focus groups.

Table 9 shows the refined ANOVAs for each sex.

Table 8

Refined Independent ANOVA Results for Systolic BP, Diastolic BP, and Heart Rate of No Focus (Control) Groups

Source	DF	SS	MS	F Value	p
Systolic BP					
Sex	(1,38)	6825.16	6825.16	13.76	<0.0007**
Condition	(3,114)	3694.12	1231.37	33.58	<0.0001**
Sex*Cond	(3,114)	92.17	30.72	0.84	<0.4758
Diastolic BP					
Sex	(1,38)	2044.90	2044.90	11.10	<0.0019**
Condition	(3,114)	608.63	202.88	6.00	<0.0008**
Sex*Cond	(3,114)	89.85	29.95	0.89	<0.4505
Heart Rate					
Sex	(1,38)	363.01	363.01	1.18	<0.2835
Condition	(3,114)	157.32	52.44	1.37	<0.2548
Sex*Cond	(3,114)	13.67	4.56	0.12	<0.9486

* $p < .05$
** $p < .01$

Table 9

Refined Independent ANOVA Results for Systolic BP, Diastolic BP, and Heart Rate For Each Sex of No Focus (Control) Groups

Source	DF	SS	MS	F Value	p
MEN					
Systolic BP					
Condition	(3,57)	2302.95	767.65	19.29	<0.0001**
Diastolic BP					
Condition	(3,57)	495.94	165.31	3.98	<0.0122*
Heart Rate					
Condition	(3,57)	125.34	41.78	1.28	<0.2903
WOMEN					
Systolic BP					
Condition	(3,57)	1483.34	494.45	14.74	<0.0001**
Diastolic BP					
Condition	(3,57)	202.54	67.51	2.60	<0.0611
Heart Rate					
Condition	(3,57)	45.65	15.22	0.35	<0.7909

* $p < .05$, ** $p < .01$

POC Scores

In order to assess dichotic listening ability, POC scores were first computed to view overall trends of ear dominance. Recall that POC scores are a dependent variable obtained through the dichotic listening task- percent of correct responses (POC). Positive POC scores indicate a right ear advantage, while negative POC scores indicate a left ear advantage in dichotic listening ability. Recall that data were analyzed in the following three design sequences: A) overall group effects (using all focus groups), B) focus effects on POC scores (using focus left and focus right groups only), and C) POC scores in the no focus (control) groups. Further, in each design, refined ANOVAs were performed for each sex.

Group means and standard deviations of POC scores are presented in Table 10. The following results come from statistical analysis design sequence A.

Independent analyses of variance (ANOVAs) performed on the POC scores for all groups (NO, FL, and FR) are presented in Table 11. A main effect of sex was found on POC scores, where men evidenced a significantly higher percentage of correct responses at the right ear than women ($\underline{F}$ (1,114) = 4.29, $\underline{p} < 0.0406$; see Figure 14). This suggests greater language laterality (in the left hemisphere) in men, compared to women.

Main effects of focus on POC scores were not found using all three focus groups.

A main effect of trial was also found, $\underline{F}$ (1,114) = 6.15, $\underline{p} < 0.0146$, where percent correct increased at the right ear following the cold pressor (see Figure 15). It is interesting to note that increased accuracy occurred following the cold pressor, which possibly created a compartmentalized arousal phenomenon. Thus, the stressor increased accuracy at the right, but not left, ear for the combined focus groups.

Refined independent analyses of variance (ANOVA) were performed for each sex and are presented in Table 12.

Women were found to evidence a main effect of focus, $\underline{F}$ (2,57) = 3.73, $\underline{p} < 0.0301$. Thus, women in the no focus (NO), focus left (FL), and focus right (FR) groups were seemingly able to shift their focus to the left ear or to the right ear to the degree that they significantly changed the percent of correct scores at each ear (see Figure 16). A main effect of focus on POC scores was not found for men. In fact, men seemed to have difficulty overcoming the right ear advantage that characterizes their language abilities being lateralized in the left hemisphere.

For women, a main effect of trial was also found, $\underline{F}$ (1,57) = 4.81, $\underline{p} < 0.0323$, where the percent of correctly identified stimuli increased significantly at the right ear after cold pressor exposure (see Figure 17). This main effect was not found for men in a refined independent analysis of variance. However, it is possible that a ceiling effect exists in the men’s POC scores, which prevents them from increasing already high positive POC scores (indicating a significant right ear advantage), as men evidenced high POC scores across all groups and trials. Refer to Appendix K for a graph of the levels and the shifts in POC scores for the different focus groups within each sex, before and after the cold-pressor.

Table 10

Means and Standard Deviations of POC Scores by Sex, Focus Group, and Trial

	Men		**Women**	
	Mean	SD	Mean	SD
No Focus Group				
Pre-Stressor	0.24	0.34	0.10	0.21
Post-Stressor	0.27	0.30	0.17	0.25
Focus Left Group				
Pre-Stressor	0.24	0.24	0.04	0.36
Post-Stressor	0.23	0.30	0.08	0.32
Focus Right Group				
Pre-Stressor	0.22	0.31	0.23	0.18
Post-Stressor	0.30	0.26	0.30	0.16

Table 11

Independent ANOVA Results for POC Scores

Source	DF	SS	MS	F Value	p
POC Scores					
Sex	(1,114)	0.566	0.566	4.29	<0.0406*
Focus	(2,114)	0.545	0.273	2.07	<0.1310
Sex*Focus	(2,114)	0.331	0.165	1.25	<0.2892
Trial	(1,114)	0.126	0.126	6.15	<0.0146*
Sex*Trial	(1,114)	0.005	0.005	0.24	<0.6264
Focus*Trial	(2,114)	0.033	0.016	0.80	<0.4507
Sex*Foc*Trial	(2,114)	0.011	0.005	0.26	<0.7713

* $p < .05$

Table 12

Refined Independent ANOVA - Results for POC Scores for Men and for Women

Source	DF	SS	MS	F Value	p
POC Scores					
Men					
Focus	(2,57)	0.018	0.009	0.06	<0.9422
Trial	(1,57)	0.041	0.041	1.83	<0.1820
Focus*Trial	(2,57)	0.039	0.019	0.87	<0.4251
Women					
Focus	(2,57)	0.858	0.439	3.73	<0.0301*
Trial	(1,57)	0.090	0.090	4.81	<0.0323*
Focus*Trial	(2,57)	0.005	0.003	0.13	<0.8771

* $p < .05$

Figure 14. Main Effect of Sex on POC Scores, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

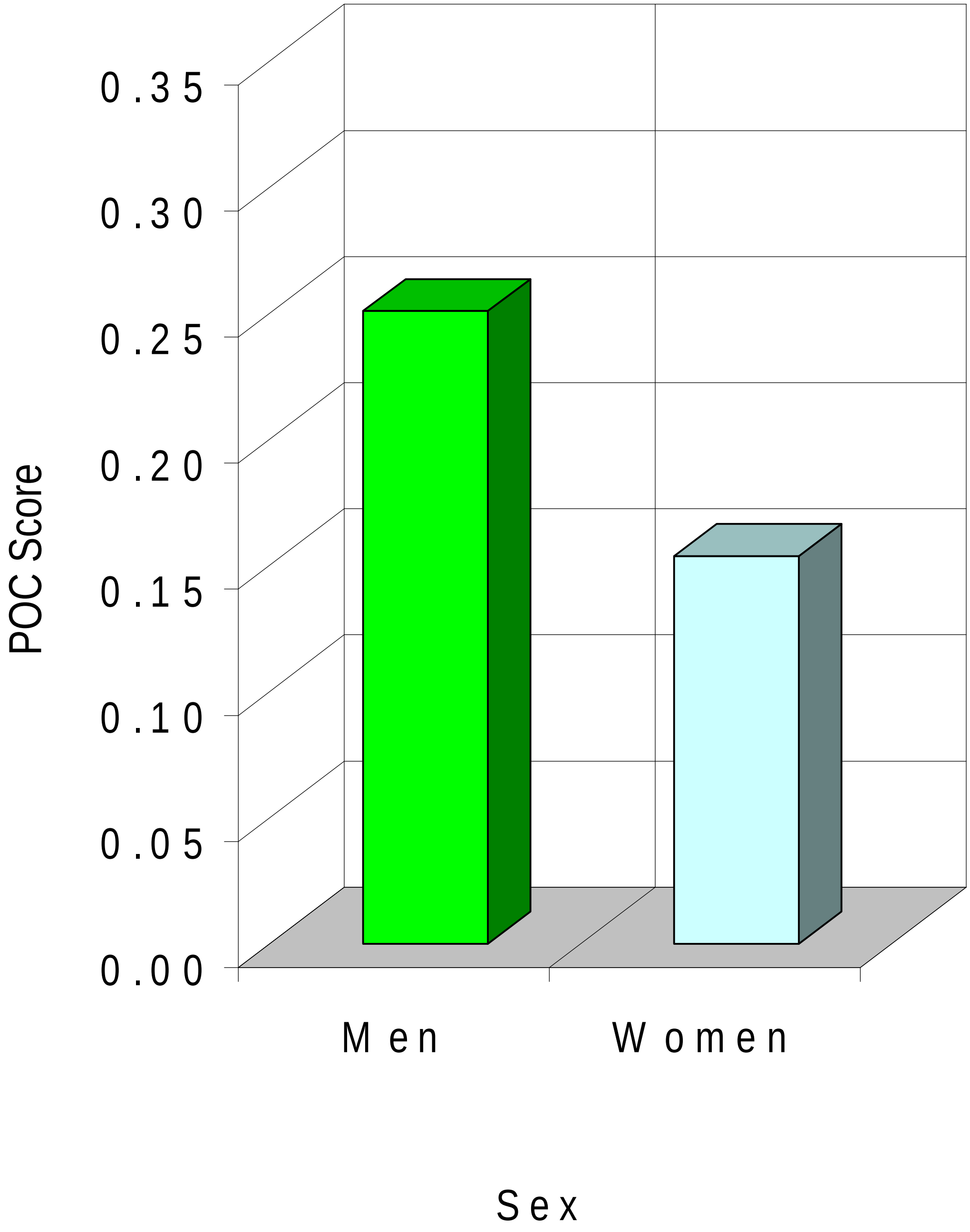


Figure 15. Main Effect of Trial on POC Scores, Using All Groups: No Focus (Control), Focus Left, and Focus Right. The Cold Pressor Enhanced POC Scores, Especially at the Right-Ear.

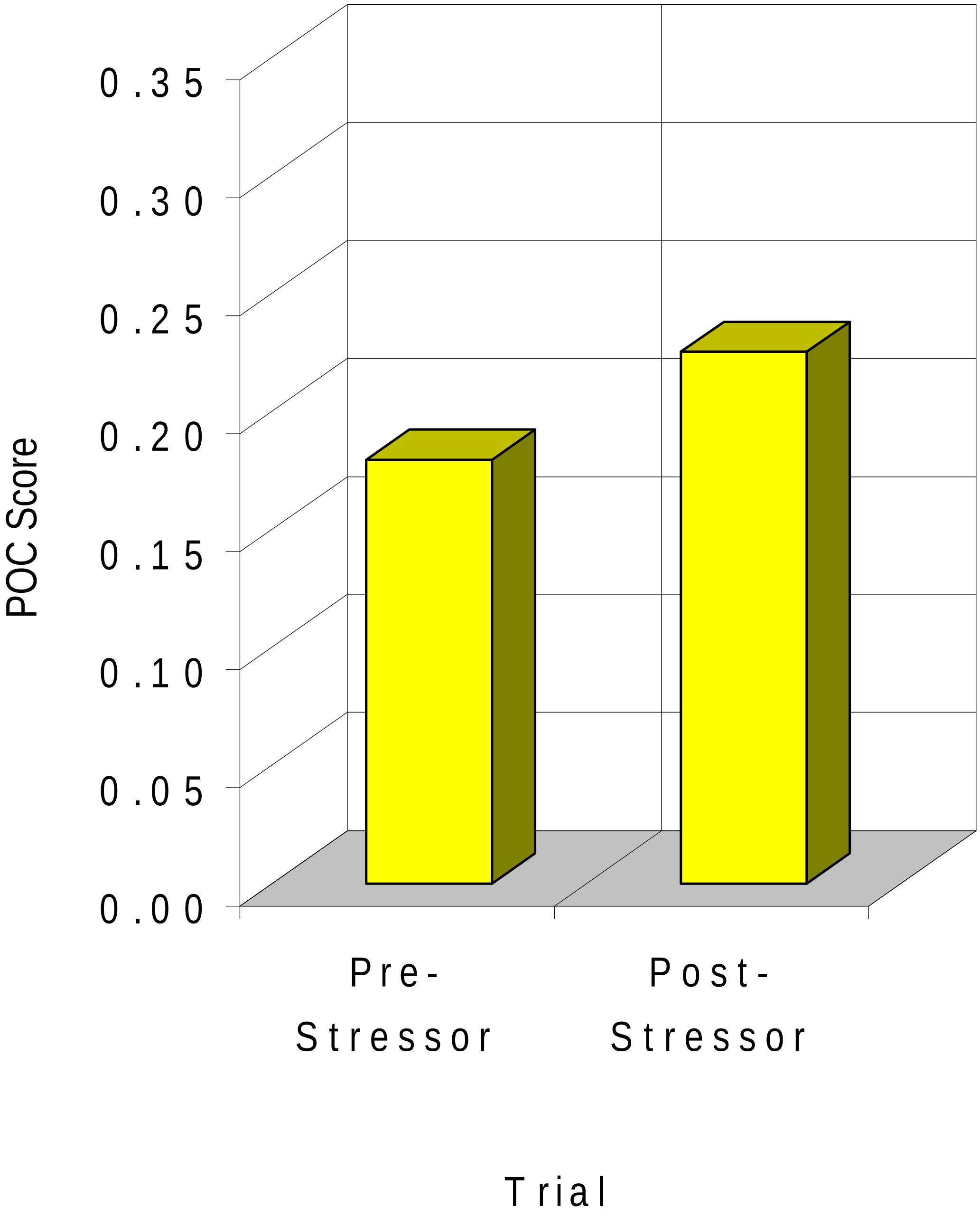


Figure 16. Main Effect of Focus on POC Scores in Women, Using All Groups: No Focus (Control), Focus Left, and Focus Right.

