HEMISPHERICITY AND NEUROENDOCRINOLOGY

by

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B.A. (Hons.), Simon Fraser University, 1983

M.A., Simon Fraser University, 1984

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENT FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in the department

of

PSYCHOLOGY

APPROVAL

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Degree: Doctor of Philosophy

Title of Thesis: Hemisphericity and Neuroendocrinology

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Date Approved: _January 7, 1992._

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ABSTRACT

Hemisphericity refers to a bias in preferred use of the right or left hemisphere in an individual's psychological functioning. In this study the direction of conjugate lateral eye movements (CLEM), eye-movements a subject makes as he\she begins to think of an answer to a question, was used as an indicator of hemisphericity, with a preponderance of left eye-movements indicating right hemisphericity and a preponderance of right eye-movements indicating left hemisphericity. Hemisphericity has been associated with a variety of behavioral and physiological measures. The purpose of this study was to investigate the relationship between hemisphericity and a) blood plasma levels of norepinephrine and cortisol and b) responses to questionnaires tapping autonomic awareness.

In experiment one the relationship of hemisphericity to blood plasma levels of norepinephrine (NE) and cortisol (C) was examined for a sample of 37 female subjects. The blood plasma NE level was significantly higher in subjects showing right hemisphericity than in those showing left hemisphericity. The blood plasma C level was significantly higher in subjects with left hemisphericity than in those showing right hemisphericity.

In light of the close relationship between NE and autonomic (sympathetic) functioning and the relationship between hemisphericity and NE found in the first experiment, the second study was designed to examine the relationship between hemisphericity and self-reports of autonomic functioning. The CLEM measure of hemisphericity was used to define groups which were compared on the Autonomic Perception Questionnaire and the Stress Audit for both male (N=64) and female (N=132) subjects. It was found that hemisphericity was not significantly associated with autonomic perception. There was also a significant sex difference in perceived autonomic activity with females reporting greater autonomic awareness than males in both the right and left hemisphericity groups.

The results of the first experiment are the first to show a relationship between hemisphericity and neurochemical and neuroendocrine variables.

These results are discussed in terms of empirical support for the concept of hemisphericity, the relationship between hemisphericity and neurochemistry, and the relationship between hemisphericity and the autonomic nervous system.

DEDICATION

There are two men to whom I would like to dedicate this
work: first, to Dr. Paul Bakan who provided unending
patience while I was unknowingly presented with challenges
that thwarted the completion of my thesis, and second, to my
husband who provided love and support when confronted with
the daily challenges we all experience. Thank you both.

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CHAPTER 1

INTRODUCTION

History of Brain Laterality

The scientific study of brain laterality has its origins with the work of Dax (1836) and Broca (1864). These early studies showed that there is an asymmetry in the functioning of the brain, such that damage to the left hemisphere, especially in the frontal region leads to important deficits with regard to speech functions. These are the deficits currently considered as aphasia. Similar damage to the right hemisphere does not produce speech deficits and thus the doctrine of a functional hemispheric asymmetry with respect to speech. Broca also suggested a relationship between this asymmetrical organization of the brain and handedness by his suggestion that there may be a reversal of the asymmetry in left-handers.

The finding of an asymmetry in speech led to a search for other asymmetries. In 1874 the British neurologist J.H. Jackson proposed that just as the left hemisphere may be dominant for speech, so the right hemisphere may be dominant for other functions. He noted especially emotion, perception and imagery as possibilities for right hemisphere dominance. Jackson's work was not as influential as Broca's

in the late 19th and early 20th centuries, and as a result the idea of hemispheric dominance is usually associated with the left hemisphere which underlies functions unique to humans, namely speech and handedness.

The importance of Jackson's view of "dual dominance" was recognized as the field of neuropsychology developed. Studies of the relationship between brain injury and psychological deficit continued to show the importance of the left hemisphere for speech, but increasingly there were reports of psychological functions especially sensitive to right hemisphere damage (Weisenberg et al., 1935; Penfield et al., 1959). The neuropsychological research, especially since World War II which provided large samples of brain injured subjects, supported the work of Jackson. This research showed that important deficits in visuo-spatial functions and emotionality occurred with right hemisphere injury (Humphrey et al., 1951; Gainotti, 1972).

The field of functional hemispheric asymmetry was further advanced by the work of Sperry and his associates (Sperry 1961, 1968; Sperry et al., 1980) for which Sperry received the Nobel Prize in 1981. Myers et al. (1958) developed a split-brain surgery which originally consisted of cutting the corpus callosum and other commissures in cats. This surgical procedure was applied to humans in the early 1960s by two neurosurgeons, J.E. Bogen and P.J. Vogel, in an attempt to correct an intractable form of epilepsy called status epilepticus. The commissures of these

patients were surgically severed to produce a failure of communication between the hemispheres (Springer et al., 1989). Medically this prevented transfer of seizure activity from one hemisphere to the other and thus improved the patients' symptoms. From an experimental point of view it provided a sample of people whose hemispheric functioning could be evaluated in the absence of interhemispheric communication. The results of the subsequent studies designed by Sperry (1968) supported the idea of functional hemispheric asymmetry.

Studies of brain injured and split-brain patients with respect to functional hemispheric asymmetry challenged a number of investigators to demonstrate functional hemispheric asymmetry in normal subjects. This was done by means of dichotic listening studies (Kimura, 1967; Curry, 1967) and studies using lateralized visual field presentation of stimuli. Thus it was shown that there is a right ear advantage for processing of verbal stimuli and a left ear advantage for processing of nonverbal stimuli when stimuli were simultaneously presented to both ears (Safer et al., 1977). In visual field studies there is a right field advantage for verbal material and a left field advantage for non-verbal material (Baker et al., 1990).

Overall the results of the studies with patients and with normal subjects provided a model of hemispheric differences. This model holds that the left hemisphere is more capable of processing analytical, time dependent, and

sequential tasks, which are important functions for language which was earlier shown to be associated with the left hemisphere (Levy, 1969, 1980, 1982; Sperry et al., 1980; Sperry, 1982). The right hemisphere is more capable for providing holistic, parallel, gestalt-like, non-verbal and emotional processing (Springer et al., 1989).

Exploration of the differences between the right and left hemisphere continues in a variety of areas including problem solving (Houtz et al., 1988), topographical orientation (Rashid et al., 1989), numerical and spatial differences (French et al., 1989), learning styles (Karnes et al., 1985), EEG patterns (Goldstein, 1983), emotional differences (Tucker, 1981; Ladavas et al., 1984; Derryberry, 1989; Wittling, 1990; Wittling et al., 1990) and artistic abilities (Hassler, 1990). There is also considerable interest in sex differences in relation to hemispheric differences (Weiten et al., 1974; Piazza, 1980; Hyde, 1981; Robinson et al., 1985).

The Concept of Hemisphericity

An important offshoot from the work of brain laterality and functional asymmetry has been the concept of hemisphericity. This concept is based on an individual difference approach with respect to the organization of the cerebral hemispheres for individuals. Bogen (1969) initially coined the term hemisphericity and defined it as an individual's tendency to rely on one hemisphere more than

the other, emphasizing the individual aspect as the core of hemisphericity.

The concept of hemisphericity is analogous to that of handedness. Just as handedness refers to an individual's tendency to rely on one hand more than the other even though he/she uses both, so hemisphericity refers to a tendency to rely on one hemisphere more than the other though both hemispheres are used for psychological functioning.

Hemisphericity assumes functional hemispheric asymmetry, but goes beyond it in assuming that an individual with right hemisphericity will manifest cognitive and affective behaviors more consonant with the functions of the right hemisphere and that an individual with left hemisphericity will manifest cognitive and affective behaviors more consonant with the functions of the left hemisphere. The research strategy dictated by the concept of hemisphericity is the comparison of groups defined by left and right hemisphericity with respect to cognitive, affective, behavioral, personality, autonomic or physiological variables.

The hemisphericity concept is employed to compare subjects with right or left hemisphericity on a number of variables. These include cognitive processing (Bogen et al., 1972), emotions (Galin, 1974; Ahern et al., 1979), cognitive style (Gordon, 1989), comprehension (Gadzella et al., 1990), creativity (Loye, 1988), personality characteristics (Vingiano, 1989), cultural differences (Moss

et al., 1985; Ten Houten, 1986) and personality defense mechanisms (Gur et al., 1974).

The bulk of hemisphericity literature is based on the CLEM measure. However various researchers have attempted to develop other measures of hemisphericity. Among these are measures of asymmetrical blood flow (Gur, 1980), EEG asymmetries (Moss et al., 1985), performance differences on verbal/nonverbal tasks (Minagawa et al., 1989) and questionnaire measures (Torrance et al., 1984; Vingiano, 1989).

Conjugate Lateral Eye Movements (CLEMs)

If individuals are to be classified on the basis of hemisphericity, there needs to be an observable indicator of hemisphericity. The indicator used in this study is the measure based on the lateral direction of eye movements shown by an individual as he/she begins to ponder the answer to a question. Such a measure was developed by Bakan (1969) and is called the CLEM measure, the acronym standing for conjugate lateral eye movement.

The rationale for the CLEM measure is based on the fact that lateral eye movements are contralaterally controlled (Bakan, 1969). It has been shown that stimulation of the right frontal eye-movement area of the cortex leads to left movements of both eyes, and that stimulation of the left frontal eye-movement area leads to right eye movements of both eyes. Bakan proposed that the characteristic direction of lateral eye-movements for an individual was a reflection

of relative hemispheric dominance, or hemisphericity. He interpreted the right-left eye movement typology originally suggested by Day (1964, 1967) as a left-right hemisphere typology. According to this theory right movers are considered as having left hemisphericity and left movers are considered as having right hemisphericity. The behavior and other characteristics of the right mover is related to greater reliance on left hemisphere functioning, and that of the left mover to greater reliance on right hemisphere functioning.