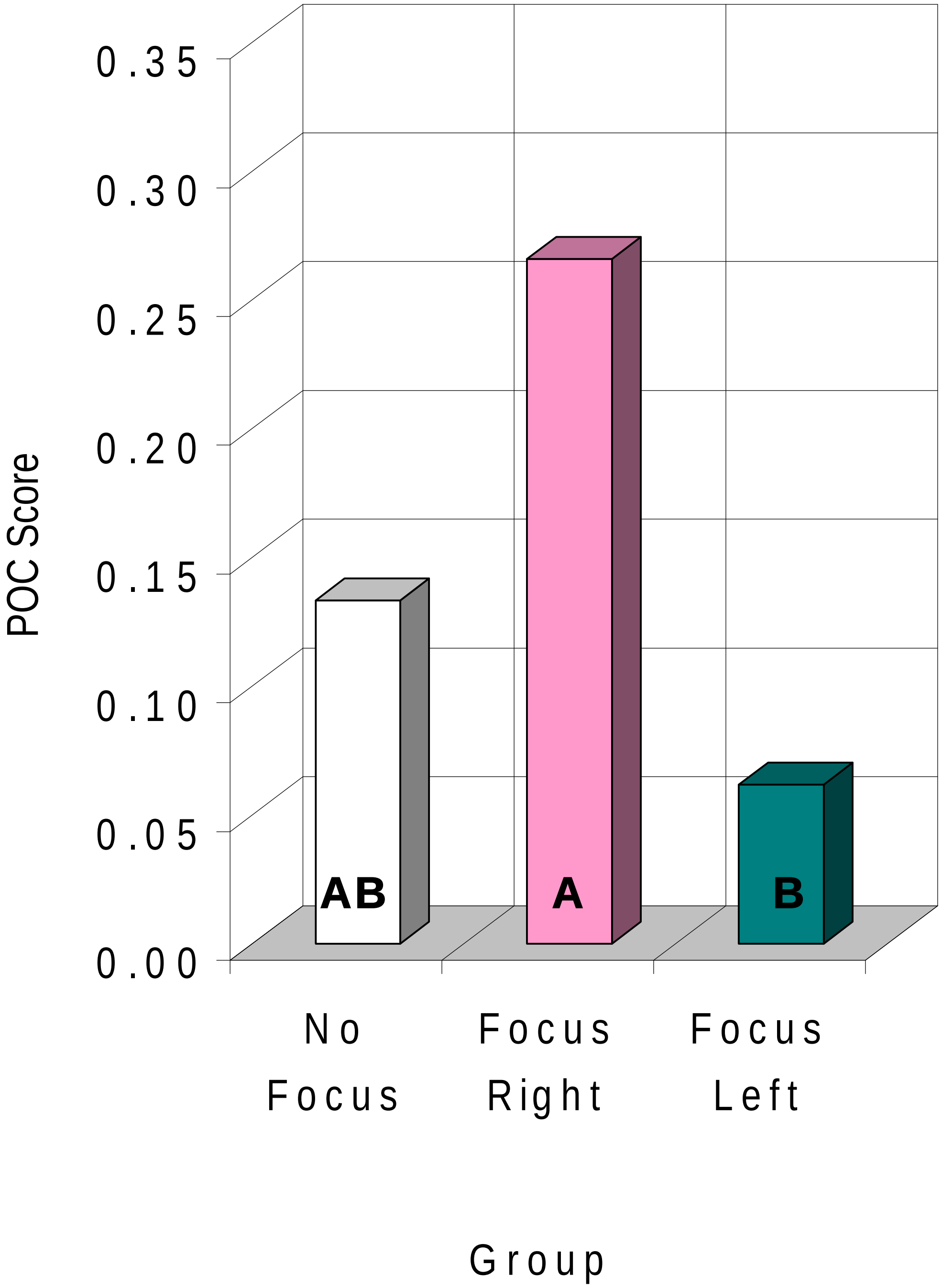
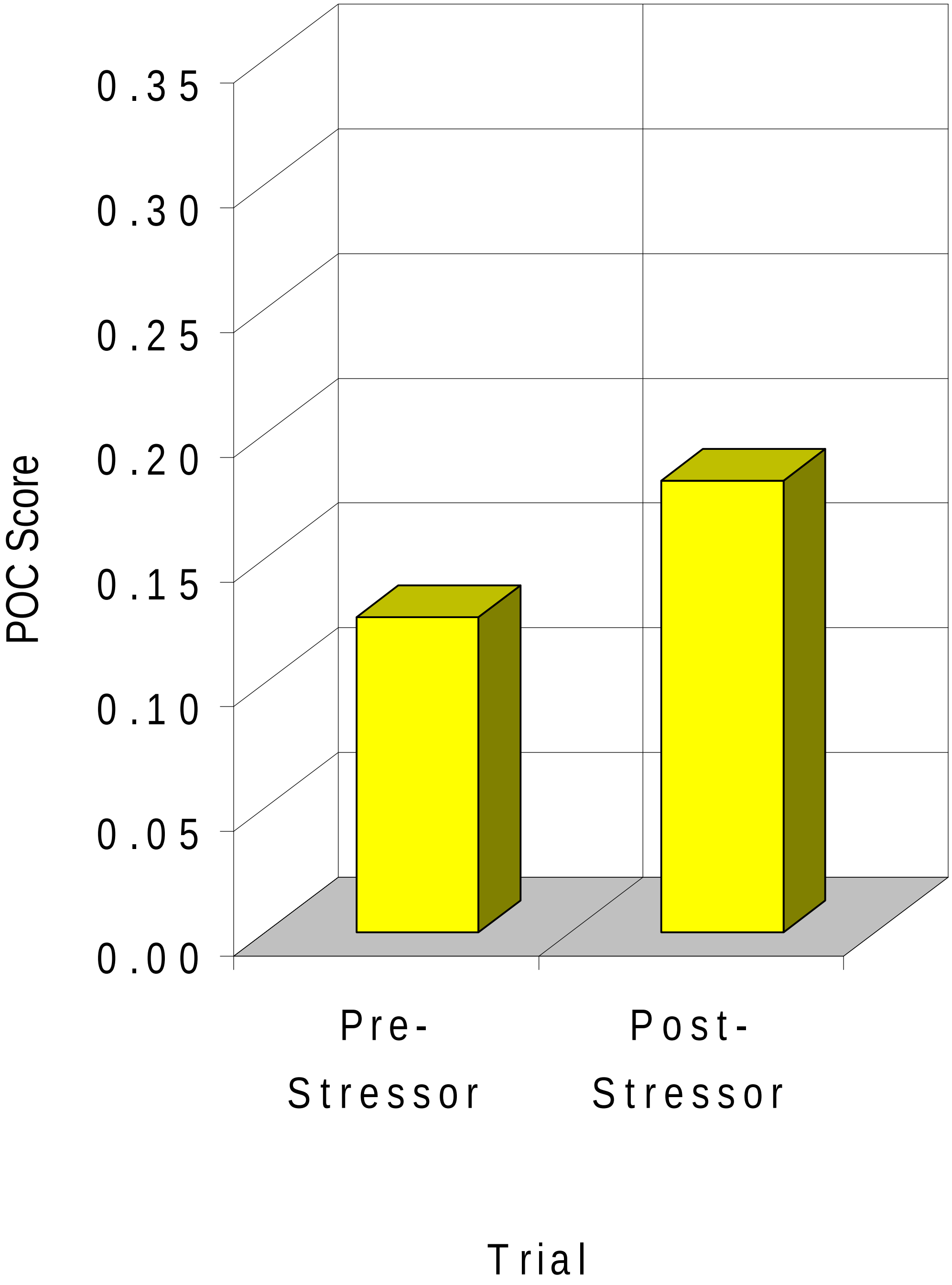


Figure 17. Main Effect of Trial on POC Scores in Women, Using All Groups: No Focus (Control), Focus Left, and Focus Right.



The following results come from statistical analysis design sequence B, described previously. Again, these analyses are refined independent ANOVAs of the POC scores for Focus Left and Focus Right groups only (presented in Table 13). This was done to provide a more accurate comparison of the groups who were asked to focus to the left ear or the right ear.

A main effect of focus on POC scores was found, where the FL and FR groups were able to significantly increase accuracy at the left ear and right ear, according to the focus group to which they were assigned, $\underline{F}$ (1,76) = 4.13, $\underline{p} < 0.0457$ (see Figure 18).

Refined analyses of variance were then performed on the men and on the women of the FL and FR groups in order to assess the contributions of each sex to this main effect (of focus). Results from these refined analyses can be found in Table 14. A main effect of focus on POC scores was found for women only $\underline{F}$ (1,38) = 6.67, $\underline{p} < 0.0138$, (see Figure 19). Thus, the FL and FR men were unable to significantly change their POC scores according to focus group assignment; whereas, the women were able to do so according to the assigned focus ear. It appears that women alone contributed to the main effect of focus on POC scores. If anything, men diminished the main effect of focus, as all of their scores were similar, despite the focus group assignment condition.

Table 13

Refined Independent ANOVA Results for POC Scores (Focus Left and Focus Right Groups only)

Source	DF	SS	MS	F Value	p
POC Scores					
Sex	(1,76)	0.283	0.283	2.16	<0.1454
Focus	(1,76)	0.539	0.539	4.13	<0.0457*
Sex*Focus	(1,76)	0.310	0.310	2.38	<0.1274
Trial	(1,76)	0.077	0.077	3.90	<0.0520
Sex*Trial	(1,76)	0.001	0.001	0.07	<0.7929
Focus*Trial	(1,76)	0.032	0.032	1.64	<0.2048
Sex*Foc*Trial	(1,76)	0.009	0.009	0.48	<0.4918

* $p < .05$

Table 14

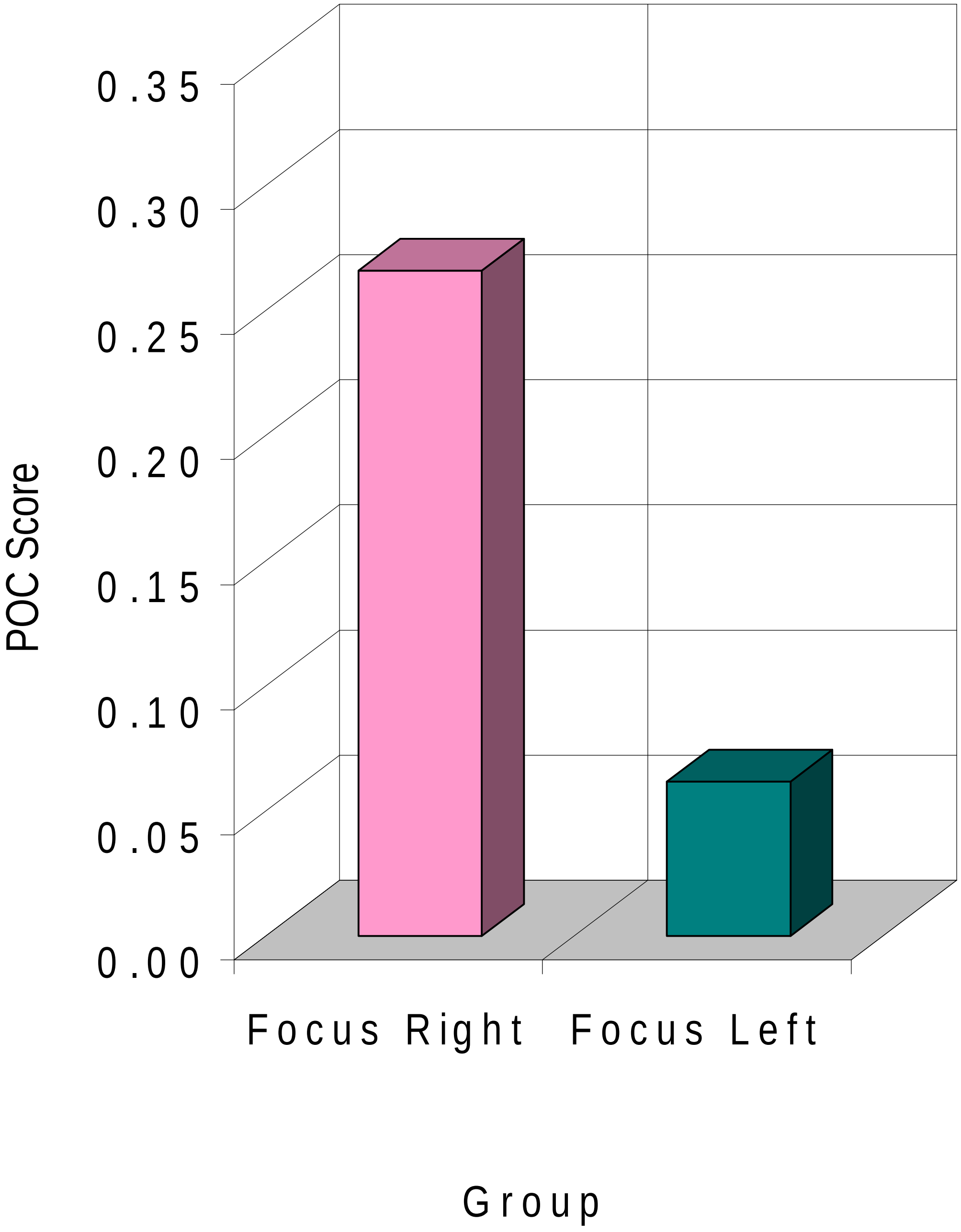
Refined Independent ANOVA Results for POC Scores for Men and for Women (Focus Left and Focus Right Groups only)

Source	DF	SS	MS	F Value	p
POC Scores					
Men					
Focus	(1,38)	0.016	0.016	0.12	<0.7361
Trial	(1,38)	0.029	0.029	1.60	<0.2142
Focus*Trial	(1,38)	0.038	0.038	2.12	<0.1539
Women					
Focus	(1,38)	0.834	0.834	6.67	<0.0138*
Trial	(1,38)	0.050	0.050	2.31	<0.1368
Focus*Trial	(1,38)	0.003	0.003	0.16	<0.6917

* $p < .05$

Figure 18. Main Effect of Focus on POC Scores in Focus Left and Focus Right Groups. Both Men and Women are Included.

Figure 19. Main Effect of Focus on POC Scores in Women (Focus Left and Focus Right Groups Only). Women's Scores Contributed to the Main Effect of Focus in the Groups (previous graph).