The CLEM measure of hemisphericity has been critically discussed by Ehrlichman et al. (1978), and has more recently been reviewed by Charlton et al. (1989).

Historical Considerations of CLEM

Bakan's choice of CLEM or conjugate lateral eye - movements, as an indicator of hemisphericity is supported by a historical background of research on eye-movements showing contralateral hemispheric control of eye-movements. This means that right hemisphere stimulation or activation in the frontal area leads to conjugate lateral eye movements to the left and vice versa for left hemispheric stimulation or activation.

The relationship between initial direction of lateral eye movements in response to a question and individual differences in behavior was noted by Day in a series of studies (Day, 1964; 1967; 1974). He showed that individuals are consistent in the direction of eye-movements as they

begin to ponder the answer to a question. A similar result had previously been reported by Teitlebaum (1954). Day reported that a major difference between subjects who moved their eyes to the right and those who moved their eyes to the left was that left-movers had a more subjective orientation than right movers.

Duke (1968) confirmed the directional consistency of CLEMs in a study which found that subjects move their eyes laterally in the same direction 86% of the time if the first lateral movement, after a question is asked of them, is observed. Bakan et al. (1973) showed that the direction of CLEMs is consistent or reliable since the test-retest (one week) correlation of CLEM was r = .70. Thus the direction of lateral eye-movements is consistent for the individual and over time.

Bakan's association of CLEM with hemisphericity was based on earlier neurological observations regarding eye-movement control by the brain. Nineteenth century neurologists were very much aware of lateral eye movements and their pathology as part of neurological syndromes (Rose et al., 1982). There are case reports in the 19th century literature noting impairment of lateral eye-movements to one side in association with hemiplegia on the same side. A patient with a right hemisphere lesion would have a left-side paralysis and at the same time be unable to move the eyes to the left, since both left body motor function and left eye movements require an intact right hemisphere. It

was also reported that an irritative lesion of the cortex results in a contralateral horizontal eye movement.

In 1868 a French neurologist Prevost published a monograph on impairments of horizontal conjugate lateral gaze. This is the source of our important neurological observation known as Prevost's Rule. The rule states that "the patient looks toward the lesion in cases with lateral cerebral involvement". His review of the literature showed that this rule applies to rabbits, dogs and sheep as well as humans. In the same year the British neurologist J.H. Jackson noted a relationship between epileptic focus and lateral eye movements. He noted that a left-sided epileptic focus leads to the deviation of both eyes to the right (Jackson, 1958).

Jackson had a strong interest in the neurological implications of lateral eye-movements. He refers to the observation that "after some epileptic fits the eyes deviate from the side to which they were strongly turned during the prior paroxysm...a matter of great importance." (Jackson, 1958).

The close relationship between eye-movements and psychological processes is noted by Jackson:

> "That movements of the eyes are represented in the
> highest motor centres (frontal lobes, motor divisions
> of the 'organ of mind'), one might infer a priori.
> Ocular movements are the most representative of all
> movements. Most mentation is carried on in visual
> perceptions and ideas; and, as there is an element of,
> or symbolising, shape in all visual perceptions and
> ideas, there is, of necesssity, a representation of
> ocular movements in the physical bases of these
> perceptions and ideas, that is, in the highest

centre." (Jackson, 1958)

Considering the relationship he observed between lateral deviation of the eyes and hemiplegia based on his observation that right hemiplegia was associated with a leftward direction of the eyes he writes:

> "The turning of the eyes to the left shows intactness of the right half of the brain; it is the inability to turn them to the right which is part of the right hemiplegia from a destructive lesion of the left cerebral hemisphere." (Jackson, 1958)

Psychological Correlates of CLEM

This and the next section constitute a selective review of the CLEM literature with an emphasis on some of the psychological and physiological correlates of CLEM.

In one of the earliest studies Day (1967) reported that people's descriptions of events were related to the direction of CLEMs. He reported that left-movers are more likely to report on the basis of subjective feelings, e.g. "I feel hungry", whereas right-movers respond in terms of actions, e.g. "I'm getting something to eat".

Bakan et al. (1969a) in an early study compared right and left-movers (i.e., left and right hemisphericity) on the Stroop Test. In this test subjects are presented a list of color words, e.g., red and yellow, printed in a colour of ink different from the word, thus the word RED is printed in blue ink. The subject is to call out the ink colour of 80 such stimuli. Thus if RED is printed in blue, the correct response is "blue". It was found that right-movers performed significantly better at this task than left-

movers. The separation of the word component from the colour component of the stimulus requires an act of analysis, one of the specialties of the left hemisphere and therefore the right-mover does better. It was also found that in a control condition of just reading the words printed in black, the right movers read faster.

In another study Bakan (1969) found that left-movers are more hypnotizable than right-movers. The hypnotic literature suggests that highly hypnotizable subjects tend to be subjectively oriented (Hilgard, 1979). Since left-movers have been described as more subjectively oriented, it might be expected that they would also be more hypnotizable. This work was supported by Gur et al. (1973).

The findings of cognitive differences between the hemispheres dictate that there might be cognitive differences between right and left hemisphericity individuals. The Stroop Test result cited above is consistent with this view. In a study by Weiten et al. (1974) right movers were found superior on a concept identification task requiring verbal and analytical skills. It was also found in a study of interests that right movers tended more to theoretical and economic interests while left-movers tended more to aesthetic and social interests.

Tucker et al. (1978) found that right-movers performed better on the verbal subtests of the WAIS, whereas left-movers did better on the spatial subtests. This result was confirmed and extended by Moretti (1982).

Other studies of cognitive differences between right and left-movers have found differences with respect to imagery (Glackman, 1976), random number generation (Charlton et al., 1990), heartbeat discrimination (Katkin et al., 1982; Hantas et al., 1984; Katkin, 1985; Katkin et al., 1988), dichotic listening (Neilsen et al., 1976; Hiscock et al., 1985) and oral contraceptive usage (Prochnau, 1983, 1985).

There is evidence that personality and clinical variables are also related to lateral eye movement direction. In a study of preferred defense mechanisms Gur (1975) found that right movers tended to use projection and outward aggression as defense mechanisms; conversely, left movers tended to use denial, repression, reaction formation, and report psychosomatic symptoms. Myslobodsky et al. (1978) found an association between both endogenous and reactive depression and conjugate lateral eye movements (i.e., patient suffering from depression were more likely to have a right hemisphericity). Gur (1978) associated hemisphere dysfunction and conjugate lateral eye movements with schizophrenia. Smokler et al. (1979) found that left movers were more inclined to have hysterical personality disorders than compulsive-obsessive personality features.

Physiological Correlates of CLEM

Further support for the CLEM/hemisphericity typology comes from evidence of physiological differences between right and left eye-movers. Day (1967) made the first such observation in a report of EEG differences between right and left-movers. Left movers (right hemisphericity) were found to have greater amplitude and lower frequency in their EEG records. Similar findings were reported by Bakan et al. (1969b).

Studies of cerebral blood flow have also shown differences between right and left-movers (Gur, 1980). Evoked potential differences are reported by Shevrin et al. (1980). Electrooculographic differences are reported by Neubauer et al. (1988). Studies of differences in physical symptoms are reported by Bliss (1971) and Bakan (1978). Differences in cardiac activity are reported by Nevlin (1981). There are a number of studies relating cardiac factors and CLEMS at both a physiological and experimental level (Walker et al., 1979; Davidson et al., 1981; Hantas et al., 1984; Montgomery et al., 1984; Katkin et al., 1988). Charlton et al. (1989) have reviewed the physiological correlates of CLEM and have also addressed some of the criticisms of the CLEM approach raised earlier by Ehrlichman et al. (1978).

Norepinephrine

In the first study of this dissertation a comparison between right and left movers with respect to blood plasma norepinephrine (NE) is reported. Norepinephrine is a very important neurotransmitter. The literature has shown that NE has a laterally asymmetric distribution in the brain and nervous system. It is for this reason that this study addressed the possibility of a relationship between hemisphericity and NE. This section constitutes a brief review of the role of NE in neural functioning.

What Norepinephrine Is

As noted earlier, NE is an important neurotransmitter. It was initially identified in 1904 as an epinephrine-like substance released onto cells in the sympathetic nervous system (SNS) (Hadley, 1984). In 1946, NE was isolated as a neurotransmitter and is now classified as a catecholamine (Lake et al., 1985). Norepinephrine is also considered as an adrenohormone, the different classifications depend on where NE is secreted from and how it functions.

The major source of neural NE is in the locus coeruleus in the brain stem, with supplementary sources released from the pons and medulla oblongata in the brain stem (Hokfelt et al., 1984; Mason, 1984a, 1984b; Elam et al., 1986a, 1986b). The locus coeruleus NE extends to both the neocortex and paleocortex, making diffuse branching projections and thus connecting up with about half of all brain cells (Aston-Jones et al., 1984; Snyder, 1986). Further, NE acts as a

neural modulator with a role in regulatory production and secretion or uptake of other neurochemicals and receptors (Aston-Jones, 1985; Sara, 1985). When NE is secreted from the adrenal medulla into the blood stream and travels up to the brain making primary connections with the hypothalamus it acts as a neurohormone.

Norepinephrine measurements for experimental and clinical purposes have been made from cerebral spinal fluid, tissues, urine and blood plasma. Though there have been some controversies regarding optimal measurement, it is generally agreed that with reasonable control of certain variables such as age, health status, stress level, diet, drugs, posture, and time of day a blood plasma method such as the one used in the first experiment of this dissertation, the high-pressure liquid chromatography method (HPLC) is quite satisfactory (Lake et al., 1985).