The following results are from statistical analysis design sequence C, described previously. Again, these analyses are refined independent ANOVAs of the POC scores for No Focus groups only (presented in Table 15). This was done to provide a control group comparison to the active focus groups.

No interactions or main effects were found for POC scores in the No focus groups. A refined ANOVA of men and of women in the No Focus groups also did not uncover any significant interactions or main effects on POC scores (see Table 16).

Table 15

Refined Independent ANOVA Results for POC Scores (No Focus – Control Groups only)

Source	DF	SS	MS	F Value	p
POC Scores					
Sex	(1,38)	0.303	0.303	2.26	<0.1410
Trial	(1,38)	0.049	0.049	2.25	<0.1419
Sex*Trial	(1,38)	0.005	0.005	0.22	<0.6450

* $p < .05$

Table 16

Refined Independent ANOVA Results for POC Scores for Men and for Women (No Focus – Control Groups only)

Source	DF	SS	MS	F Value	p
POC Scores					
Men					
Trial	(1,19)	0.012	0.012	0.38	<0.5425
Women					
Trial	(1,19)	0.042	0.042	3.18	<0.0904

* $p < .05$

Dichotic Listening

In order to assess dichotic listening ability, POC scores were first computed to view overall trends of ear dominance. Next, the number of correctly identified speech stimuli at each ear were analyzed. This was done to infer cerebral activation patterns and corresponding cardiovascular changes. Recall that data were analyzed in the following three design sequences: A) overall group effects (using all focus groups); B) focus effects on Dichotic Left Ear and Dichotic Right Ear scores (using focus left and focus right groups only); and C) Dichotic Left Ear and Dichotic Right Ear scores in the no focus (control) groups. Further, in each design, refined ANOVAs were performed for each sex.

Group means and standard deviations of the number of correctly identified stimuli at the left ear (Dichotic Left), and number of correctly identified stimuli at the right ear (Dichotic Right) are presented in Table 17.

Results from statistical analysis design A are as follows: Independent analyses of variance (ANOVAs) were performed on the two dependent variables obtained through the dichotic listening task- Dichotic Left and Dichotic Right. The independent ANOVA results are presented in Table 18.

The main effect of sex was significant for Dichotic Left, F (1,114) = 4.25, $p < 0.04$. Women correctly identified speech sound stimuli presented at the left ear significantly more than men (see Figure 20). However, there was also a main effect of sex for Dichotic Right, F (1,114) = 3.84, $p \leq 0.05$. Men were able to identify significantly more stimuli at the right ear than women.

The main effect of trial was significant only at the right ear, F (1,114) = 16.28, $p < 0.0001$. Thus, accuracy in identifying stimuli presented to the right ear significantly increased after the cold pressor (see Figure 22), whereas the cold pressor did not significantly increase left-ear accuracy of speech sounds identification.

Following the stressor, both men and women were able to significantly increase accuracy scores at the right ear. Refined independent analyses of variance (ANOVAs) were performed separately for men and for women. These data are presented in Table 19. The main effect of trial seen at the right ear was significant for both men and women, F (1,57) = 8.19, $p < 0.0059$, and F (1,57) = 8.14, $p < 0.0060$, respectively.

For women, a main effect of focus on Dichotic Left was found, F (2,57) = 3.42, $p < 0.0395$. That is to say, women in the different focus groups were able to shift their focus enough to significantly increase or decrease the number of speech sounds correctly identified at the left ear (see Figure 23). Men were not able to do this, however, as explained previously, this might be partially due to ceiling effects.

Table 17

Means and Standard Deviations of Stimuli Correctly Identified at the Left Ear and at the Right Ear by Sex, Focus Group, and Trial

	Men		Women	
	Mean	SD	Mean	SD
LEFT EAR				
No Focus Group				
Pre-Stressor	8.3	3.7	9.5	2.7
Post-Stressor	7.9	3.0	9.2	3.1
Focus Left Group				
Pre-Stressor	8.0	2.6	10.5	4.2
Post-Stressor	8.6	3.0	10.3	3.8
Focus Right Group				
Pre-Stressor	8.5	3.7	8.2	2.3
Post-Stressor	7.7	2.8	7.8	2.3
RIGHT EAR				
No Focus Group				
Pre-Stressor	14.0	4.8	11.7	3.0
Post-Stressor	14.5	4.9	12.8	3.4
Focus Left Group				
Pre-Stressor	13.1	3.7	11.7	4.9
Post-Stressor	14.5	4.9	12.3	4.8
Focus Right Group				
Pre-Stressor	13.3	3.9	13.1	2.5
Post-Stressor	14.7	3.7	14.3	3.0

Table 18

Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear. All Focus Groups were Included (NO, FL, & FR).

Source	DF	SS	MS	F Value	p
LEFT EAR – Dichotic Left					
Sex	(1,114)	70.42	70.42	4.25	<0.0416*
Focus	(2,114)	66.41	33.20	2.00	<0.1398
Sex*Focus	(2,114)	48.41	24.20	1.46	<0.2367
Trial	(1,114)	3.27	3.27	0.98	<0.3240
Sex*Trial	(1,114)	0.15	0.15	0.05	<0.8323
Focus*Trial	(2,114)	6.61	3.30	0.99	<0.3739
Sex*Foc*Trial	(2,114)	4.38	2.19	0.66	<0.5204
RIGHT EAR – Dichotic Right					
Sex	(1,114)	110.70	110.70	3.84	<0.0525*
Focus	(2,114)	37.98	18.99	0.66	<0.5197
Sex*Focus	(2,114)	35.61	17.80	0.62	<0.5412
Trial	(1,114)	63.038	63.04	16.28	<0.0001**
Sex*Trial	(1,114)	0.20	0.20	0.05	<0.8188
Focus*Trial	(2,114)	1.98	0.99	0.26	<0.7753
Sex*Foc*Trial	(2,114)	4.91	2.45	0.63	<0.5324

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

Table 19

Refined Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear of Men and of Women. Each Sex was Analyzed Separately. Also, all Focus Groups were Included (NO, FL, & FR).

Source	DF	SS	MS	F Value	p
MEN					
Left Ear – Dichotic Left					
Focus	(2,57)	1.07	0.53	0.03	<0.9683
Trial	(1,57)	1.01	1.01	0.30	<0.5890
Focus*Trial	(2,57)	10.87	5.43	1.59	<0.2126
Right Ear – Dichotic Right					
Focus	(2,57)	4.01	2.03	0.06	<0.9408
Trial	(1,57)	35.21	35.21	8.19	<0.0059**
Focus*Trial	(2,57)	4.27	2.13	0.50	<0.6114
WOMEN					
Left Ear – Dichotic Left					
Focus	(2,57)	113.75	56.88	3.42	<0.0395*
Trial	(1,57)	2.41	2.41	0.74	<0.3926
Focus*Trial	(2,57)	0.12	0.06	0.02	<0.9822
Right Ear – Dichotic Right					
Focus	(2,57)	69.52	34.76	1.42	<0.2492
Trial	(1,57)	28.03	28.03	8.14	<0.0060**
Focus*Trial	(2,57)	2.62	1.31	0.38	<0.6857

* $p < .05$
** $p < .01$

Figure 20. Main Effect of Sex on Dichotic Left (all Focus groups: NO, FL, FR).

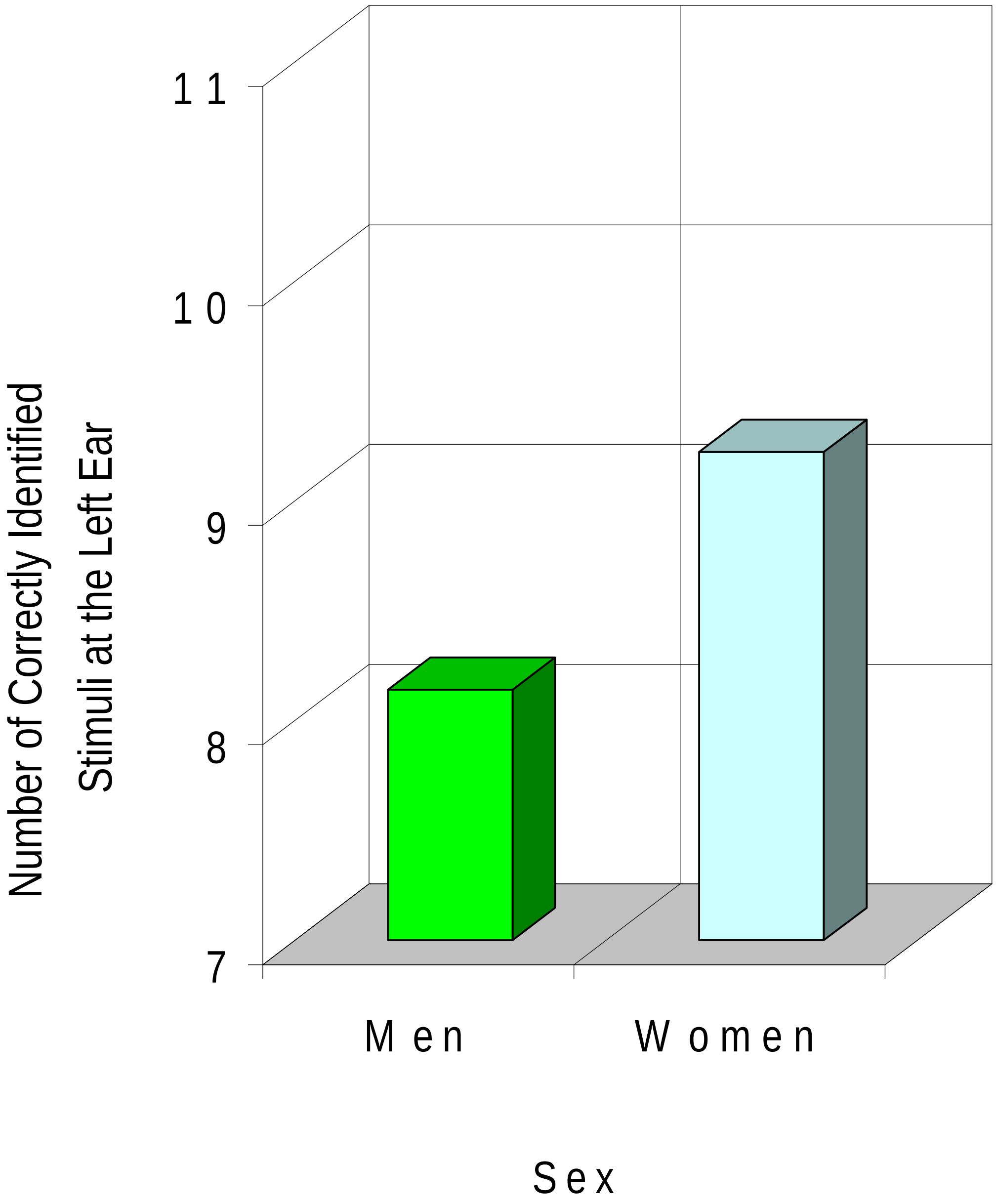


Figure 21. Main Effect of Sex on Dichotic Right (all Focus groups: NO, FL, FR).

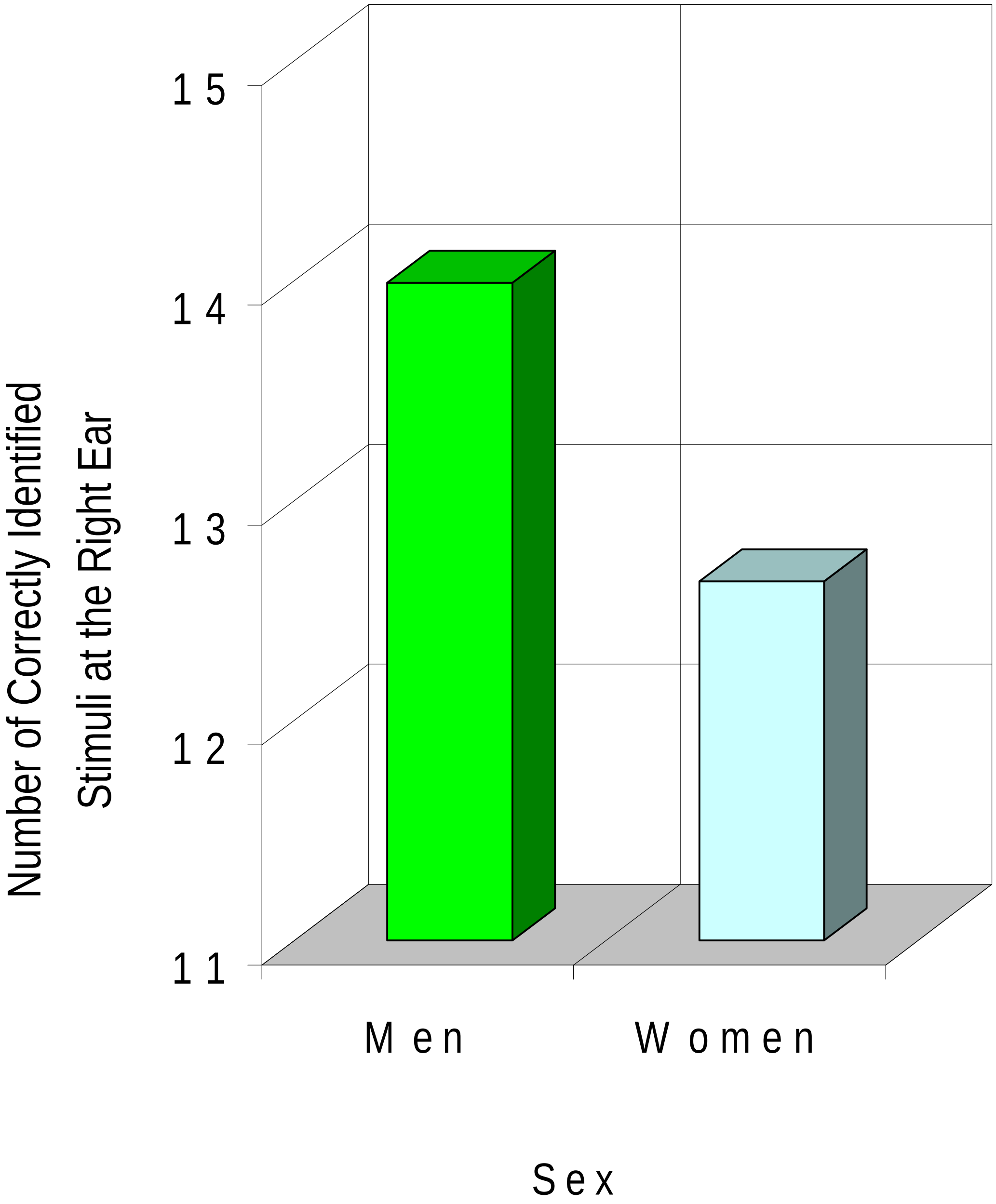


Figure 22. Main Effect of Trial on Dichotic Right (all Focus groups: NO, FL, FR). This effect was not observed at Dichotic Left.