Norepinephrine and the Autonomic System

The autonomic nervous system (ANS) is composed of two components, the SNS and the parasympathetic nervous system (PSNS). There is an intimate relation between NE and the SNS. In fact, the SNS is referred to as a NE system (Barr et al., 1983). The reason for referring to the SNS as a NE system is due to the fact that in the SNS the neurotransmitter that flows between the postganglionic neurons and effector cells is NE. Further, when SNS nerves are electrically stimulated plasma levels of NE increase (Wallin et al., 1981; Wallin, 1984). There is a close

relationship between central and peripheral NE sympathetic activity (Elam et al., 1986a, 1986b). Just as there are inverse relations between the SNS and the PSNS, so there appear to be inverse relationships between NE and the PSNS. In fact, NE suppresses ANS signals in the brain that are engaged in parasympathetic functions (Elam et al., 1986b).

Aston-Jones et al. (1984) reviewed several theories concerning locus coeruleus NE and concluded that this nucleus correlates positively with external, excitatory stimuli. They further suggested that increases in locus coeruleus NE excite the phasic SNS processes that cope with activities like immediate behavioral responses. Conversely, reductions in locus coeruleus secretion engage the tonic, "endogenously generated brain programs which mediate tonic vegetative behaviors" (Aston-Jones et al., 1984, p.111), i.e., the parasympathetic system. This further supports the relationship between locus coeruleus NE and the SNS.

Noxious and non-noxious thermal sensory stimuli also provide information regarding the relationship between the SNS and NE. These stimuli cause a parallel increase in the locus coeruleus NE and the SNS, which is accompanied by increases in blood pressure and heart rate (Elam et al., 1986a). NE responses to both noxious and non-noxious cutaneous stimulation is of further interest because both the central (locus coeruleus-NE) and the peripheral (NE-sympathetic) sympathetic systems respond virtually identically to these tactile stimuli, indicating a

consistency in the relationship between the SNS and NE. Elam et al. (1986a) claimed their study provided additional support for the hypothesis concerning the locus coeruleus NE control of sympathetic behavior, and thus provided further support for a relationship between NE and the SNS.

Norepinephrine is also used to indicate decreased SNS activity with NE suppression (Roy-Byrne et al., 1988) and increases in SNS activity with emotional stress is related to increases in NE (Lake et al., 1976; Hadley, 1984; Lake et al., 1985). The use of NE to indicate SNS activity suggests an intimate association between NE secretion and SNS activity.

Another reflection of this interaction between NE and the SNS is indicated when one compares NE levels taken from "normal" subjects sitting and standing. When standing, the NE levels almost double (Lake et al., 1985) indicating that NE increases with increases in SNS activity.

An increase in NE also occurs with stress, arousal and increased sympathetic activity (Barr et al., 1983). Thus, a novel or stressful environment will correlate positively with sympathetic functioning throughout the body (Elam et al., 1982). In conclusion, the literature reviews regarding NE and the ANS have revealed a definite association between the ANS and NE, i.e., NE secretion increases with increased SNS activity.

Research concerning anxiety has also provided supportive evidence of the relationship between the SNS and

NE. A consistent positive relationship appears between anxiety, NE, and SNS activity (Elam et al., 1982). Research has found that not only does NE increase during stressful situations (Ida et al., 1985) but so does the SNS (Wallin et al., 1981; Elam et al., 1982; Heninger et al., 1988). Elam et al. (1982) suggested that the positive correlation found between central (locus coeruleus) and the peripheral NE (sympathetic neurons) is supportive of the theory that anxiety is associated with NE secretion in both the central and the peripheral NE sympathetic systems. These findings again provide evidence of an association between NE secretion and SNS activity.

In light of the relationship between NE and the SNS, there is good reason for using plasma NE levels as a diagnostic tool in evaluating SNS responsitivity (Lake et al., 1985).

Norepinephrine and the Right Hemisphere

From a hemispheric and hemisphericity perspective NE is especially interesting since it seems involved in the lateral hemispheric organization of the nervous system by virtue of its own asymmetric presence in the brain. The search for metabolic and biochemical asymmetries in the brain is a growing area of research associated with the study of functional hemispheric asymmetry (Oke et al., 1978; Amaducci et al., 1981; Gainotti et al., 1982; and Flor-Henry, 1985b).

The work of Oke et al. (1978) with rats was the first to show a NE asymmetry in the brain. They noted that greater amounts of NE were found on the right than on the left side of the thalamus. The thalamus plays an important role in the maintenance and regulation of consciousness, alertness and attention (Barr et al., 1983).

Evidence from neuropathology also bears on the problem of NE asymmetry. Tucker et al. (1984) cite several studies showing an association between right hemisphere frontal lesions and decreased levels of NE (Robinson, 1979; Pearlson et al., 1981). These lesions actually decreased production of NE in its major source, the locus coeruleus, suggesting that the right hemisphere may have a role in the production of NE and that a relatively active right hemisphere (in a hemisphericity sense) might be associated with a higher overall level of NE. Interestingly, corresponding lesions in the left hemisphere did not have these results.

Pharmacological studies are also relevant to the NE/right hemisphere association. It has been shown that drugs which increase right hemisphere activity also produce an increase in NE (Tucker et al., 1984). Decreases in NE are associated with the affective disorders, i.e., depression (Major et al., 1984; Linnoila et al., 1988) and during depression there is a decrement in skills involving right hemisphere performance. Drugs which alleviate depression increase NE levels and lead to better performance on right hemisphere skills (Tucker et al., 1984). Manic

episodes, the reverse of depression, are associated with increases in NE (Safer et al., 1977). Drugs which control manic episodes also reduce elevated NE. In a study of children treated for depression with NE enhancing drugs there was an improvement in right hemisphere cognitive processes (Tucker et al., 1984).

Norepinephrine and the Lateralization of Neural Arousal

The dual arousal system concept is a broad framework which brings together the interactive functioning of the right hemisphere, NE and the SNS in a manner which makes it plausible to discuss their relationship in conjunction with hemisphericity, and in particular, the relationship between right hemisphericity and NE. Further, the hemispheric asymmetry of neurotransmitters, such as NE, is compatible with the concept of dual arousal systems. First, a review of Pribram et al.'s and McGuinness et al.'s theories will be presented followed by Tucker et al.'s and then Flor-Henry's theories. As noted above, this review will make it feasable to argue for an exploration of a relationship between hemisphericity and the hemispheric asymmetry of biochemicals.

Briefly, results from the neurological studies have indicated that the two hemispheres operate with different arousal systems, utilizing different neurotransmitter systems (Pribram et al., 1975; McGuinness et al., 1980; Koella, 1982; Tucker et al., 1984). Pribram et al. (1975) recognized these two systems as mediating perceptual input

and motor readiness. They labelled these two arousal systems arousal and activation; and McGuinness et al. (1980) claimed that the hippocampus is responsible for coordinating the two systems.

Pribram et al. (1975) defined the arousal system as a phasic response to new or novel input which corresponds with both right hemisphere activity, NE secretion, and SNS activity. They identified the right hemisphere's mode of operation as the process of habituation and further claimed that NE increases the right hemisphere's ability to attend to novel stimuli. Conversely, the activation system maintains a constant readiness or vigilance for repetitive input which McGuinness et al. (1980) claimed corresponds with left hemisphere activity and dopamine (DA) secretion.

Not only are the two arousal systems based on different neurotransmitter systems, but each system responds uniquely to different types of stimulation. Locus coeruleus NE neurons respond to novel stimuli and decrease their firing in response to repetitive stimulus, i.e., increasing the process of habituation; conversely, neurons in the DA pathway increase their firing in response to continued repetitive stimulus (Pribram et al., 1975, McGuinness et al., 1980; Tucker et al., 1984). Further, the right hemisphere NE arousal system responds to external stimuli with perceptual arousal, whereas the left hemisphere DA system is an internally controlled mechanism associated with motor movement.

Lorden et al. (1980) agreed with McGuinness et al. (1980) and claimed that the locus coeruleus NE innervates the hippocampus which, as noted above, is identified as the coordinator of the two arousal systems. This suggests that NE actually mediates the entire system. Lorden et al. (1980) further claimed that increased locus coeruleus-NE, i.e., which corresponds with the right hemisphere, acts as a filter to screen out irrelevant information from the stimulus flux, thus allowing for selective attention, especially when focusing on novel stimuli; all of which correspond with right hemisphere processing.

Several others have also considered the concept of dual neural arousal systems, including Tucker et al. (1984). Following an impressive history of research using the functional hemispheric asymmetry (FHA) approach, Tucker et al. (1984) provided an extensive literature review supporting their proposal of asymmetric neural control systems related to the left and right hemispheres. Together, they presented an article reviewing extensive evidence that identifies similarities between the hemispheric asymmetry of the arousal systems and the asymmetry of neurotransmitters (Tucker et al., 1984). As did Pribram et al. (1975), Tucker et al. (1984) claimed two arousal systems: the arousal system, which corresponds with right hemisphere activity, NE secretion and emotions; and the activation system, which corresponds with left hemisphere activity, DA secretion and motivation. They

proposed that each system stems from different neural
sources; projects through different channels; mediates
different conditions; and thus, provides different
functions.

Pribram et al. (1975), McGuinness et al. (1980) and
Tucker et al. (1984) all elaborated on the physiology of the
right hemisphere's arousal system identifying the locus
coeruleus as the primary source of neural NE. The locus
coeruleus NE neurons have extensive connections throughout
the brain which project to the frontal cortex innervating
the limbic (i.e., hippocampus, amygdala, anterior olfactory
cortex), thalamus and hypothalamus, and the neocortex
(especially the parietal and occipital lobes). These
neurons are important to short term phasic fluctuations of
arousal, and appear especially responsive to novel
environmental stimuli (Pribram et al., 1975; McGuinness et
al., 1980; Aston-Jones, 1981). The finding that this right
hemisphere arousal system is associated with NE and the
limbic system, provided further support of the above
mentioned relationship between emotions, affective
disorders, the right hemisphere and NE.