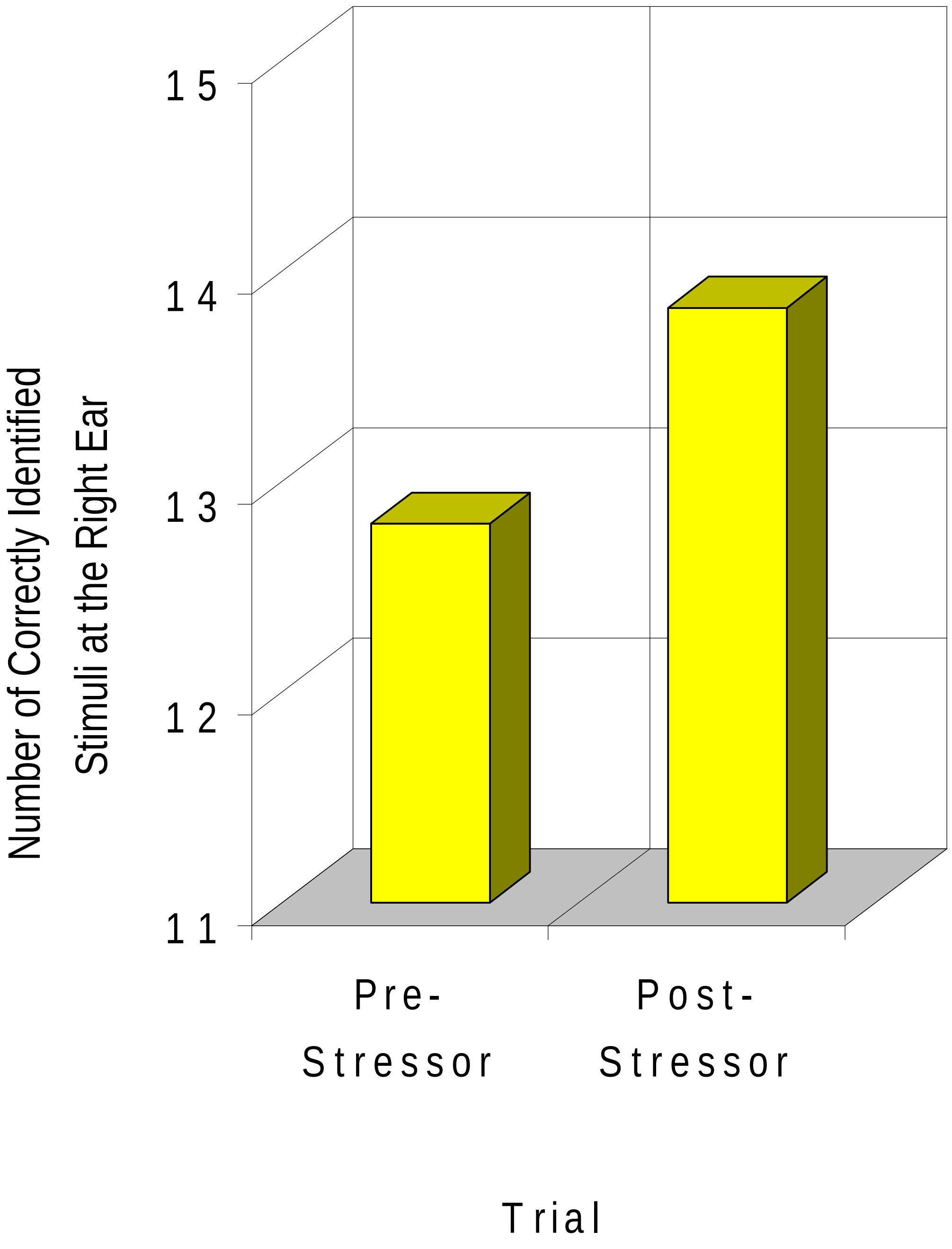
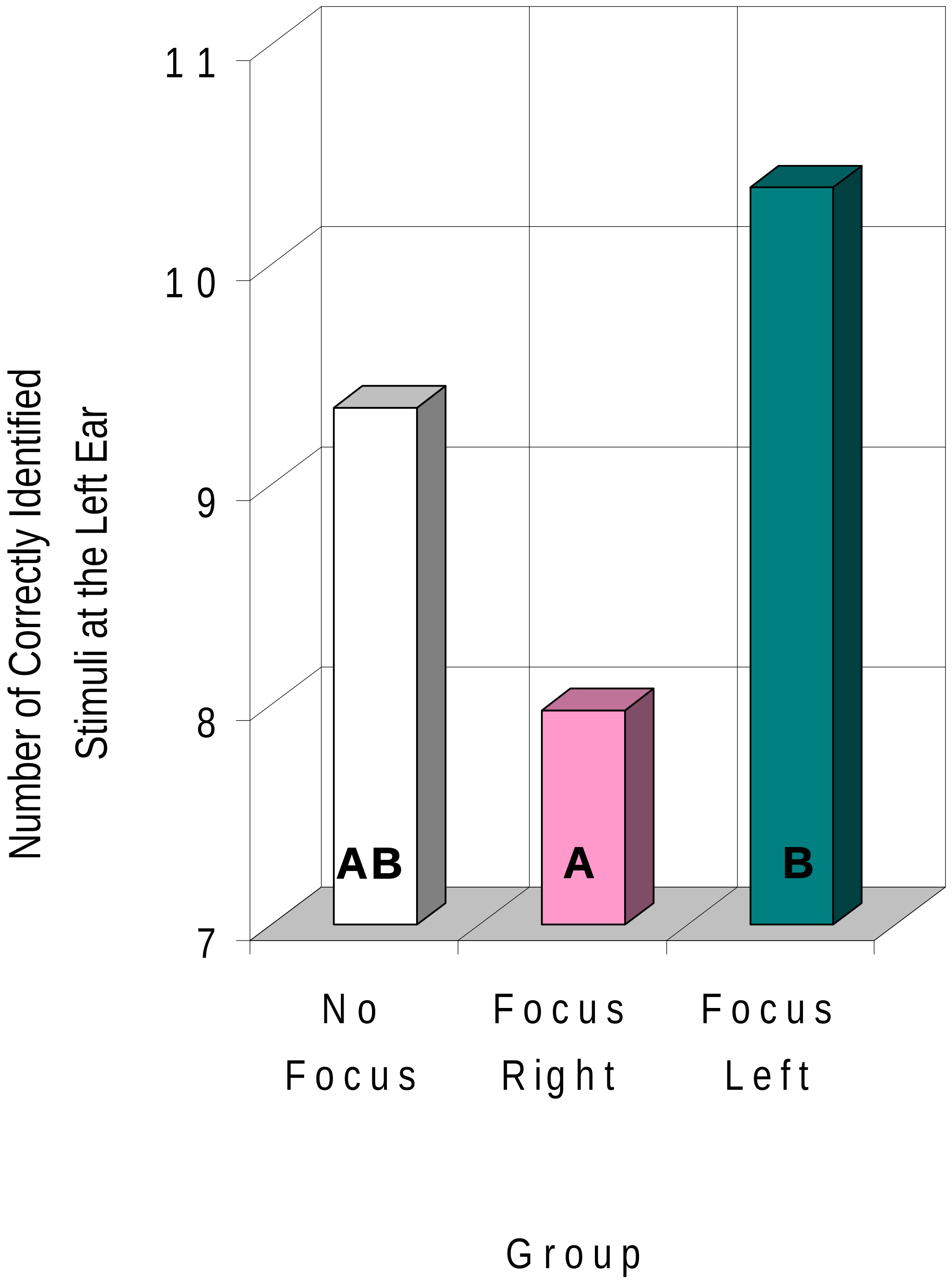


Figure 23. Main Effect of Focus on Dichotic Left Scores for Women (all Focus groups: NO, FL, FR). This effect was not observed at Dichotic Right for Women.



The following results arise from statistical analysis design sequence B, described previously. Again, these analyses are refined independent ANOVAs of the Dichotic Left and Dichotic Right scores for Focus Left and Focus Right groups only (presented in Table 20). This was done to provide a more accurate comparison of the groups who were asked to focus to the left ear or the right ear.

A main effect of focus was found on Dichotic Left, F (1,76) = 4.02, $p < 0.0486$. The number of stimuli correctly identified at the left ear by Focus Left and Focus Right participants was increased as a function of focusing on the specified ear.

Also, a main effect of trial was found on Dichotic Right, F (1,76) = 11.66, $p < 0.0010$. The number of stimuli correctly identified at the right ear by Focus Left and Focus Right participants increased as a function of the cold pressor.

Refined analyses of variance were then performed on the men and on the women of the FL and FR groups in order to assess the contributions of each sex to the main effects. Results from these refined analyses can be found in Table 21. Men evidenced a main effect of trial on Dichotic Right, F (1,38) = 8.17, $p < 0.0069$, where the number of stimuli correctly identified at the right ear by Focus Left and Focus Right men increased as a function of the cold pressor.

A main effect of focus on Dichotic Left was found for women, F (1,38) = 6.50, $p < 0.0149$. Women were able to significantly increase accuracy at the left ear when asked to focus there.

Table 20

Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear. Only FL and FR Groups were Included.

Source	DF	SS	MS	F Value	p
LEFT EAR – Dichotic Left					
Sex	(1,76)	39.01	39.01	2.36	<0.1284
Focus	(1,76)	66.31	66.31	4.02	<0.0486*
Sex*Focus	(1,76)	47.31	47.31	2.87	<0.0945
Trial	(1,76)	1.06	1.06	0.30	<0.5851
Sex*Trial	(1,76)	0.51	0.51	0.14	<0.7053
Focus*Trial	(1,76)	6.01	6.01	1.71	<0.1950
Sex*Foc*Trial	(1,76)	3.91	3.91	1.11	<0.2950
RIGHT EAR – Dichotic Right					
Sex	(1,76)	43.06	43.06	1.53	<0.2193
Focus	(1,76)	37.06	37.06	1.32	<0.2541
Sex*Focus	(1,76)	23.26	23.26	0.83	<0.3655
Trial	(1,76)	49.51	49.51	11.66	<0.0010**
Sex*Trial	(1,76)	2.26	2.26	0.53	<0.4682
Focus*Trial	(1,76)	1.06	1.06	0.25	<0.6193
Sex*Foc*Trial	(1,76)	1.06	1.06	0.25	<0.6193

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

Table 21

Refined Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear of Men and of Women. Each Sex was Analyzed Separately. Only FL and FR Groups were Included.

Source	DF	SS	MS	F Value	p
MEN					
Left Ear – Dichotic Left					
Focus	(1,38)	0.80	0.80	0.05	<0.8223
Trial	(1,38)	0.05	0.05	0.02	<0.8989
Focus*Trial	(1,38)	9.80	9.80	3.21	<0.0813
Right Ear – Dichotic Right					
Focus	(1,38)	0.80	0.80	0.03	<0.8685
Trial	(1,38)	36.45	36.45	8.17	<0.0069**
Focus*Trial	(1,38)	0.00	0.00	0.00	<1.0000
WOMEN					
Left Ear – Dichotic Left					
Focus	(1,38)	112.81	112.81	6.50	<0.0149*
Trial	(1,38)	1.51	1.51	0.38	<0.5408
Focus*Trial	(1,38)	0.11	0.11	0.03	<0.8672
Right Ear – Dichotic Right					
Focus	(1,38)	59.51	59.51	2.18	<0.1483
Trial	(1,38)	15.31	15.31	3.80	<0.0586
Focus*Trial	(1,38)	2.11	2.11	0.52	<0.4734

* $p < .05$
** $p < .01$

The following results follow statistical analysis design sequence C, described previously. Again, these analyses are refined independent ANOVAs of the Dichotic Left and Dichotic Right scores for No Focus (Control) groups only (presented in Table 22). This was done to provide a control group comparison to the active focus groups.

A main effect of trial on the number of correct stimuli identified at the right ear (Dichotic Right) was found for the No Focus groups, F (1,38) = 4.62, p < 0.0380. Thus, even in the No Focus groups, accuracy at the right ear, but not the left ear, increased as a function of the cold pressor (M = 12.8 to M = 13.7).

Refined ANOVAs of men and of women in the No Focus groups revealed a significant main effect of trial on Dichotic Right scores for women only, F (1,19) = 5.81, p < 0.0263 (see Table 23).

As heretofore stated, this might be partially due to ceiling effects, as men's Dichotic Right scores increased from M = 14.0 to M = 14.5 following the cold pressor (trial 1 to trial 2, an increase of 0.5), while women's Dichotic Right scores increased from M = 11.7 to M = 12.8 following the cold pressor (trial 1 to trial 2, an increase of 1.1).

Table 22

Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear. Only No Focus (Control) Groups were Included.

Source	DF	SS	MS	F Value	p
LEFT EAR – Dichotic Left					
Sex	(1,38)	32.51	32.51	1.94	<0.1716
Trial	(1,38)	2.81	2.81	0.95	<0.3360
Sex*Trial	(1,38)	0.11	0.11	0.04	<0.8465
RIGHT EAR – Dichotic Right					
Sex	(1,38)	80.00	80.00	2.63	<0.1130
Trial	(1,38)	14.45	14.45	4.62	<0.0380*
Sex*Trial	(1,38)	1.80	1.80	0.58	<0.4526

* p < .05
** p < .01

Table 23

Refined Independent ANOVA Results for the Number of Correctly Identified Syllables Presented to the Left and Right Ear of Men and of Women. Each Sex was Analyzed Separately. Only No Focus (Control) Groups were Included.

Source	DF	SS	MS	F Value	p
MEN					
Left Ear – Dichotic Left					
Trial	(1,19)	2.03	2.03	0.49	<0.4923
Right Ear – Dichotic Right					
Trial	(1,19)	3.03	3.03	0.76	<0.3938
WOMEN					
Left Ear – Dichotic Left					
Trial	(1,19)	0.90	0.90	0.50	<0.4875
Right Ear – Dichotic Right					
Trial	(1,19)	13.23	13.23	5.81	<0.0263*

* $p < .05$
** $p < .01$

Self Report Scales

At the end of the experiment, participants rated the level of stress and pain that they experienced from the cold-pressor. The scale was a 7 point scale, where 1 = not stressful at all, 4 = moderately stressful, and 7 = extremely stressful (see Appendix I). The scores were analyzed using t-tests to assess group differences between men and women. No significant sex differences in stress scores were found, as men's self-reported stress scores ($M = 4.0$, $SD = 1.6$) were slightly lower than women's ($M = 4.5$, $SD = 1.6$), $T(118) = -1.65$, $p < .10$. No significant sex differences in pain scores were found either, with men reporting pain scores ($M = 4.5$, $SD = 1.3$) slightly lower than women ($M = 4.8$, $SD = 1.3$), $T(118) = -1.02$, $p < .31$.

However, in order to assess how hostility may play a role in the experience of stress and/or pain perception, refined independent analyses of variance (ANOVAs) were performed on the CMHO, stress, and pain scores. It is interesting to note that a sex by group interaction effect on stress perception was found between level of hostility (high vs. low) and the self-reported perception of stress for each sex. That is to say, high-hostile men reported experiencing significantly less stress than high-hostile women (Table 24, $F(1,40) = 5.18$, $p < 0.0283$; Figure 24). A trend toward a sex by group interaction effect on pain perception was also found between level of hostility (high vs. low) and the self-reported perception of pain for each sex. That is to say, high-hostile men reported experiencing less pain than high-hostile women (Table 25, $F(1,40) = 3.14$, $p < 0.0839$; Appendix L).

Fillingim and Maixner (1996) discussed the effects of blood pressure on pain perception, with an exploration of sex differences in these factors. They postulated that increased blood pressure correlates with decreased pain perception. As high-hostiles have consistently shown increased blood pressure levels compared to low-hostiles, and men have shown higher blood pressure levels than women (and parallel cardiovascular disease increases), it seems reasonable that the high-hostile men would report the lowest stress and pain levels. Further, this seems like a logical extension of previous findings and an interesting platform for future study.

Table 24

Means and Standard Deviations of Stress and Pain Scores by Sex and Hostility Group

	Men		**Women**	
	Mean	SD	Mean	SD
Stress Scores				
Low Hostile Group	4.0	1.4	3.9	1.5
High Hostile Group	3.1	1.7	5.4	1.3
Pain Scores				
Low Hostile Group	4.5	0.5	4.2	1.5
High Hostile Group	4.2	1.5	5.4	0.9

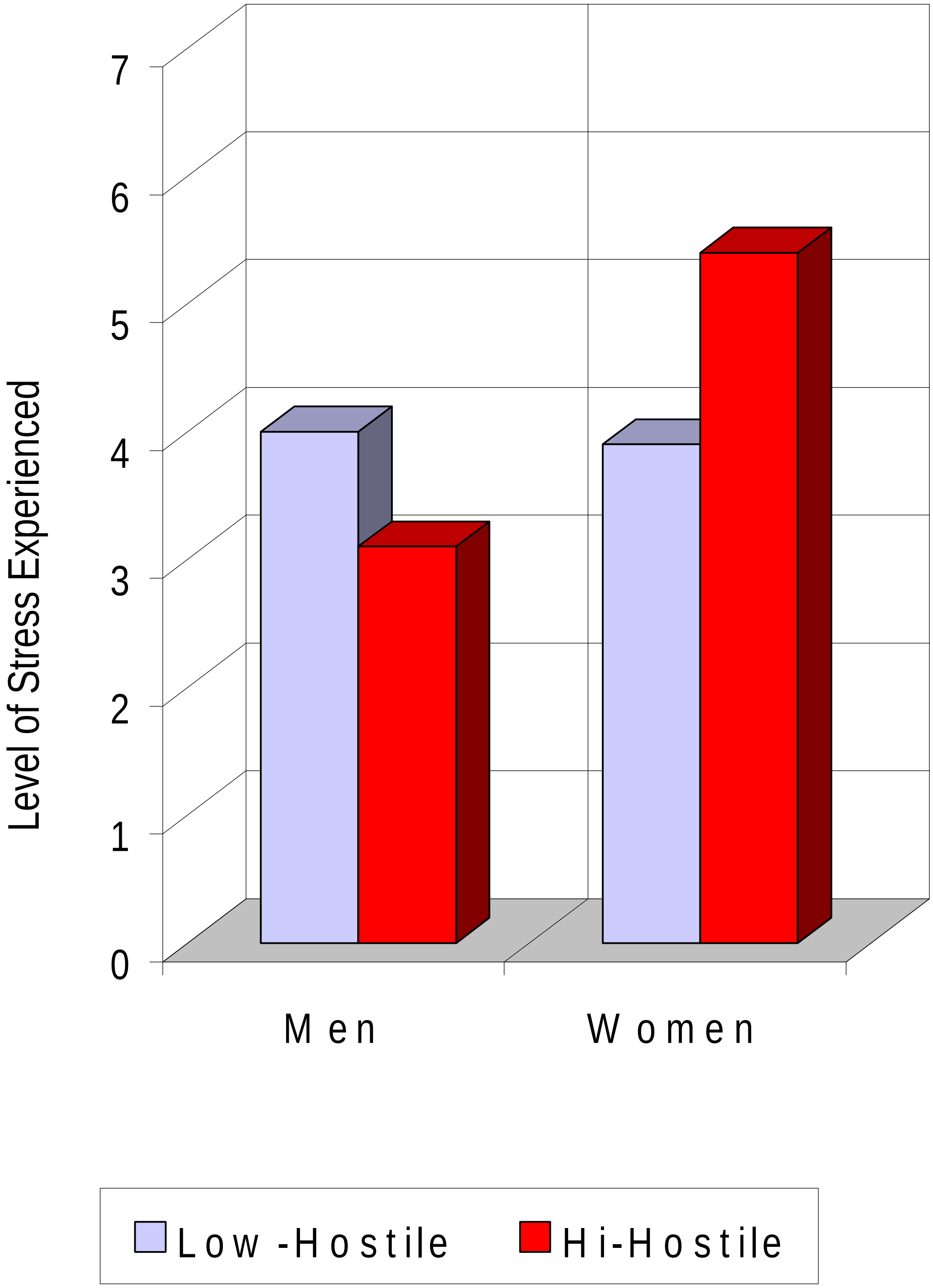
Table 25

Refined Independent ANOVA Results for the Stress and Pain Scores for Low and High Hostile Groups

Source	DF	SS	MS	F Value	p
Stress Scores					
Sex	(1,40)	5.35	5.35	2.25	<0.1415
Group	(1,40)	0.10	0.10	0.04	<0.8412
Sex*Group	(1,40)	12.31	12.31	5.18	<0.0283*
Pain Scores					
Sex	(1,40)	0.13	0.13	0.08	<0.7828
Group	(1,40)	0.83	0.83	0.50	<0.4839
Sex*Group	(1,40)	5.22	5.22	3.14	<0.0839

* $p < .05$
** $p < .01$

Figure 24. Refined Analysis of High and Low-Hostile Groups (regardless of Focus). The Interaction Effect of Sex by Group on Stress Perceived from the Cold Pressor.



Discussion

The primary finding of this research is that measures reflecting cerebral asymmetry differ between men and women. The men who focused left during the experiment experienced a significant increase in systolic blood pressure compared to the women who focused left. Further, this increase was not seen in men or women who focused right or who were in the no focus groups. Thus, the theory that cerebral (a)symmetry differs for men and women was supported. Further, men showed more systolic blood pressure reactivity, and high blood pressure has been shown to be a risk factor centrally involved in the causation of atherosclerotic disease and its multiple clinical manifestations, especially coronary heart disease (Stamler, 1992).

The second major finding of this study is that arousal is a compartmentalized phenomenon, as increased asymmetry facilitated compartmentalization of behavior for specialization of cerebral regions' performance under stress. After the cold pressor task, rather than seeing a generalized arousal pattern where both hemispheres were affected equally, a dynamic, selective arousal pattern was evidenced where brain areas in the processing of speech were affected differently than homologous areas in the right hemisphere. Accuracy significantly increased at the right, but not left, ear after the cold-pressor in both men and women. That is to say, the right ear advantage for speech perception was significantly enhanced, while the left ear did not evidence a similar increased accuracy. Cerebral activation was not necessarily a global phenomenon responding to an arousal mechanism, but a specific response according to discrete stimuli.

The construct of functional cerebral space in the field of neuropsychology was supported by this research. In essence, this model postulates enhancement or interference of one activity by virtue of a concurrent activity (Filimonov, 1940; Kinsbourne & Cook, 1971; Kinsbourne, 1978). For example, in this experiment, the dichotic listening task interfered with blood pressure regulation in men who were asked to focus left. By focusing left, the men activated their right cerebrum relatively more than their left cerebrum, which may have interfered with blood pressure regulation. As cerebral areas competed for resources, dysregulation occurred. Kinsbourne (1982) explained that diffuse interconnections exist between functionally specialized areas of the cerebrum and differences in the degree of connection define a "functional cerebral space." This research would suggest that men have more functionally specialized areas in the brain, and that one consequence of increased specialization is a greater risk of cerebral system dysregulation when neighboring systems are activated.

A third implication of this study's findings is that it replicated previous research concerning cardiovascular health risks with emotional states. Findings from this study support previous indications of more lateralized cerebral functions in men; however, this study attempts to extend lateralized function of language abilities and emotional regulation in men to more lateralized function of cardiovascular regulation as well. Support for differences in cerebral (a)symmetry in men and women was found in the present study for both dichotic listening ability and blood pressure regulation. Future studies of sex differences in cerebral asymmetry might consider the possibility that cardiovascular regulation may be functionally different in each sex, that men seem to exhibit more functional asymmetry in blood pressure regulation compared to women. This difference might play a role in the different rates of cardiovascular disease in men and women.

Data from this study also suggest that women were able to identify significantly more dichotic sounds at the left ear than men, which suggests that women have more functional symmetry for verbal processing, compared to men (see also Shaywitz et al., 1995). That is to say, women seem to have more language processing ability in the right hemisphere than men. Women were also able to focus on dichotic sounds at the left or right ear, significantly increasing accuracy at either ear. Men were unable to dynamically change their accuracy of dichotic sound identification as a function of focusing their intention to the respective ear location. Overall, men identified the dichotic sounds presented primarily to the right ear. The right ear advantage for speech processing in men was prevalent across focus groups (see Appendix K), this underscored previous research suggesting more functional asymmetry for language in men, relative to women (see studies previously listed).

Sex differences in verbal abilities appear to be related to language lateralization in the brain. Nearly all men and women have a left hemisphere dominance for language, however, this lateralized specialization is greater in men than in women (Hines, 1990). With increased lateralization comes a decreased ability to perform multiple tasks that tap proximal brain areas. Such is the case with cardiovascular regulation and speech processing, as men were less accurate at the left ear than women, and at the same time, men experienced more cardiovascular reactivity than women, which reactivity may contribute to increased rates of CVD and CHD (Krantz & Raisen, 1988) in men.

The dichotic listening test was used to assess cerebral activation as a function of sex, prior to a stressor (the cold pressor) and following the stressor. Physiological variables (systolic blood pressure, diastolic blood pressure, and heart rate) were also measured. A major focus of the experiment was to find whether there were sex differences in dichotic listening test performance in response to a stressor. By analyzing dynamic changes in dichotic listening test performance to a stressor, it was possible to imply brain area activity augmented by the stressor. However, the focus of the research extends beyond dichotic listening test performance. Rather, the more global purpose of the experiment was to consider the implications of changing functional brain systems according to various experimental conditions. Sex differences in physiological reactivity to a cold pressor were analyzed, and the conventional increased cardiovascular disease risk among men, relative to women, was found in the pattern of cardiovascular responding. Systolic blood pressure was significantly higher in men than in women. Nevertheless, women evidenced significantly higher diastolic blood pressure than men in this experiment.

Diastolic blood pressure measures peripheral resistance, a function of neural innervation of the arterial walls via the peripheral nervous system. In contrast, systolic blood pressure has been associated with beta adrenergic responsivity of the heart, devoid of neural innervation of this structure. The only innervation of the heart is the vagus nerve with cholinergic, rather than adrenergic properties. Therefore, systolic blood pressure responsivity may relate more directly to neural humoral systems with frontal lobe interactions with the adrenal gland through the pituitary axis. This latter system is a global response to a stressor which persists indefinitely, whereas heightened specificity of the response through direct neural innervation may be regulating diastolic blood pressure.

Systolic and diastolic pressures are differentially related to heart and peripheral circulatory variables. Systolic blood pressure is influenced by stroke volume and heart rate and it is modulated by arterial distensibility (Steptoe, 1980); it is the measurement of the force of blood passing through the left brachial artery during ventricular contraction (Tortora & Anagnostakos, 1990). However, diastolic blood pressure is related to the rate and time involved for blood to flow out of the arterial tree, as well as peripheral resistance (Steptoe, 1980); it is the measurement of the force of blood passing through the left brachial artery during ventricular relaxation (Tortora & Anagnostakos, 1990). As such, systolic blood pressure provides information about the force of left ventricular contraction, while diastolic blood pressure provides information about the resistance level of the left brachial artery; diastolic blood pressure can be seen as a measure of physiological resistance (Snyder, Harrison, & Shenal, 1998; Tortora & Anagnostakos, 1990). Neural mechanisms involved in differential levels of systolic blood pressure and diastolic blood pressure should be considered with other risk factors (Guyton, Coleman, & Granger, 1972). Further, systolic blood pressure and diastolic blood pressure regulation mediated by adrenal-medullary and parasympathetic systems cannot be viewed as orthogonal systems, but rather as complementary, coacting systems.

A history of increased cardiovascular reactivity to stress has been shown in men, primarily measured through systolic blood pressure. However, as sex differences continue to be explored, future research should include measures of diastolic blood pressure and systolic blood pressure, given the findings and corresponding implications of this experiment (see also Lawler, Wilcox, & Anderson, 1995). Otherwise, sex differences in cardiovascular reactivity may be partial to men or women if considering only systolic blood pressure or diastolic blood pressure. A more detailed psychophysiological analysis of SBP versus DBP is encouraged.