According to McGuinness et al. (1980), the reticular
activating system is the neural system responsible for
regulating the arousal of the right hemisphere and orienting
to novel stimuli. Conversely, the DA based, left hemisphere
activation system originiates in the substantia nigra and
the DA neurons project to and innervate the basal ganglia -

extrapyramidal system. These findings support a relationship between the activation system and the left hemisphere, DA and the extrapyramidal system. Further, these findings are supported clinically. For instance, the left hemisphere's, DA activation system is related to motor readiness and motor dyscontrol, e.g., Parkinson-like behavior occurs with decreased DA and a dysfunctional extrapyramidal system (Lake et al., 1985).

Not only are the systems associated with different hemispheres and different neurotransmitters, but they also function differently. For instance, Tucker et al. (1984) agreed with Aston-Jones et al. (1981) regarding increases in NE activity in response to environmental/novel stimuli and which provides widespread phasic alertness to incoming perceptual data. They associated the right hemisphere NE arousal system with perceptual, spatial stimuli and claimed that the NE system is maintained by a sensitivity to habituation. Conversely, they associated the left hemisphere DA system with repetitive activity and/or repetitive stimuli, thus apparently maintaining a tonic readiness for restricted, practiced, organized, motor activity. Tucker et al. (1984) agreed with both Pribram et al. (1975) and Lorden et al. (1980) who suggested that the hippocampus is responsible for regulating these two systems. In summary, the right hemisphere NE phasic arousal system responds to external, perceptual, novel input, by increasing habituation; whereas the left hemisphere DA tonic activation

system responds to internal, repetitive, stimuli with sequential, routinized, motor behavior.

Tucker et al. also acknowledged, as mentioned above, that NE appears to act as a widespread inhibitor, reducing background cell activity, thereby augmenting selective attention. On the other hand, DA appears to affect motor activity by maintaining a tight control over specific areas, thus providing a strict organization of behavior. Consequently, the hemispheric asymmetry of the arousal systems in general, the processes of the systems, and the functions and the neurotransmitters associated with the systems all combine to provide support for the concept of dual arousal systems.

Backon (1981) also supported the concept of dual hemispheric arousal systems and labelled them the drive and motivation systems. He incorporated the ANS into his theory and presented further theories concerning an interactive biochemical system to explain how the systems functioned. In accordance with this paper, Backon also associated the ANS with the hemispheres, i.e., greater SNS activity occurs with the right hemisphere arousal system and greater PSNS activity occurs with the left hemisphere system.

The clinical data also support the dual arousal hypothesis. For instance, Shapiro's (1965) interpretation of the hysteric personality is consistent with the right hemisphere arousal concept. According to the above, the right hemisphere arousal system attends to novel stimuli and

Shapiro claimed that a hysteric has a strong tendency to become caught up in novel situations, form new relationships impulsively, and repeatedly change his or her living situation. Due to the hysteric's constant need for change and novel stimuli, his or her relationships are superficial and short-lived. As noted earlier, the person with right hemisphericity habituates rapidly and has poor vigilance. Extreme examples of these right hemisphere characteristics identify the hysteric personality, and thus link right hemisphere psychopathology with right hemisphere characteristics and with the right hemisphere arousal system. In addition, Smokler et al. (1979) also associated the hysteric personality with hemisphericity, i.e., hysteric personalities are more likely found among people with right hemisphericity than people with left hemisphericity. These findings provide support for a relationship between hemisphere characteristics and arousal systems, i.e., attention to novel stimulus and the arousal system, both of which are attributed to right hemisphere functioning. Further, NE corresponds with the right hemisphere, the arousal system, and the orienting reflex. Thus, clinical data support the dual arousal hypothesis.

Studies concerning aviation pilots and catecholamines are also consistent with theories that correlate NE secretion with abilities attributed to the right hemisphere. Night landing on a moving carrier is considered the most difficult piloting task, requiring precise perceptual and

spatial orientation, both characteristic of right hemisphere functioning. MHPG, a metabolite of NE, was found to vary with the difficulty of the piloting task (Van Toller, 1983) thus providing another field of study supporting a relationship between NE and right hemisphere activity.

After considerable work regarding NE and its relation to various right hemisphere disorders, Flor-Henry (1985) went on to discuss the functioning of two arousal systems at a higher and more complex level of functioning. He also proposed an intricate interaction between DA and NE based on findings indicating that DA is lateralized to the left hemisphere and NE is lateralized to the right hemisphere.

The following is a biochemically based concept of a dual neural system featuring NE and DA with a basis in Pribram et al.'s framework but extended by the work of Flor-Henry. As previously discussed by Tucker et al. (1984), Flor-Henry (1985) also proposed that the neurotransmitters DA and NE are associated with specific hemispheres, i.e., NE corresponds with the right hemisphere and DA corresponds with the left hemisphere. Note, these proposals do not suggest that a given neurotransmitter is found only in one hemisphere, but rather, greater amounts of that neurotransmitter is found in one hemisphere and/or that the same neurotransmitter fluctuates with activities associated with that hemisphere. Flor-Henry identified the right hemisphere as primarily excitatory and the left hemisphere as primarily inhibitory and further proposed that a

reciprocal relationship exists between left hemisphere DA
and right hemisphere NE which is mediated by the
cholinergic-NE relationship. For example, acetylcholine
(ACh) activation correlates with the left hemisphere
neurotransmitter DA, i.e., ACh increases with decreases in
DA. The latter allows for increased gamma-aminobutyric
(GABA) inhibition which in turn increases left hemisphere
inhibition. In addition, ACh also interacts with right
lateralized neurotransmitters. Although greater amounts of
ACh occur in the left hemisphere (Flor-Henry, 1985b), ACh
increases correspond with decreases in the right lateralized
NE. The decrease in NE provokes increases in the right
hemisphere serotonin, and thus increases overall right
hemisphere inhibition. Conversely, left lateralized DA
increases provoke a reduction of the left hemisphere
inhibitor GABA, reducing the left hemisphere's inhibition of
the right hemisphere. Further, DA increases occur with ACh
decreases and NE increases, and consequently, decreases of
the right hemisphere inhibitor, serotonin.

Working in reverse, increases in right hemisphere NE
occur with decreases in serotonin inhibition allowing for
right hemisphere excitation, and contralaterally, left
hemisphere over-excitation. A clinical example of this was
briefly presented above with regard to the role of NE in
schizophrenia. Recall that both NE and DA were elevated in
acute schizophrenia which was attributed to either enhanced
DA activity after NE depletion or Flor-Henry's theories

regarding the interactive reciprocal systems. In Flor-
Henry's account of the interactive neurotransmitter systems,
increased right hemisphere NE activity may over-excite the
left hemisphere DA activity which would result in
schizophrenia.

The physiological and psychological characteristics
associated with the right hemisphere established from a FHA
approach, both interact with and support the concepts of a
hemispheric typology, clinical asymmetry, and the dual
arousal approach. The FHA approach identified the
cognitive, psychological, physiological, clinical and
personality characteristics that are attributed to the right
hemisphere. The hemispheric typology approach claims that
people with a right hemisphericity are more likely to reveal
these same cognitive characteristics, i.e., creative,
analogue, parallel, holistic, perceptual processes, as well
as, personality, psychological, clinical and physiological
characteristics that correspond with right hemisphere
activity than the complementary characteristics that
identify left hemisphere activity. Thus, the studies from
the FHA approach and hemispheric typology approach are
consistent with each other. The physiology approach
incorporates both the association between the biochemicals
and the hemispheres (i.e., NE and right hemisphere
activity), and the psychopathologies and the hemispheres
(e.g., depression and hysteria and the right hemisphere)
supporting both the FHA approach and the hemispheric

typology approach. Finally, the dual arousal approach identifies a right hemisphere arousal system based on the asymmetrical neurotransmitter NE. This proposed arousal system utilizes all of the above-noted characteristics and processes and thus provides a framework for further study of the hemispheres.

Pribram et al. (1975) presented the orienting reflex as an example characteristic that involved and supported all the above approaches. The FHA approach indicates that the right hemisphere alerts or attends to novel stimulus and has a NE base; the hemispheric typology approach suggests that those with right hemisphericity have greater novelty in their lives; the physiology approach indicates that as with the classic orienting response, arousal is augmented with increasing novelty or complexity of the stimulus and greater NE and SNS activity. Tucker et al. (1984) further claimed that this novel orienting process is based on an arousal system that utilizes an habituation bias and allows for the following: one, a broad attentional coverage taking advantage of a wide scope of data; and two, allows processing of the information across parallel operations, all characteristics of the right hemisphere according to the FHA approach. The hemispheric typology approach and CLEM research also contribute here. If the right hemisphere is superiour for creative, analogue, parallel, holistic, perceptual processes, then those with right hemisphericity are more likely to perceive novel data in an holistic

fashion, using a topographical orientation, and then
creatively organize the information into parallel frameworks
using an analogue system (Bradshaw et al., 1981; Tucker et
al., 1984). Thus, the right hemisphere takes new
information and processes these data in a parallel mode,
enabling a generation of multiple representations of the
information. This allows the individual to create new
patterns and constructs (Tucker et al., 1984). Furthermore,
NE's extensive connections throughout the sensorimotor,
visual, and auditory associative cortex regions allow for a
creative organization of novel stimuli. The NE system
encourages an orientation to novel stimuli, whether it
consists of different people, employment, habitat, places,
hobbies or concepts. Subsequently, the right hemisphere
constructs new frameworks and/or reorganizes old constructs.
Thus, the right hemisphere is suited for creative problem
solving. In summary, each research approach interacts with
and is consistent with other approachs, e.g., biochemical,
physiological, psychological, etc., thus providing further
support.

Again, although we attempt to attribute various
functions to specific neurotransmitters or transmitter
systems, it is important to recognize that the brain works
as a unit. Consequently, when one aspect of the unit, e.g.,
NE, increases or decreases its function, it affects many
other units, e.g., DA, within the system.

In summary, despite the interactive complexity of the neural system, the theories and evidence presented on these dual arousal systems suggest that NE indeed corresponds with right hemisphere activity. Furthermore, recall Bogen's definition of hemisphericity, Bakan's theory relating CLEM and hemisphericity, and the subsequent studies regarding hemisphericity. In each account the following claims were made: people within each hemisphericity group have significant similarities; and, reveal greater similarities to the anatomical, physiological, cognitive and personality characteristics of of that same hemisphere than of the contralateral hemisphere. Assuming a correlation between hemisphere characteristics and hemisphericity, i.e., those with right hemisphericity have more of the right hemisphere characteristics, these findings provide support for the hypothesis that individuals with right hemisphericity should have greater blood plasma NE. It is thereby possible that people within each hemisphericity group are not only more comfortable with a given hemisphere's processes and characteristics but also have greater amounts of the biochemicals associated with that same hemisphere.

Cortisol

A second neurochemical whose blood plasma level is examined with respect to CLEM defined hemisphericity in this dissertation is cortisol (C). A case can be made for laterality in the functioning of C just as has been made for NE. In some ways C lateralization appears to be opposite to NE, i.e., the available evidence suggests a C/left hemisphere association just as it suggests a NE/right hemisphere connection. Extending this to hemisphericity leads to an analogy: right hemisphericity is to relatively elevated NE as left hemisphericity is to relatively elevated C.

What Cortisol Is

Cortisol is not a classical neurotransmitter as is NE. Cortisol is the main glucocorticoid hormone produced in the adrenal cortex. Cortisol secretion increases in response to stressful stimulation and is associated with the hypothalamus-hypophyseal (pituitary)-adrenal axis (HHAA). Physical exercise and intense muscular work resulting in decreases of energy stimulate the synthesis and release of C. There is evidence that the components of psychological stress important in stimulating C are emotional ego-involvement and a suspenseful anticipation of noxious events (Kirschbaum et al., 1989).

Cortisol has an active part in the HHAA system, but information is required regarding how C interacts with neurotransmitters, thus enabling an exploration of how C is

associated with the hemispheres, and subsequently, with
hemisphericity.

When C is secreted from the adrenals, it travels back
to the hippocampus which subsequently provokes a response in
the hypothalamus, i.e., decreasing corticotrophin releasing
hormone (CRH). This HHAA feedback loop has the same effect
as NE on the secretion of C, i.e., C decreases. Further
studies have revealed an association between DA and C.
Rothchild et al. (1984, 1989) found a positive correlation
between C secretion and DA secretion. In addition, NE
effects an indirect decrease in C secretion from the NE rich
hypothalamus, whereas DA provokes an increase in
adrenocorticotrophic (ACTH) secretion from the DA rich
pituitary, thus indicating an inverse relationship between
NE and C, and a positive relationship between DA and C.

Cortisol's Relation to Norepinephrine and the Autonomic System

Incorporating data regarding the ANS, we find that as
the SNS is associated with NE, so is the PSNS associated
with the cholinergic neurotransmitter ACh (Hadley, 1984).
Acetycholine, which is inversely related to NE, is known to
provoke both CRH secretion in the hypothalamus and ACTH
secretion in the pituitary (Jones et al., 1979; Muller et
al., 1989). This again indicates an inverse relationship
between NE and C.

Although both C and NE appear related to stress,
various researchers have claimed that the two biochemicals
are related to different types of stress. For instance,

Vernikos-Danellis et al. (1975) and Rodin (1980) found that C decreased with an increase in perceived personal control. Conversely, Henry (1980, 1983) found that when subjects perceived a loss of control there was a corresponding increase in C. On the other hand, increases in NE occur with the fight-flight concept of stress, which is related to the SNS-adrenal-medullary system. As noted above, both the NE secretion and SNS activity are related to right hemisphere activity. Accordingly, researchers who studied right hemisphere activation during stress, i.e., Tucker et al. (1977) and Tucker (1978a) invoked a SNS-right hemisphere type of stress. The finding that C decreases and NE increases correspond with the fight-flight type of stress is again consistent with an inverse relationship between NE and C (Long, 1986a, 1986b). Thus these dual stress-arousal systems are consistent with the concept of separate systems for NE and C which, in conjunction with the above noted patterns, suggests a possible underlying hemispheric asymmetry for C.

Wittling et al. (1990) identified another source of research which is consistent with the theory that the right and left hemispheres mediate C differently, and perhaps, in accordance with the type of data processing. They found that when the right hemisphere was presented with an emotionally aversive film, using a technique which lateralizes visual stimuli, there was an *increase* in C. Secondly, when the left hemisphere was presented with the

same emotionally aversive film, C *decreased*. Thirdly, when presented with a neutral film, C decreased in both hemispheres. Wittling et al. claimed their findings suggested that the emotional content is dealt with by the right hemisphere, and not the left hemisphere and concluded, that the regulation of C in emotion-related situations is under control of the right hemisphere. Of importance, however, is that the regulation of C is mediated differently by the hemispheres in the same situation. When the film was presented to the emotion processing right hemisphere, the increases in C may have come from a sense of lack of control over the presentation of ECT administration to patients shown in the film. Conversely, when the aversive film was presented to the left hemisphere, a more analytical response to the film was revealed, *not* resulting in a lack of perceived loss of control and thus not requiring an increase in C, but rather a decrease. Thus, both hemispheres respond to the emotional film in their own way, each mediating the C secretion differently.

The results are consistent with Dimond et al.'s (1976) findings regarding asymmetric presentations of various emotion-packed films. The latter found that the ratings of the film depended on the hemisphere it was presented to. When presented to the right hemisphere, the viewers rated the films more negatively, thus producing a greater emotional response. This would emphasize the sense of loss of control and thus provoke C secretion. Further, when the

film was presented to the left hemisphere C decreased below baseline levels. A decrease below the baseline is a response. Thus, extending Wittling's claim, i.e., only the right hemisphere mediates C differently between the emotion and non-emotion presentations, the results also indicate a C response to both films for both hemispheres. As suggested earlier, the left hemisphere responds with greater analytical processing whereas the right hemisphere responds with greater emotional processing. Thus, perhaps C decreases when certain types of left hemisphere cognitive processes occur, i.e., analysis and recall of perceptual stimuli.

Studies which involved the SNS, are also consistent with the theory that C and NE have opposite or at least complementary roles. For instance, Charney et al. (1986) found that when greater SNS activity occurred during panic attacks, subjects who experienced the greatest anxiety and fear, also had the greatest C decreases. Conversely, NE increases with increases in panic attacks and SNS activity. Indicating again that the type of emotion/stress response determines the activity of the inversely related NE and C, and further, that C decreases with SNS activity.

Frankenhaeuser et al. (1980) found that sympathetic-adrenal NE increased and HHAA C decreased in response to achievement demands. This is consistent with an inverse relationship between NE and C.

In summary, as NE corresponds with with right hemisphere activity, SNS activity, and the hypothalamus; so does C negatively correspond with the same. Further, C decreases during SNS activity whereas NE increases. In addition, although both NE and C appear related to stress concepts, i.e., fight-flight and personal control, evidence indicates that the two biochemicals operate inversely during each type of stress.

Stress and arousal also reveal the different roles that C and NE have in our system. There are two arousal systems associated with stress: the HHAA C secreting system, and the SNS-adrenal medulla NE secreting system, both discussed above. Both systems increase biochemical secretion during stress, but the literature reveals that different types of stress provoke different biochemical systems, i.e., C increases with a perceived loss of personal control whereas NE increases with the SNS fight-flight response (Henry et al., 1977; Ursin et al., 1978: Rodin, 1980). Frankenhaeuser et al. (1983a, 1983b) suggested that NE based stress is effort related, i.e., it corresponds with both SNS activity and the emotional processing of the right hemispehere; whereas the C based stress is related to distress, i.e., it corresponds with the analytical processes of the left hemisphere. Further, when effort and distress are both experienced, both systems are provoked resulting in a positive correlation between NE and C.

Another set of variables which suggest C has an asymmetric bias concerns the use of oral contraceptives. First, Prochnau (1983, 1985) found that use of oral contraceptives among females correlated significantly correlated with hemisphericity, i.e., those who used oral conceptives for a prolonged period were more likely to present a left hemisphericity. Later, Linden et al. (1987) found that women on birth control pills had consistently elevated levels of C. This is consistent with the hypothesis that prolonged oral contraceptive use increases C secretion which subsequently increases left hemisphere activity. Prochnau (1985) found that those subjects with left hemisphericity claimed prolonged oral contraceptive use. These findings open up a wide field for speculation and research regarding the cause of hemisphericity and the possibility of chemically altering it. These findings also provide support for a possible relationship between hemisphericity and asymmetric biochemicals.

Individually, these findings regarding the inverse relationship between C and NE are insufficient to justify a theory of dual hemispheric asymmetry for NE and C on their own because an inverse relationship can occur between biochemicals that are lateralized in the same direction. If the findings are taken together, however, they do provide support for both an inverse relationship between C and NE and a dual asymmetric hemisphere association. One can thus

hypothesize that greater C secretion occurs with left hemisphere activity than with the right hemisphere activity.