Physiological reactivity was also analyzed in response to the dichotic listening task. For this, men, but not women, experienced a significant decrease in systolic blood pressure following the first dichotic listening test. This suggests that men’s regulation over parasympathetic activity may be more asymmetrically organized than women’s. It also suggests that activation of the left hemisphere in men may increase regulation of the parasympathetic control of the heart, and that diastolic blood pressure increases may be parasympathetically-mediated.

Further, for both sexes, the focus right groups experienced the lowest diastolic blood pressure, and for men only, the focus right group experienced the lowest systolic blood pressure. Finally, heart rate decreased significantly following the cold pressor for women only. There were no sex differences in self-reported levels of stress or pain experienced from the cold pressor.

Intention or focus of the participants had a significant impact on both cardiovascular reactivity and dichotic listening measures. This replicates previous research with similar focus effects. Hagopian and Harrison (1994) researched dichotic listening abilities in reading disabled and non-reading disabled children. They found that reading disabled children were not able to significantly decrease their right ear advantage (as reflected in positive POC scores) when asked to focus left, whereas, non-reading disabled children were able to significantly decrease their right ear advantage when asked to focus left. Similarly, a study of younger (mean age = 20 years) and older (mean age = 72 years) women revealed that younger women did not have difficulty switching their intention between left and right focus, measured through accuracy at each ear, whereas, older women had difficulty shifting their intention to the left but not right ear (Alden, Harrison, Snyder, & Everhart, 1997).

Dynamic laterality can also be enhanced or diminished by the amount of stress experienced by research participants in a pseudo-social interaction, such as this experiment. This stress may account for some of the effects measured, with differential sex effects. An integration of the above research would suggest that men's right cerebrum has been differentially implicated in the manifestation of negative emotions and cardiovascular reactivity. Thus, being more lateralized, or asymmetrically organized, may contribute to increased cardiovascular disease in men, as proximal neural systems are taxed by multiple demands (i.e., the right hemisphere by emotional processing, speech processing, and cardiovascular sympathetic regulation), therefore, neural system dysfunction becomes more likely. Future research should evaluate the role that hostility plays in the incidence of cardiovascular disease as a function of the neuropsychology of sex differences.

Sex differences in cardiovascular reactivity and functional cerebral activation patterns may contribute to the differing incidence of coronary heart disease in men and women. The emerging perspective of dynamic functional cerebral laterality can be examined when considering these results. The results replicate previous findings of decrements in blood pressure through left cerebral activation (speech processing) and contribute to the literature on sex differences in functional cerebral laterality. Further, decreased functional laterality for speech among women yields differences in the impact of speech processing on cardiovascular measures. Moreover, the results may be found relevant in emotional processing or therapy research (e.g., cognitive therapies) where speech processing may differentially impart emotional processing systems (Crews & Harrison, 1995) as evidenced here in blood pressure indices.

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Appendix A

Informed Consent For Participants Of Investigative Projects

Title of the Project: Sex Differences in Cardiovascular Reactivity in Response to a Stressor:
Evidence for Dynamic Functional Cerebral Laterality.
Dane A. Higgins. Experiment Number: 98-151

I. THE PURPOSE OF EXPERIMENT

You are invited to participate in a study to obtain data on measures purportedly associated with stress.

II. PROCEDURES TO BE FOLLOWED IN THE STUDY

To accomplish the goals of this study, you will be asked to complete four questionnaires. Later, you may be called by telephone and asked to participate further in this research.

III. DISCOMFORTS AND RISKS THROUGH PARTICIPATION IN THE STUDY

You may feel some embarrassment when answering the questionnaires. You may omit any questions that you feel are embarrassing. If you continue to have any problems associated with this study after you have left the experiment, please call Dr. David W. Harrison at 231-4422 so that he may assist you directly or direct you to other appropriate, available services.

IV. BENEFITS OF THIS PROJECT

Your participation in the project may help determine scores that identify the functions of certain neuropsychological sex differences and the potential cardiovascular benefits of differential coping mechanisms associated stress. However, no specific guarantee of benefits has been made to encourage you to participate.

V. ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF RESULTS

Identifying information will be kept strictly confidential. At no time will the researchers release your personal information from the study to anyone other than individuals associated with the project without your written consent. The information you provide will have your name removed and only a participant number will identify you during subsequent analyses and written reports of this research.

VI. EXTRA CREDIT COMPENSATION

For participation in this study, you will receive one point extra credit for Psychology 2004 or the psychology class for which you are attempting to earn one point of extra credit.

VII. FREEDOM TO WITHDRAW

You are free to withdraw from this study at any time without penalty. If you choose to withdraw, you will not be penalized by reduction in points or grade for Psychology 2004 or the psychology class for which you are attempting to earn extra credit. There are alternative choices for receiving extra credit for the course evaluation.

VIII. USE OF RESEARCH DATA

The information from this research may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published and reproduced in professional journals, books, or used for any other purpose that the Psychology Department at Virginia Tech considers in the proper interest of education, knowledge, or research.

IX. APPROVAL OF RESEARCH

This project has been approved by the Human Subjects Committee of the Department of Psychology and by the Institutional Review Board of Virginia Tech.

X. PARTICIPANT'S RESPONSIBILITIES

I voluntarily agree to participate in this study. I agree to disclose if I have a history of any of the following medical conditions: history of a severe head injury, stroke, epilepsy, seizures, paralysis, neurological surgery, other neurological or nervous system problems, Reynaud's syndrome, extreme sensitivity to cold temperatures, asthma, arthritis, or psoriasis.

XI. PARTICIPANT'S PERMISSION

I have read and understand the above description of the study. I have had an opportunity to ask questions and have had them all answered to my satisfaction. I hereby acknowledge the above and give my voluntary consent for participation in this study. I also understand that I may withdraw from participation at any time without penalty.

____

Participant's Signature Date Telephone Number Participant #

Should I have any questions regarding this research and its conduct, I should contact any of the persons named below:

Dane A. Higgins Primary Researcher	552-6065 dane@vt.edu
David W. Harrison, Ph.D. Faculty Advisor	231-4422 dwh@vt.edu
Robert J. Harvey, Ph.D. Chair, HSC	231-7001 harveyrj@vtvm1.cc.vt.edu
H. T. Hurd Chair, IRB	231-5281 Hurd@vt.edu

Appendix B

Head Injury / Medical History Inventory (HIMHI)

Name:______________________________ Student I.D.#:____________________

Please circle items which you have been diagnosed with / experienced in the past or in the present. Please explain any “Yes” responses below.

1.	Severe head trauma or injury	Yes	No
2.	Stroke	Yes	No
3.	Learning disabilities (problems with reading, writing, or comprehension)	Yes	No
4.	Epilepsy or seizures	Yes	No
5.	Paralysis	Yes	No
6.	Neurological surgery	Yes	No
7.	Other neurological or nervous system problems	Yes	No
8.	Alcohol or drug problems	Yes	No
9.	Are you using alcohol or drugs (other than for prescribed purposes) at present?	Yes	No
10.	Past psychological / psychiatric problems	Yes	No
11.	Are you currently taking any prescription medications?	Yes	No
12.	Are you currently suffering from any medical conditions or illnesses?	Yes	No
13.	Reynaud’s Syndrome	Yes	No
14.	Head or lung problems	Yes	No
15.	Do you experience extreme sensitivity to cold temperatures?	Yes	No
16.	Asthma	Yes	No
17.	Arthritis	Yes	No
18.	Psoriasis	Yes	No

*Please explain “Yes” responses:*____

____

Appendix C

Coren, Porac, and Duncan (CPD) Laterality Questionnaire

Circle the appropriate number after each item:	Right	Left	Both
With which hand would you throw a ball to hit a target?	1	-1	0
With which hand do you draw?	1	-1	0
With which hand do you use an eraser on paper?	1	-1	0
With which hand do you remove the top card when dealing?	1	-1	0
With which foot do you kick a ball?	1	-1	0
If you wanted to pick up a pebble with your toes, which foot would you use?	1	-1	0
If you had to step up onto a chair, which foot would you place on the chair first?	1	-1	0
Which eye would you use to peep through a keyhole?	1	-1	0
If you had to look into a dark bottle to see how full it was, which eye would you use?	1	-1	0
Which eye would you use to sight down a rifle?	1	-1	0
If you wanted to listen to a conversation going on behind a closed door, which ear would you place against the door?	1	-1	0
If you wanted to listen to someone's heartbeat, which ear would you place against their chest?	1	-1	0
Into which ear would you place the earphone of a transistor radio?	1	-1	0

Subject # ________________

\# of Right + # of Left = Total Score
_______ + _______ = _______

Is mother left or right hand dominant? _________
Is father left or right hand dominant? _________

Appendix D

CMHO

Directions: **If a statement is true or mostly true, as pertaining to you, circle the letter T.**
If a statement is false or usually not true about you, circle the letter F.
Try to give a response to every statement.

1. When I take a new job, I like to be tipped off on who should be gotten next to. T F
2. When someone does me wrong I feel I should pay him back if I can, just for the principle of the thing. T F
3. I prefer to pass by school friends, or people I know but have not seen for a long time, unless they speak to me first. T F
4. I have often had to take orders from someone who did not know as much as I did. T F
5. I think a great many people exaggerate their misfortunes in order to gain the sympathy and help of others. T F
6. It takes a lot of argument to convince most people of the truth. T F
7. I think most people would lie to get ahead. T F
8. Someone has it in for me. T F
9. Most people are honest chiefly through the fear of getting caught. T F
10. Most people will use somewhat unfair means to gain profit or an advantage, rather than to lose it. T F
11. I commonly wonder what hidden reason another person may have for doing something nice for me. T F
12. It makes me impatient to have people ask my advice or otherwise interrupt me when I am working on something important. T F
13. I feel that I have often been punished without cause. T F
14. I am against giving money to beggars. T F
15. Some of my family have habits that bother and annoy me very much. T F
16. My relatives are nearly all in sympathy with me. T F
17. My way of doing things is apt to be misunderstood by others. T F
18. I don’t blame anyone for trying to grab everything he can get in this world. T F
19. No one cares much what happens to you. T F
20. I can be friendly with people who do things which I consider wrong. T F
21. It is safer to trust nobody. T F
22. I do not blame a person for taking advantage of someone who lays himself open to it. T F
23. I have often felt that strangers were looking at me critically. T F

24. Most people make friends because friends are likely to be useful to them. T F
25. I am sure I am being talked about. T F
26. I am likely not to speak to people until they speak to me. T F
27. Most people inwardly dislike putting themselves out to help other people. T F
28. I tend to be on guard with people who are somewhat more friendly than I had expected. T F
29. I have sometimes stayed away from another person because I feared saying or doing something that I might regret afterwards. T F
30. People often disappoint me. T F
31. I like to keep people guessing what I’m going to do next. T F
32. I frequently ask people for advice. T F
33. I am not easily angered. T F
34. I have often met people who were supposed to be experts who were no better than I. T F
35. I would certainly enjoy beating a crook at his own game. T F
36. It makes me think of failure when I hear of the success of someone I know well. T F
37. I have at times had to be rough with people who were rude or annoying. T F
38. People generally demand more respect for their own rights than they are willing to allow for others. T F
39. There are certain people whom I dislike so much that I am inwardly pleased when they are catching it for something they have done. T F
40. I am often inclined to go out of my way to win a point with someone who has opposed me. T F
41. I am quite often not in on the gossip and talk of the group I belong to. T F
42. The man who had most to do with me when I was a child (such as my father, step-father, etc.) was very strict with me. T F
43. I have often found people jealous of my good ideas just because they had not thought of them first. T F
44. When a man is with a woman he is usually thinking about things related to her sex. T F
45. I do not try to cover up my poor opinion or pity of a person so that he won’t know how I feel. T F
46. I have frequently worked under people who seem to have things so that they get credit for good work but are able to pass off mistakes onto those under them. T F
47. I strongly defend my own opinions as a rule. T F
48. People can pretty easily change me even though I thought that my mind was already made up on a subject. T F
49. Sometimes I am sure that other people can tell what I am thinking. T F
50. A large number of people are guilty of bad sexual conduct. T F

Appendix E

MCSDS

Listed below are a number of statements concerning personal attitudes and traits. Read each item and decide whether the statement is true or false as it pertains to you personally.

1. Before voting I thoroughly investigate the qualifications of all the candidates. T F
2. I never hesitate to go out of my way to help someone in trouble. T F
3. It is sometimes hard for me to go on with my work if I am not encouraged. T F
4. I have never intensely disliked anyone. T F
5. On occasion I have had doubts about my ability to succeed in life. T F
6. I sometimes feel resentful when I don’t get my way. T F
7. I am always careful about my manner of dress. T F
8. My table manners at home are as good as when I eat out in a restaurant. T F
9. If I could get into a movie without paying and be sure I was not seen, I would probably do it. T F
10. On a few occasions, I have given up doing something because I thought too little of my ability. T F
11. I like to gossip at times. T F
12. There have been times when I felt like rebelling against people in authority even though I knew they were right. T F
13. No matter who I’m talking to, I’m always a good listener. T F
14. I can remember “playing sick” to get out of something. T F
15. There have been occasions when I took advantage of someone. T F
16. I’m always willing to admit it when I make a mistake. T F
17. I always try to practice what I preach. T F
18. I don’t find it particularly difficult to get along with loud-mouthed, obnoxious people. T F
19. I sometimes try to get even, rather than forgive and forget. T F
20. When I don’t know something I don’t at all mind admitting it. T F
21. I am always courteous, even to people who are disagreeable. T F
22. At times, I have really insisted on having things my own way. T F
23. There have been occasions when I felt like smashing things. T F
24. I would never think of letting someone else be punished for my wrongdoings. T F
25. I never resent being asked to return a favor. T F
26. I have never been irked when people expressed ideas very different from my own. T F
27. I never make a long trip without checking the safety of my car. T F
28. There have been times when I was quite jealous of the good fortune of others. T F

29. I have almost never felt the urge to tell someone off. T F
30. I am sometimes irritated by people who ask favors of me. T F
31. I have never felt that I was punished without cause. T F
32. I sometimes think when people have a misfortune they only got what they deserved. T F
33. I have never deliberately said something that hurt someone’s feelings. T F

Appendix F

Informed Consent For Participants Of Investigative Projects

Title of the Project: Sex Differences in Cardiovascular Reactivity in Response to a Stressor:
Evidence for Dynamic Functional Cerebral Laterality.
Dane A. Higgins. Experiment Number: 98-151

I. THE PURPOSE OF EXPERIMENT

You are invited to participate in a study to obtain data on measures purportedly associated with stress. This research attempts to determine the effects of sex on physiological and brain-related activity in response to the cold pressor task.

The listening part of this study helps assess the activity level of the right and left sides of your brain. This research is designed to assess how the cold pressor may affect your brain's activity level.

II. PROCEDURES TO BE FOLLOWED IN THE STUDY

To accomplish the goals of this study, you will be asked to wear a pair of headphones and identify when you hear a tone. This will help the researchers assess your hearing ability.

You will also be asked to undergo a stress condition called the cold pressor test. During this test, you will be asked to keep you hand in ice water for 45 seconds. The cold pressor paradigm is the primary method used to assess cardiovascular reactivity and has been a component of over 1,000 research articles. It is the most widely accepted method to induce cardiovascular changes in humans.

You will be hooked up to heart rate and blood pressure equipment to be monitored and recorded before and after the cold pressor test. This will help determine physiological reactivity to the cold pressor test.

Before and after the cold pressor test, you will be required to wear headphones and identify words that are presented to you. Again, this will help the researchers determine activity of the left and right sides of the brain.

You will also be required to answer a short questionnaire about your experiences with the cold pressor test and your perception of your own emotions about it.

III. DISCOMFORTS AND RISKS THROUGH PARTICIPATION IN THE STUDY

You may feel some discomfort during this experiment due to your participation in the cold pressor procedure. The water will be cold and may be painful. You may also experience some discomfort related to the inflation of the blood pressure cuff.

Safeguards that will be used to minimize your discomfort include the constant opportunity to terminate the experiment without penalty to yourself (i.e., losing extra credit points) should you ever feel uncomfortable. A thorough debriefing discussing any issues that may be of concern to you will also be provided at the end of the experiment. At that time you will be given ample opportunity to ask any additional questions about the research that you may feel were inadequately addressed by the debriefing. If you continue to have any problems associated with this study following the experiment, please call Dr. David W. Harrison at 231-4422 so that he may assist you directly or direct you to other appropriate, available services.

IV. BENEFITS OF THIS PROJECT

Your participation in the project may help identify the functions of certain neuropsychological sex differences and the potential cardiovascular benefits of differential coping mechanisms associated stress. However, no specific guarantee of benefits has been made to encourage you to participate.

You may request a synopsis or summary of this research after completion. Please leave a self-addressed envelope if you are interested in receiving this information.

V. ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF RESULTS

Identifying information will be kept strictly confidential. At no time will the researchers release your personal information from the study to anyone other than individuals associated with the project without your written consent. The information you provide will have your name removed and only a participant number will identify you during subsequent analyses and written reports of this research.

VI. EXTRA CREDIT COMPENSATION

For participation in this study, you will receive one point extra credit for Psychology 2004 or the psychology class for which you are attempting to earn one point of extra credit.

VII. FREEDOM TO WITHDRAW

You are free to withdraw from this study at any time without penalty. If you choose to withdraw, you will not be penalized by reduction in points or grade for Psychology 2004 or the psychology class for which you are attempting to earn extra credit. There are alternative choices for receiving extra credit for the course evaluation.

VIII. USE OF RESEARCH DATA

The information from this research may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published and reproduced in professional journals, books, or used for any other purpose that the Psychology Department at Virginia Tech considers in the proper interest of education, knowledge, or research.

IX. APPROVAL OF RESEARCH

This project has been approved by the Human Subjects Committee of the Department of Psychology and by the Institutional Review Board of Virginia Tech.

X. PARTICIPANT’S RESPONSIBILITIES

I voluntarily agree to participate in this study. I agree to disclose if I have a history of any of the following medical conditions: history of a severe head injury, stroke, epilepsy, seizures, paralysis, neurological surgery, other neurological or nervous system problems, Reynaud's syndrome, extreme sensitivity to cold temperatures, asthma, arthritis, or psoriasis.

XI. PARTICIPANT'S PERMISSION

I have read and understand the above description of the study. I have had an opportunity to ask questions and have had them all answered to my satisfaction. I hereby acknowledge the above and give my voluntary consent for participation in this study. I also understand that I may withdraw from participation at any time without penalty.

Participant's Signature	**Date**	**Telephone Number**	Participant #

Should I have any questions regarding this research and its conduct, I should contact any of the persons named below:

Dane A. Higgins Primary Researcher	552-6065 dane@vt.edu
David W. Harrison, Ph.D. Faculty Advisor	231-4422 dwh@vt.edu
Robert J. Harvey, Ph.D. Chair, HSC	231-7001 harveyrj@vtvm1.cc.vt.edu
H. T. Hurd Chair, IRB	231-5281 Hurd@vt.edu

Appendix G

BA DA GA KA PA TA

Appendix H

AUDITEC DICHOTIC C-V (0 Msec Lead) **Response Record Form for Rand I**

Hearing Screen		Cardiovascular Reactivity			
Left Track Ch. 1	Right Track Ch. 2		SBP	DBP	HR
PA	KA	T1	____	____	____
DA	KA	T2	____	____	____
KA	TA	T3	____	____	____
PA	BA	T4	____	____	____
KA	DA		FOCUS ________	Hpos	________

T1 Left Track Ch. 1	Right Track Ch. 2	**T2** Left Track Ch. 1	Right Track Ch. 2
PA	BA	PA	BA
KA	PA	KA	PA
GA	TA	GA	TA
DA	PA	DA	PA
KA	DA	KA	DA
BA	TA	BA	TA
GA	PA	GA	PA
DA	GA	DA	GA
BA	KA	BA	KA
PA	DA	PA	DA
BA	GA	BA	GA
PA	GA	PA	GA
TA	BA	TA	BA
KA	GA	KA	GA
KA	TA	KA	TA
TA	DA	TA	DA
GA	KA	GA	KA
TA	PA	TA	PA
BA	PA	BA	PA
DA	KA	DA	KA
TA	GA	TA	GA
GA	BA	GA	BA
DA	TA	DA	TA
KA	BA	KA	BA
GA	DA	GA	DA
DA	BA	DA	BA
PA	KA	PA	KA
TA	KA	TA	KA
BA	DA	BA	DA
PA	TA	PA	TA

Ear ______ ______ ______ ______

#COR______ ______ ______ ______

Appendix I

Please circle the most appropriate answer to each of the following questions:

1) How stressful was putting your hand in the cold water during the cold pressor test?

(1 = not stressful at all, 4 = moderately stressful, 7 = extremely stressful)

1 2 3 4 5 6 7

2) What level of pain did you experience when you put your hand in the cold water during the cold pressor test?

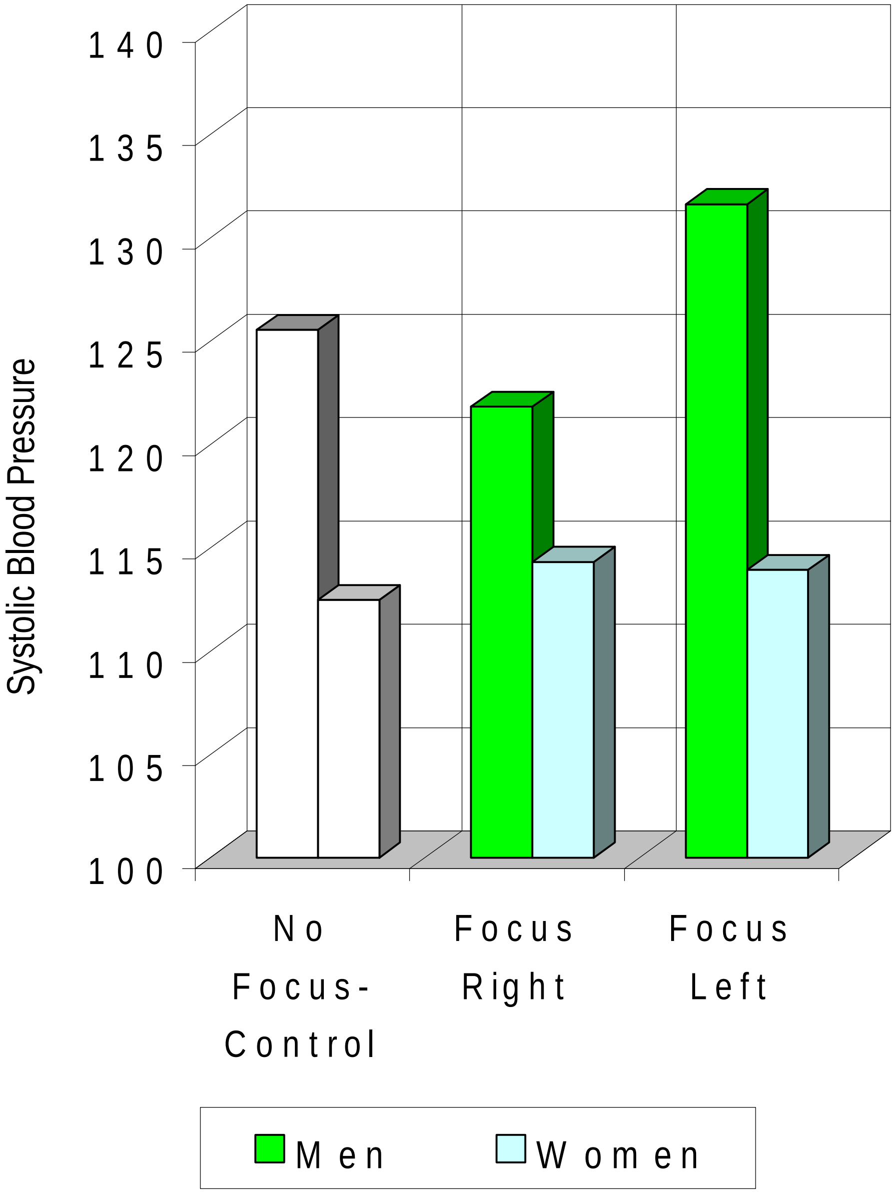
(1 = not painful at all, 4 = moderately painful, 7 = extremely painful)

1 2 3 4 5 6 7

Thank you for your time and your participation in this study.

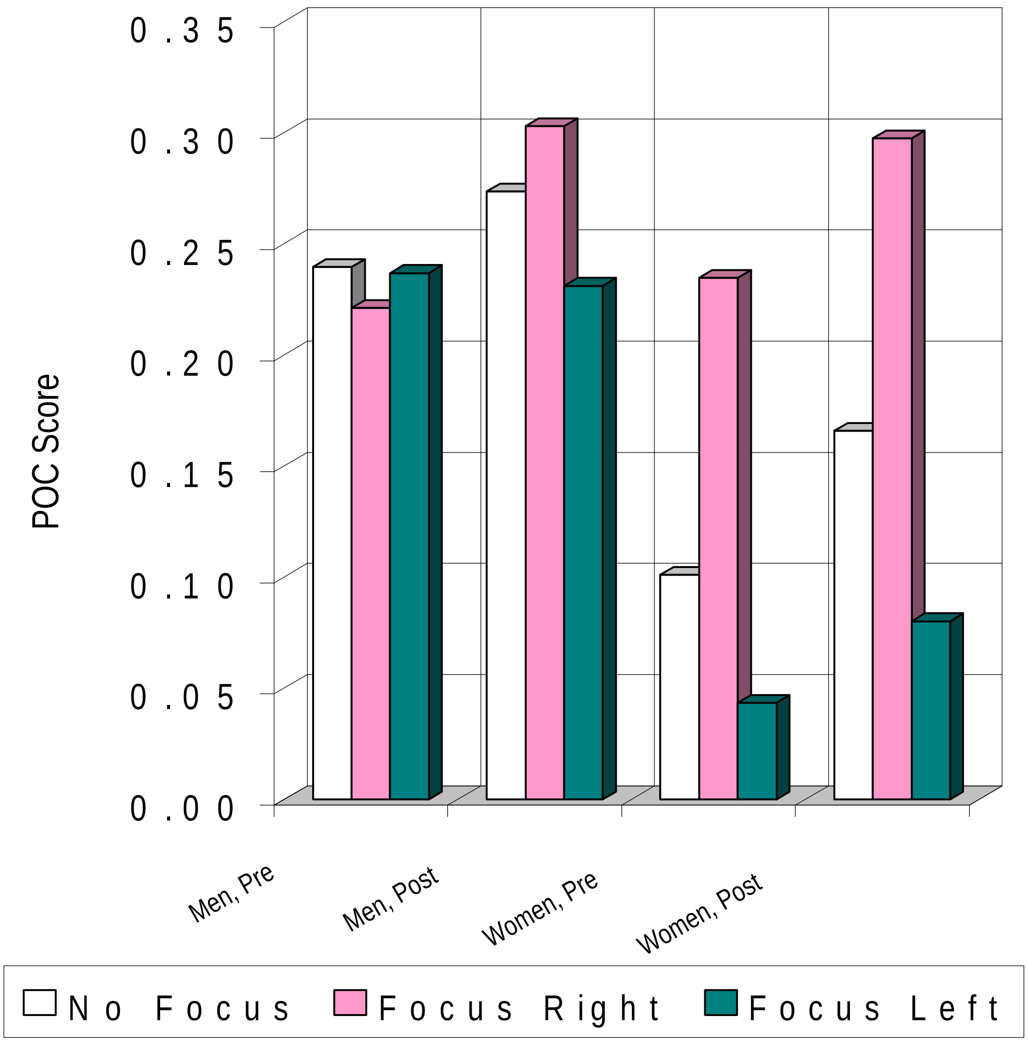
Appendix J

Figure "J". Analysis of all groups: No Focus (Control; striated appearance), Focus Left, and Focus Right. This Sex by Focus Interaction Effect on SBP approached significance, F (2,114) = 2.46, $p < 0.0896$ (see Table 5 in text). When the Focus Left and Focus Right groups were analyzed separately in a refined analysis, significant differences in SBP were evidenced. It is important to see the sex differences in SBP as a function of the focus conditions. That is to say, women's SBP remained relatively stable across focus groups (suggesting more functional cerebral symmetry), while men's SBP varied according to focus group.