To summarize, the right hemisphere and SNS-related NE inhibit C secretion at all levels of the HHAA. Further, NE is negatively correlated with C both during depression and anxiety. Conversely, the left hemisphere DA and ACh provoke C secretion in both the hypothalamic and the pituitary components of the HHAA. In addition, although both NE and C are related to stress, they are related to different types of stress. These different types of stress may in turn be related to the different hemispheres. As well, one might suggest that as a correlation may exist between hemisphericity and NE (i.e., people with right hemisphericity and greater NE secretion), a parallel correlation may exist between hemisphericity and C (i.e., people with left hemisphericity and greater C secretion). Further elaboration will follow below.

Cortisol and the Lateralization of Neural Arousal

Although the concepts concerning dual arousal were considered earlier with regard to NE, they will be reviewed again more extensively, incorporating C.

There are several parallel characteristics between the hemispheric typology and the hemispheric asymmetry of the neuroendocrine system. The primary focus of this section is the association between the hemispheres and the lateralization of biochemicals.

First, a brief discussion will identify the dual
arousal system, with regard to the hemispheres, biochemicals
and associated variables. Second, a brief review will
outline how these variables assist the individual
hemsisphere in processing information. A final presentation
will incorporate all the evidence, presenting a case
supporting an exploration of a relationship between
hemisphericity and the hemispheric asymmetry of
biochemicals.

Two Arousal Systems

In consideration of the unique psychological and
physiological characteristics attributed to each of the
hemispheres, the organization and mediation of such a
complex system came under question. In response, various
researchers have proposed dual arousal brain systems.

As previously noted, with regard to NE and neural
arousal, Pribram et al. (1975) and McGuinness et al. (1980)
suggested two arousal systems identified as arousal and
activation. They proposed that each system is associated
with different neural paths and that the hippocampus is
responsible for coordinating the two systems (Pribram et
al., 1975; McGuinness et al., 1980). In addition, the
systems interact with different neural regions and specific
nuclei. Pribram et al. (1975) and McGuinness et al. (1980)
claimed that the phasic arousal system corresponds with
right hemisphere activity where neurons increase their
firing in response to novel stimuli and decrease their

firing when presented with repetitious stimuli. They claimed that the limbic system modulates the hypothalamic arousal system. Further, they suggested that the tonic, activation system corresponds with left hemisphere activity where neurons increase firing when presented with repetitive stimuli and is controlled through the basal ganglia and extrapyramidal system.

On the basis of this brief description, the next section will elaborate on the processes and biochemicals equated with the activation system, DA and C, and the left hemisphere.

Left Hemisphere, Activation and Cortisol

In contrast with the right hemisphere's arousal system which is characterized by NE secretion, SNS activity, phasic processing, and a novel stimuli orientation, is the left hemisphere's activation system which is characterized by DA secretion, PSNS activity, tonic processing, and a repetitive, motor, logic-based orientation, and indirectly linked with C. Further, Pribram et al.'s (1975) and McGuinness et al.'s (1980) typology asserts that the right hemisphere's arousal system complements the left hemisphere's activation system. In contrast to the right hemisphere system, with its arousal and external orienting aspects, the left hemisphere activation system is directed by an internal mode of orienting. The latter mode of operating supports evidence concerning the left hemisphere's greater vigilance ability.

Further, this activation system increases neural firing with repetitive input, restricting possible organized motor responses to a few well-practiced routines. Pribram et al. (1975) and McGuinness et al. (1980) suggested that this left hemisphere system evolved to maintain a tonic readiness for organized motor action.

Considering that one of the left hemisphere's prime functions concerns motor control, it is not surprising that the activation system is regulated by the basal ganglia and the substantia nigra. The latter are intimately connected with the pyramidal and extrapyramidal motor systems (Tucker et al., 1984) which control the complex motor activity of the right hand. Tucker et al. (1984) presented Cools et al.'s (1970) study, which showed a reduction in muscle tone with increased NE secretion and a corresponding increase in muscle tone with increased DA, as support for the activation system's connection with motor control. Additionally, the basal ganglia DA neurons have a substantial number of connections in the left hemisphere and with the frontal cortex. These findings support DA's involvement with both the motor system and the logical, analytical cognitive properties of the left hemisphere.

McGuinness et al. (1980) claimed that this left hemisphere arousal system is a dopaminergic based system. Dopamine neurons do not extend as extensively as the NE neurons, however, there is an abundance of DA neuron receptors in deep cortical layers, especially in the frontal

lobes. This evidence supports other conclusions that the DA system is important for higher motivational processes (e.g., learning, memory, and attention span) and linear cognitive processes (Glick et al., 1979; Denenberg, 1981; Glick et al., 1982; Van Toller, 1983; Tucker et al., 1984). Abundant amounts of DA are also found in the pituitary. Pituitary DA provokes ACTH which enhances the HHAA system, thus provoking greater C secretion from the adrenal glands. This interactive system is consistent with a positive relationship between C and the left hemisphere related DA.

Tucker et al. (1984) reviewed additional studies that have provided evidence indicating a lack of dopamine neurons caudally, especially in the posterior cortex. Conversely, the right hemisphere NE neurons have extensive connections to the posterior cortex. These findings are consistent with the association between spatial abilities and the right hemisphere, i.e., decreased spatial ability with increased left hemisphere activity and greater spatial ability with increased right hemisphere activity. Further, NE is abundant in the hypothalamus and reduces CRH secretion, thus reducing HHAA activity and subsequently decreasing C secretion. This chain of biochemical effects suggests a negative relation between C and the right hemisphere related DA.

There is widespread evidence to support the claim that the left hemisphere activation system is DA based. For instance, DA's involvement with motor control and activity

is facilatated through the left hemisphere. Although DA activates motor activity, DA regulation also facilitates a tight control on behavior. The left hemisphere activation system facilitates the selection of specific motor behavior, and determines the ordered sequence of that behavior (Tucker et al., 1984). Thus, DA mediates motor activity by restricting behavior to routinized stereotyped actions. This extensive motor control is presumably the basis for the contralateral right hand's superior manual skill ability in the majority of people. Due to the various possibilities regarding the cause of left handedness, the neural systems of left handers will not be explored.

Another finding in support of the left hemisphere's ability to organize sequential motor control comes from studies involving patients with damage to the left hemisphere. Kimura found that patients so damaged had significant disruption of sequencing motor behavior indicating the left hemisphere's important role in sequencing behavior (Kimura, 1977; Tucker et al., 1984). Kimura also suggested that the sequential motor control is especially important in the production of speech, i.e., previously established as a left hemisphere function. In addition, Tomer et al. (1982) found that patients with dyskinesias (uncontrolled motor movements, e.g., Parkinsonian movements) produced a high incidence of right conjugate lateral eye movements during a CLEM test which is

also consistent with the theory that dopaminergic motor control is a function of the left hemisphere.

The ordered, routinized type of motor control also applies to higher order cognitive-motor processing. For example, specific routinized sequential motor skills are required for language. First, the left hemisphere is characterized by the following cognitive characteristics: logical, digital, linear, and analytical. Like a digital system, this hemisphere deals with a limited number of alternatives, compared to the analogue right hemisphere's infinite number of creative possibilities. The left hemisphere system is analytical and logical, reducing stimuli into smaller logical components. Further, analyses proceed in a linear, sequential, and logical fashion. As a consequence, this hemisphere is skilled to provide both linguistically ordered ideation and control of the intricate skills of the right hand.

The left hemisphere's linear mode of processing restricts the information input range, but enables attention to be focused, as opposed to the parallel processing of the right hemisphere. The result is an increase in the degree of analytical processing (Levy, 1969; Bradshaw et al., 1981). The restrictive and focusing aspects of linear processing further support the consensus that the more analytical cognitive abilities are characteristic of the left hemisphere.

When defining stress, Frankenhaeuser et al. (1983a, 1983b) claimed that C is involved in a distress based stress as compared to the SNS-emotional-NE based stress which has been attributed to the right hemisphere. With these definitions one might attribute the distress type of stress to the more cognitive elements of the left hemisphere. As such, there is a relationship between C and the left hemisphere.

McGuinnes et al. (1980) also claimed that the dorsolateral frontal cortex (which has a greater concentration of DA neurons) facilitates more analytical cognitive processing when presented with more repetitive stimuli. Further, the left hemisphere appears to be more active during rote memory than during establishment of new creative memories. Conversely, McGuinness et al. (1980) claimed that the posterior frontal lobe (consisting of a greater concentration of NE neurons) minimizes the redundancy mode. As a result it is more receptive to novel information. The left hemisphere redundancy mode of operation enables an internal control of behavior within a distracting (novel) environmental situation.

Clinical studies also support a relationship between left hemisphere activity, DA and the activiation system. Several studies have found chronically high levels of DA among schizophrenics (Ellinwood, 1967; Meltzer, 1979; Tucker et al., 1984). In addition, studies have also found high levels of left hemisphere activity among schizophrenics

(Serafetinides, 1973; Flor-Henry, 1976; Gur, 1978).
Finally, chronic and acute schizophrenics display a
considerable amount of routinized behavior, e.g., pacing and
dyskinesias, indicative of increased DA. Cortisol is also
associated with clinical disorders that reveal increases in
DA. Increases in both C and DA are found in patients with
psychotic major depression (Rothchild et al., 1989). These
findings suggest that DA and C are associated with the left
hemisphere, i.e., hyper increases in DA and C occur with
greater cognitive impairment in the left hemisphere. In
summary, clinical studies indicate an association between
left hemisphere activity, DA and C, the activation system
and left hemisphere pathology.

In contrast to the right hemisphere, the left
hemisphere is usually described as nonemotional (Schwartz et
al., 1975) in contrast to the emotional characteristics of
the right hemisphere. McGuinness et al. (1980) also agreed
with this construct suggesting that activation and
motivation are intimately related to one another and the
left hemisphere, whereas arousal is important to emotion and
the right hemisphere.

Although we have discussed the left and right neural
arousal systems, functions, and biochemistry as two discrete
systems, they are extensively interconnected, as previously
suggested in Flor-Henry's (1985) reciprocal neurotransmitter
system. Further, Sperry et al. (1980) produced evidence
that an intact corpus callosum integrates information

extensively from both hemispheres. In addition, Glick et al. (1982) claimed that their findings regarding the hemispheric asymmetry of DA indicated that those with less DA tend to be "left-biased" and those with more DA tend to be "right-biased". These findings provide another excellent framework for exploring the relationship between hemispheric asymmetry, hemisphericity and biochemicals suggesting more interactive systems rather than systems with absolute cut-offs.

A more direct relationship between C and the left hemisphere is found in a study by Otto et al. (1991). They found a significant correlation between ear asymmetry and plasma C levels. A greater right ear advantage on a dichotic listening task was associated with higher levels of C. The right ear advantage represents better left hemispheric functioning and this is found when C levels are higher.

Summary

Again, the purpose of this research is to explore the possibility of an association between hemisphericity and neurochemical asymmetry. That is to say, is there an association between an individual's preferred mode of processing and and his/her NE or C secretion.

The introductory examination of relevant studies appears to provide sufficient evidence to support the following claims:

1) That the hemispheric typology alluded to historically and formally proposed by Bakan is valid and that the validity is presented in terms of right and left hemisphericity. Further, that the CLEM test is a valid and reliable indication of an individual's hemispthericity.

2) That the functional hemispheric asymmetry approach has provided sufficient evidence of the hemispheric asymmetry of the biochemicals NE and C.

3) That there is a neurological lateralization of NE and C, i.e., greater NE secretion with increased right hemisphere activity and greater C secretion with increased left hemisphere activity.

To summarize, subjects having a right hemisphericity might also secrete greater levels of blood plasma NE. Likewise, those having a left hemisphericity might secrete greater C.

CHAPTER II

EXPERIMENT ONE: HEMISPHERICITY, NOREPINEPHRINE AND CORTISOL

Method

Norepinephrine

The study from which the neurochemical data were derived was a repeated measures analysis of neurobiological secretions. This study was an attempt to determine the different patterns of neuroendocrine response to laboratory stressors between physically "fit" and "unfit" females. Prior to each session in the two day study, subjects were screened to insure they were not on medications and would follow the necessary instructions. They were instructed to fast overnight but were permitted to consume a light breakfast that did not include coffee, tea or cocoa; subjects were denied use of alcohol, cigarettes or drugs for 12 hours before data collection. Blood samples of NE and C were taken between 7:30 and 10:30 AM, while subjects sat in an armchair with a curtain drawn in front of the blood sampling equipment. Four blood samples were taken during four phases of response: a base rate period; upon presentation of the stressor; after a five minute reaction period; and after a 30 minute recovery period (see Long, 1986a, 1986b)

Plasma NE Assay

Each blood sample was centrifuged as soon as possible at 4470g for 10 minutes in a refrigerated centrifuge (Model TJ-6, Beckman Instruments Ltd., Vancouver), and the plasma was stored at -70 centigrade until assayed.

NE assays, performed by Dr. Richard Wall of the Department of Pharmacology at the University of British Columbia, were a modification of the high pressure liquid chromatography Method II of David, Kissinger, and Shoup (1981).

For the NE analysis, 100 μl of 4.5 x 10^{-4} M dihydroxybenzylamine as internal standard, 20 mg of acid-washed Al_2O_3, 250 μl tris buffer (pH 8.7), and 50 μl 10% EDTA were added to 1 ml plasma in a micro centrifuge tube which was shaken for 5 minutes to absorb the catecholamines to the Al_2O_3. The tubes were spun for 0.5 minutes in an Eppendroff micro centrifuge, and the supernatant was removed. The Al O was washed twice with 1 ml of deionized H_2O. The catechols were desorbed from the Al_2O_3 into 100 μl of 0.1 M HClO . After being shaken for 5 minutes and centrifuged for 0.5 minutes, the filtered supernatant was injected into the high-performance liquid chromatograph system (Model 590 pump, Waters Ltd., Mississauga, Ont., fixed loop injector, ODS Hypersil (5μM) column 125 x 4.6 mm, Shandon Southern Products Ltd., Runcorn, U.K.). The separation was effected using an isocratic solvent solution of 0.1 M potassium phosphate monobasic, 250 μl/l sodium

octylsulfate (40% solution), 600 ul/l of 10% EDTA and 9%
methanol pH 3.83. Potassium phosphate and methanol were
HPLC grade (Fisher) and the other chemicals were reagent
grade. A flow rate of 1.0 ml/min was maintained. The
chromatographed catechols were detected amperometrically at
a carbon-paste detector electrode (TL-3, Bioanalytical
Systems Inc., Layfayette, Ind.) packed with a graphite:
mineral oil paste (CP-O, Bioanalytical Systems Inc.). An
applied potential of +0.7 V versus a silver/silver chloride
reference electrode was maintained with a Metrohm 641VA-
Detector (Brinkmann Instruments Inc., Toronto, Canada). The
resulting chromatograms were recorded on a strip chart
recorder (Canlab), and the data were also analyzed using an
ADALAB interface with Chromatochart Programming (Interactive
Microware Inc., State University, PA) on an Apple II Plus
computer to integrate the areas of each peak.

Calculations of the amount of NE present in each sample
were made using the following formula:

Norepinephrine (pg/ml) =

$$\frac{\dfrac{\text{(area CA) in sample}}{\text{(area DHBA)}}}{\dfrac{\text{(area CA) in spiked PO}}{\text{(area DHBA)}}} \times 1000 \text{ pg}$$

The amount of internal standard recovered from the
multiple pooled samples with the present technique was 51.9
±11.0%. Coefficients of variation were 8% for 10 samples of
pooled plasma. For further detail see (Davis et al., 1981).

Cortisol

Cortisol was measured by radioimmunoassay in the laboratory of Dr. Joanne Weinberg, University of British Columbia using her adaptation of the method of Kaneko, Kaneko, Shinsako, and Dallman (1981). Antiserum was obtained from Radioassay Systems Laboratories, Inc., Carson, CA; tracer $(1,2,6,7,-^3H)$ C was obtained from Calbiochem, LaJolla, CA. Dextran coated charcoal was used to absorb and precipitate free steroids after incubation. Samples were counted in Atomlight obtained from New England Nuclear. Total C (bound plus free) expressed in ug/100 ml was determined by this method. Intra-assay variance was less than 10% and inter-assay variance was less than 15%.

Subjects

A list of the subjects used in Long's stress-neuroendocrine study was obtained from Dr. Long (1986a, 1986b). The subjects were contacted via mail and/or telephone. Each volunteer was presented with an explanation of the requirements for participation in this extended study. The opportunity was given to each subject to make an appointment with the experimenter at either UBC or SFU. A total of 35 subjects met individually with the experimenter at UBC, and two met with the experimenter at SFU.

A total of 37 subjects successfully completed this second study. The subjects ranged in age from 18 to 55, with a mean and median of 32, and a mode of 27. All subjects reported a right handed bias.

Conjugate Lateral Eye Movement (CLEM) Test

The questionnaire used to determine hemisphericity was Bakan's CLEM test. The test consists of 20 thought provoking questions. Day (1967) claimed that the questions presented to the subject must not arouse anxiety, as the effect of anxiety was not known; moreover, Duke (1968) claimed that eye movements occur more often when the subject is presented with questions which require reflective thought. Both criteria were met in the 20 CLEM questions which researchers have frequently used to determine hemisphericity, see Appendix 3.

A scale from 1 - 12 follows each question, and enables the experimenter to keep a record of the initial eye movement each subject makes when presented with each question. The experimenter superimposes the image of a clock on the subject's face, thus enabling the report of 12 possible eye movements. When subjects close their eyes, one can still follow their eye movements; consequently, regular notation of the eye movement is recorded. If the subject stares straight ahead, initiating no eye movement, the scale is left blank. If the initial eye movement is directly up or down, the smallest indication to the left or right determines the noted recording; e.g., if the subject looks directly up and then slightly to his left, it would be recorded as a "1".

The CLEM Rooms

The rooms at both universities were similar with regard to size and lack of stimuli (i.e., blank walls). Doors and windows were located out of the subject's peripheral sight. Each room was organized with the subject sitting across the table, on which a microphone was placed, from the experimenter.

Procedure

Each subject was met and seated at the table in the CLEM room. Each was requested to sign a protocol and consent form, see Appendix 2. The subject was again verbally informed of the procedure used for the CLEM test:

> I am going to ask you a series of 20 questions concerning grammar and proverbs. There are no right or wrong answers so there is no reason for anxiety. Please answer the questions verbally, speaking into the microphone. If you have any questions, please feel free to ask; or if you wish to move on to the next question, we will. Don't allow the microphone to upset you, its only there to pick up anything I might miss.

So as not to make the subject suspicious of the true nature of the study, the experimenter pushed the appropriate buttons on the nonfunctioning tape deck situated on floor. Thus, the subjects, unaware of the nonuse of the tape deck, were more inclined to look at the experimenter while listening to, pondering, and answering the questions. Consequently, the experimenter was able to determine more accurately the subject's eye movements.

As the subject pondered the questions, the experimenter coded the initial eye movement while giving the pretence of

recording their responses. This also helped to eliminate any possible suspicions the subject might entertain concerning the true nature of the recordings.

Upon completion of the CLEM test, the subjects noted their handedness at the bottom of the consent form and were asked whether they had any questions. The questions were answered honestly. It was explained that prior knowledge of the CLEM test eliminated potential volunteers, thus asking the subjects not to reveal to others the nature of the CLEM test.

Results

Responses of 37 right handed females were analyzed in this study. The CLEM measurement was recorded as a ratio for the purposes of the analysis. The total number of right eye movement responses to the questions was divided by the total number of eye movement responses (maximum of 20, minimum of 13). Thus, a ratio exceeding .50 indicated left hemisphericity. There was a total of 21 ratios below .50, and a total of 16 ratios .50 and above.