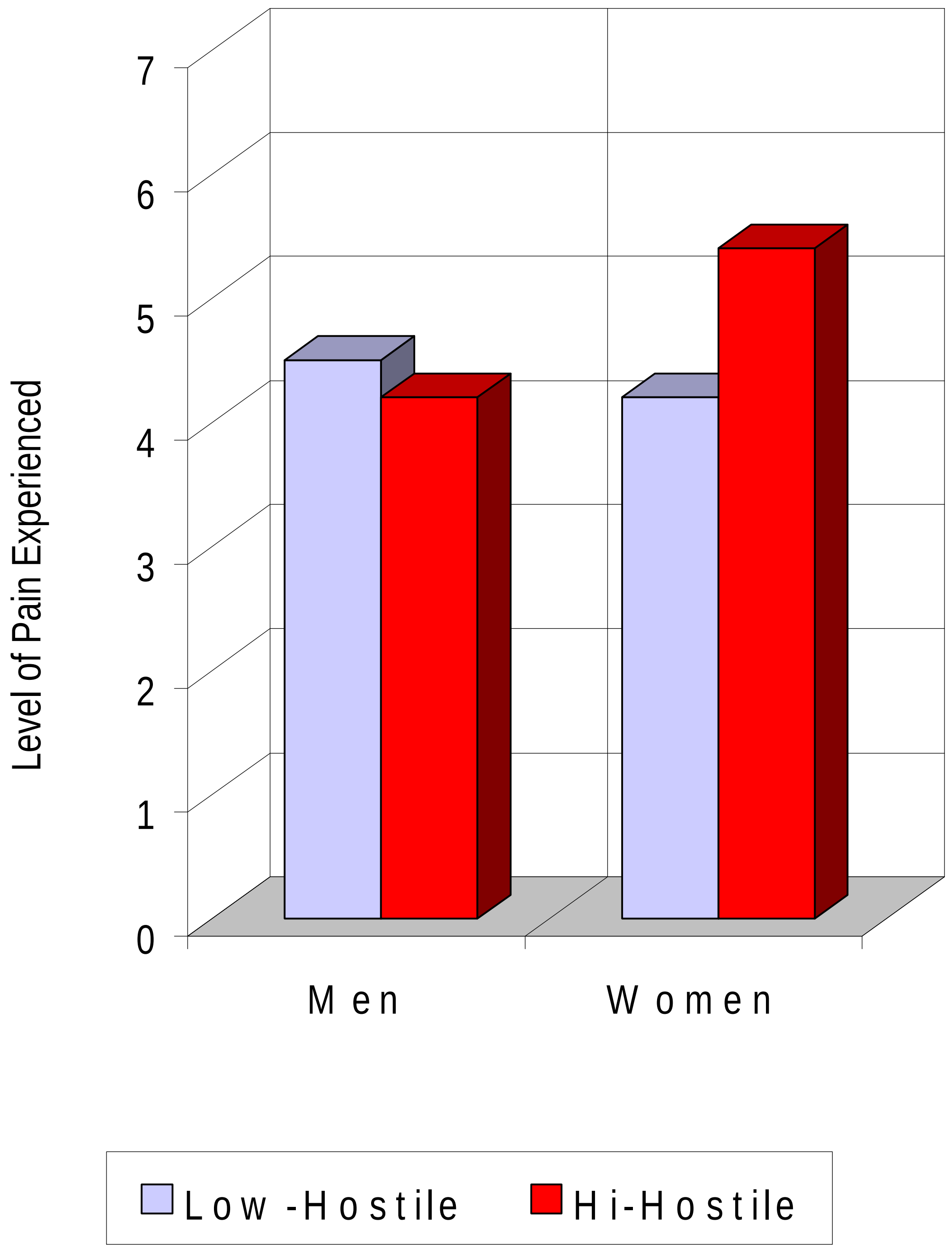
Appendix K

Figure "K". Analysis of all groups: No Focus (Control), Focus Left, and Focus Right. The Sex by Focus Interaction Effect on POC Scores was not significant, F (2,114) = 1.25, $p < 0.2892$ (see Table 13 in text). However, it is important to view the sex differences in POC scores as a function of the focus conditions across trials (pre- and post-cold pressor). That is to say, women's POC scores were dynamic (suggesting more functional cerebral symmetry), changing with each focus group and with the stressor; while men's POC scores were static in each focus group (suggesting increased asymmetry or laterality), with a right-ear advantage across focus conditions, before and after the stressor.



Appendix L

Figure "L". Refined Analysis of High and Low-Hostile Groups (regardless of Focus). The Interaction Effect of Sex by Group on Pain Perceived from the Cold Pressor (p<.08).



Appendix M

CURRICULUM VITA

Dane A. Higgins

2003 Lombardi Drive, Blacksburg, Virginia 24060
(540) 552-6065, e-mail: dane@vt.edu

Education

Current: Clinical Psychology Graduate Student
Virginia Polytechnic Institute and State University, Blacksburg, VA

Undergraduate: Arizona State University, Tempe, Arizona, 1994
Bachelor of Science. cum laude. Major: Psychology.
Psychology G.P.A.: 3.78, 4 year cumulative G.P.A.: 3.65

Honors and Awards

Arizona State University Honors College Graduate, 1994. Honors Thesis, "Changing Gender Differences in Aggression?: Clarification Through Meta-Analysis."
Regent's Scholarship Recipient, Arizona State University, 1993-1994
Dean's Honor List, Arizona State University: Spring 1993, Fall 1993, Spring 1994
Member of PSI CHI, National Honor Society in Psychology, 1993-1995

Clinical Training

1997-1998 Assessment Practicum Team for Child Study Center (CSC)
Virginia Polytechnic Institute and State University, Blacksburg, VA

Graduate level assessment practicum team specializing in the assessment and treatment of a variety of learning and psychological disorders including ADHD, adjustment disorders, anxiety, depression, family difficulties, learning, math, reading disorders, and others.

Supervisor: Dr. Thomas H. Ollendick

1997-1998 Externship, Carilion St. Albans Psychiatric Hospital, Radford, VA

Worked through rotations in the three main psychiatric units of the hospital, the third being a locked unit. Each unit specializes in treatment for patients at differing levels of need. Assessed and treated individuals (adolescents and adults) with anger, chemical dependence, depression (with or without anxiety, mania, and suicidal ideation), and various other disorders with or without psychotic features. Assisted and sometimes led the cognitive, community support, coping strategies, and life skills group therapy sessions. Also, organized follow-up care at time of discharge.

Supervisor: Rick Seidel, Ph.D., Licensed Clinical Psychologist

1997-1998 Graduate Supervisor at the Psychological Services Center and CSC
Virginia Polytechnic Institute and State University, Blacksburg, VA

Responsible for the following: therapeutic duties, including the supervision of graduate clinician records; aiding in the conceptualization and organization of the PSC's library of Empirically-Supported Treatment Protocols; maintenance of the PSC's computer systems, Physiology Laboratory, and other clinic equipment on a regular basis; training sessions offered on the computer administration and scoring programs available at the PSC; and design and maintenance of the PSC internet web page.

Supervisor: Dr. Thomas H. Ollendick

1995-1999 Neuropsychological Assessment Practicum Team
Psychological Services Center and Child Study Center
Virginia Polytechnic Institute and State University, Blacksburg, VA

Graduate level practicum team specializing in the assessment and treatment of neuropsychological disorders resulting from cerebrovascular, congenital, convulsive, neoplastic, and traumatic disorders of the brain.

Supervisor: Dr. David W. Harrison

1995-1997 Clinical Practicum Team, Psychological Services Center and CSC
Virginia Polytechnic Institute and State University, Blacksburg, VA

Graduate level practicum team specializing in the assessment and treatment of a variety of psychological disorders including anxiety, assertiveness training, depression, learning disorders, marital difficulties, and relationship problems.

Supervisors: Dr. Robert S. Stephens & Dr. Jack W. Finney (1995-1996)
Dr. George A. Clum (1996-1997)

1995-1997 Therapist, Psychological Services Center and Child Study Center

Responsibilities included the assessment and treatment of a variety of psychological disorders including anxiety, depression, learning disorders, personality disorders, and relationship problems.

Supervisors: Dr. Robert S. Stephens & Dr. Jack W. Finney (1995-1996)
Dr. George A. Clum (1996-1997)

Teaching Experience

Spring, 1997 Teaching Assistant
Physiological Psychology
Virginia Polytechnic Institute and State University, Blacksburg, VA.

Spring, 1997 Teaching Assistant
Social Psychology
Virginia Polytechnic Institute and State University, Blacksburg, VA.

1995-1996 Laboratory Instructor
Introductory Psychology
Virginia Polytechnic Institute and State University, Blacksburg, VA.

Relevant Work Experience

1994-1995 Neuropsychological Rehabilitation Specialist
Residential and Day Treatment Programs
NeuroCare, Inc., Phoenix, Arizona

Responsibilities included over 1,200 hours of neurological rehabilitation activities. The Residential Program involved helping those with severe head injuries to learn coping skills, stress management, relaxation skills, anger control, and behavior-management programs. The Day Treatment Program focused on improving patient’s attention, memory, speed of processing, orientation, and other areas of cognitive difficulty. Worked extensively with physical, occupational, speech, and vocational therapists in designing and implementing rehabilitation programs for both Day Treatment Program and Residential Program patients (children, adolescents, and adults).

Supervisor: John Van Doren, Ph.D., Licensed Clinical Neuropsychologist

Professional Affiliations

International Neuropsychological Society (INS)- Associate Member
National Academy of Neuropsychology (NAN)- Graduate Student Affiliate
American Psychological Association (APA)- Graduate Student Affiliate
American Psychological Society (APS)- Graduate Student Affiliate
American Psychological Association of Graduate Students (APAGS) Member
Southeastern Psychological Association (SEPA)- Student Member
Virginia Psychological Association (VPA)- Student Member
Division 40, APA: Clinical Neuropsychology- Graduate Student Affiliate
Division 12, APA: Clinical Psychology- Graduate Student Affiliate
Division 6, APA: Behavioral Neuroscience and Comparative Psychology- Graduate Student Affiliate

Current Research and Scholarly Interests

Cortical, subcortical, and autonomic correlates of cognition, emotion, and aging. Sex differences in cardiovascular health as mediated by neuropsychological factors. Methods in neuropsychology, psychophysiology, and psychopharmacology.

Journal Publications

Everhart, D. E., Higgins, D. A., & Harrison, D. W. (1997). Neuropsychological effects of anxiety without depression on facial affect perception. The Clinical Neuropsychologist, 11(3), 319-320.

Knight, G. P., Fabes, R. A., & Higgins, D. A. (1996). Concerns about drawing causal inferences from meta-analyses: An example in the study of gender differences in aggression. Psychological Bulletin, 119(3), 410-421.

Higgins, D. A. (1994). Changing gender differences in aggression?: Clarification through meta-analysis. Proceedings: Eighth National Conference on Undergraduate Research, 1, 441-445.

Conference Presentations and Posters

Higgins, D. A., Everhart, D. E., & Harrison, D. W. (1999, March). Quantitative electroencephalography as an assessment tool for pseudoseizure diagnosis. Poster session presented at the annual meeting of the Southeastern Psychological Association, Savannah, Georgia.

Williamson, J., Higgins, D. A., Demaree, H. A., & Harrison, D. W. (1999, March). Diminished asymmetry in hostile men: Motor performance. Poster session presented at the annual meeting of the Southeastern Psychological Association, Savannah, Georgia.

Higgins, D., Shenal, B., Moore, T., Rhodes, R., & Harrison, D. W. (1998, April). Quantitative electroencephalography (QEEG) facilitates neuropsychological syndrome analysis: An alternative to the nomothetic approach. Paper presented at the Spring meeting of the Virginia Psychological Association, Charlottesville, Virginia.

Everhart, D. E., Higgins, D. A., & Harrison, D. W. (1997, August). Neuropsychological effects of anxiety without depression on facial affect perception. Poster session presented at the annual meeting of the American Psychological Association, Chicago, Illinois.

Higgins, D. A. (1994, April). Changing gender differences in aggression?: Clarification through meta-analysis. Paper presented at the annual meeting of the National Conference on Undergraduate Research, Kalamazoo, Michigan.

Manuscripts in Preparation

Shenal, B., Moore, T., Rhodes, R., Higgins, D., & Harrison, D. W. (1999). Quantitative electroencephalography (QEEG) facilitates neuropsychological syndrome analysis: An alternative to the nomothetic approach. Manuscript submitted for publication.

Higgins, D. A., Demaree, H. A., Williamson, J., & Harrison, D. W. (1999). Diminished asymmetry in hostile men: Motor performance. Unpublished manuscript, Virginia Polytechnic Institute and State University.

Higgins, D. A., Everhart, D. E., & Harrison, D. W. (1999). Quantitative electroencephalography as an assessment tool for pseudoseizure diagnosis. Unpublished manuscript, Virginia Polytechnic Institute and State University.

Higgins, D. A., & Harrison, D. W. (1999). Sex differences in cardiovascular reactivity and speech perception in response to a stressor: Evidence for dynamic functional cerebral laterality. Unpublished master’s thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Professional Conference Participation

March, 1999.	Southeastern Psychological Association. Savannah, GA.
Nov., 1998.	National Academy of Neuropsychology Conference. Washington, D.C.
April, 1998.	Virginia Psychological Assoc. Spring Convention. Charlottesville, VA.
Nov., 1997.	National Academy of Neuropsychology Conference. Las Vegas, NV.
Aug., 1997.	American Psychological Association Conference. Chicago, IL.
Feb., 1997.	International Neuropsychological Society Conference. Orlando, FL.
Oct., 1996.	National Academy of Neuropsychology Conference. New Orleans, LA.
Aug., 1996.	American Psychological Assoc. Conference. Toronto, Ontario, Canada.

Computer Proficiency & Personal Information

Adobe PageMaker and PhotoShop.
Microsoft Access, Excel, FrontPage, PowerPoint, Publisher, and Word.
SAS and SPSS.
Local Area Network Design, Administration, and Maintenance.
Web Page Authoring and Maintenance.
Computer software and hardware troubleshooting and repair.

Served 2 year mission for L.D.S. church.
Eagle Scout.
Date of Birth: April 3, 1969.

Signed: ____________________________________

Dane A. Higgins