Correlational Analysis

Correlations between hemisphericity and the neuroendocrine measures were computed. Correlations were computed between hemisphericity, i.e., the CLEM measure, and the plasma measures of the biochemicals NE and C. Five plasma measures were used for each of the biochemicals: base rate; test reaction; 5 minute recovery; 30 minute

recovery; and a combined measure based on the sum of the four measures.

Norepinephrine

Three of the NE measures correlated significantly with hemisphericity: the test reaction, the 5 minute recovery, and the total secretion variables ($r = -0.3238$, $p < 0.05$; $r = -0.3140$, $p < 0.05$; $r = -0.3062$, $p < 0.05$, respectively). The negative correlation indicates a greater plasma NE for females with a right hemisphericity than for females with a left hemisphericity.

Cortisol

The C measures correlated significantly with the CLEM measure at all five stages of analysis, i.e., baseline; test reaction; 5 minute recovery; 30 minute recovery; and total secretion ($r = 0.4398$, $p < 0.01$; $r = 0.4331$, $p < 0.01$; $r = 0.3843$, $p < 0.01$; $r = 0.4191$, $p < 0.01$; $r = 0.4294$, $p < 0.01$, respectively). Thus indicating that plasma C correlates consistently and positively with hemisphericity. The analysis indicates greater C secretion among females with a left hemisphericity than among females with a right hemisphericity.

The opposite directions of the correlations for plasma NE and C indicate that the plasma levels of NE increase with right hemisphericity and that the levels for C increase with left hemisphericity.

Norepinephrine and Cortisol

Norepinephrine's negative correlations with and C's positive correlations with the CLEM measure suggests that there should be a negative correlation between NE and C. This was found for all correlations between NE and C, but only the 'test reaction' value approached significance ($r = -0.2918$, $p < 0.10$).

Both NE and C levels are significantly correlated with hemisphericity. Cortisol increases and NE decreases with left hemisphericity. That is to say, there is a positive correlation between right hemisphericity and plasma NE: and between left hemisphericity and plasma C.

ANOVA Results

Two groups were constituted for an ANOVA, a right hemisphericity (left mover) group and a left hemisphericity (right mover) group. The right hemisphericity group included those subjects with CLEM scores between 0 and 40. The left hemisphericity group included those subjects with CLEM scores between 60 and 100. Consequently, those subjects with an ambihemisphericity, i.e., CLEM scores between 41 and 59, were eliminated. The right hemisphericity group consisted of 15 subjects and the left hemisphericity group consisted of 12.

ANOVAs revealed that both NE and C differed between the right and left hemisphericity groups. However, whereas the analyses indicated that NE was not signicantly different at every stage of analysis, C was significantly different at

every stage of analysis. Further, although the interaction
between hemisphericity and the stages of analysis did not
produce significant NE results, they did produce different
patterns. Conversely, the same interaction for C was
significant at each stage. See TABLEs 1 and 3 for the means
of the four measures of NE and C and, TABLEs 2 and 4 for the
ANOVAs.

TABLE 1

TABLE OF MEANS FOR EACH OF THE FOUR NE MEASURES

	1	2	3	4	MEAN
Right Hemisphericity	510.38	533.47	578.97	596.61	554.86
Left Hemisphericity	334.77	297.24	292.53	375.86	336.08
MEAN	432.33	428.48	488.69	480.99	

TABLE 2
REPEATED MEASURES ANOVA FOR NOREPINEPHRINE

SOURCE	SS	DF	MS	F	TAIL PROB
HEMISPHERICITY (A) 1276376.82		1	1276376.82	5.15	0.0321
ERROR	6192581.00	25	247703.24		
REPEATED VARIABLE (N) 77220.07		3	25740.02	1.72	0.1695
AXN	27498.69	3	9166.23	0.61	0.6083
ERROR	1120367.85	75	14938.24		

The means for NE are presented in TABLE 1 and indicate
greater plasma NE for females with right hemisphericity.

Table 2 indicates that the blood plasma NE is significantly different between the two hemisphericity groups, $F(1,25) = 5.15$; $p < 0.05$.

Analyses of the different stages of analysis (repeated variable) and the hemisphericity by stage interaction revealed no significant effects for NE.

TABLE 3

TABLE OF MEANS FOR EACH OF THE FOUR C MEASURES

	1	2	3	4	MEAN
Right Hemisphericity	13.15	15.85	15.19	11.74	13.98
Left Hemisphericity	24.53	24.58	24.36	22.50	23.99
MEAN	18.21	19.73	19.27	16.52	

TABLE 4
REPEATED MEASURES ANOVA FOR CORTISOL

SOURCE	SS	DF	MS	F	TAIL PROB
HEMISPHERICITY (A)	2671.11	1	2671.11	8.87	0.0064
ERROR	7531.26	25	301.25		
REPEATED VARIABLE (C)	150.27	3	50.09	11.58	0.0000
AXC	32.21	3	10.74	2.48	0.0673
ERROR	324.31	75	4.32		

The means for plasma C are presented in TABLE 3 and indicate greater plasma C for females with left

hemisphericity. Table 4 indicates that plasma C is also significantly different between the hemisphericity groups, $F(1,25) = 8.87$; $p < 0.01$. Table 4 also reveals that the C means are significantly different between the four stages of analysis, $F(3,75) = 11.58$; $p < 0.000$. There is a rise from stage one to stage two, followed by a fall from stage two to stage four. The hemisphericity by stage interaction is not significant at the 0.05 level.

Summary

As noted earlier, the correlational analyses indicate greater plasma C and less plasma NE secretion with left hemisphericity. That is to say, greater plasma NE was found for those with right hemisphericity and greater plasma C was found for those with left hemisphericity. In conjunction with the correlational results, the ANOVAs indicate a significant difference between the right and left hemisphericity groups for NE and C. Thus evidence is provided to affirm that there is an association between hemisphericity and the amounts of neurochemicals that are associated with hemispheric asymmetry.

CHAPTER III

EXPERIMENT TWO: HEMISPHERICITY AND PERCEIVED AUTONOMIC ACTIVITY

Rational

The second study of this dissertation is a follow-up and extension based on one of the results of the first study, namely the finding of a relationship between hemisphericity, defined by the CLEM measure and the blood plasma level of NE. It is generally agreed by NE researchers (Lake et al., 1984) that there is a positive relation between NE and autonomic activity, especially the activity of the SNS. There is also some evidence that perception of autonomic activity is related to such activity (Galin, 1974; Luria et al., 1977; Walker et al., 1979, 1982; Davidson et al., 1981; Hantas et al., 1984).

Thus one can set up the following chain of hypotheses:

1) Right hemisphericity is associated with relatively high levels of plasma NE.

2) High levels of plasma NE can serve as an indicator of a relatively high level of SNS.

3) Subjects with a high level of plasma NE will have a greater awareness or perception of symptoms of SNS responses.

4) Therefore it should be the case that subjects tending to make left CLEMs, i.e., subjects with right hemisphericity (and therefore high NE levels

and more sympathetic activity and more sympathetic awareness) should report a greater awareness of sympathetic nervous activity.

The second experiment was designed to test hypothesis number four above, and by implication the chain of hypotheses cited above.

Furthermore, the second study is designed so as to partly compensate for a limitation of the first study, namely that it used only one sex, female subjects. By including males in the second study it was hoped to determine whether sex differences in the hemisphericity/NE association need to be considered. The addition of the sex variable in the second study does not fully compensate for failure to consider sex in the first study, but it does provide at least an indirect approach to the sex/NE/hemisphericity/SNS connection.

Robinson (1985) in a review of various neural asymmetries (neurochemistry, neural lesions, neuroanatomy) was struck by the very small number of studies which addressed the issue of sex differences. Of the studies which included sex comparisons a large majority found sex differences for the studied variables. In studies involving neurochemical asymmetries 94% showed evidence of sex differences.

A brief description of the components of the ANS, i.e., the SNS and the PSNS, and their functions will provide a basis from which to explore the relationship between SNS

activity and both NE secretions and right hemisphere activity; and thus the use of perceived SNS activity as a proxy for NE measures.

The autonomic system refers to that system which extends from the cranial and spinal nerves, innervating exocrine and endocrine glands, as well as, smooth visceral muscles (heart, lungs, stomach, intestines, kidneys, etc.). The ANS consists of two counter-balancing systems, i.e., the SNS and the PSNS systems. The sympathetic system mediates functions associated with arousal, e.g., increasing the heart rate, blood pressure, blood sugar, and directing the blood flow to skeletal muscels. Conversely, the parasympathetic system mediates those functions that occur during the relaxed, vegetative state when the body is conserving and restoring energy, e.g., decreasing the heart rate, lowering blood pressure, augmenting digestive activity, etc. (Carlson, 1977).

Activity of the two components of the autonomic system tend to function out of phase, which follows from their counter-balancing functions. A reaction is elicited from the autonomic systems when the body moves from an PSNS state to an active, SNS state, i.e., orienting, attending, or reacting to novel stimulus. Moving to the active state, the sympathetically controlled cardiovascular reflex responds with immense blood flow shifts accompanied by heart rate acceleration and a respiratory block. These changes combine to emphasize the acceleration effect (McGuinness et al.,

1980). Following the SNS activity, the body decelerates and returns to a vegetative state again, restoring expended bodily resources. This deceleration is controlled by the *parasympathetic system*. The two parts of the autonomic system are thus complementary to each other.

Method

Questionnaires

Autonomic Perception Questionnaire (APQ)

Mandler et al. (1958a, 1958b) developed a self-report questionnaire concerning autonomic perception. The questions concerned awareness of such autonomic activity as visceral activity and skeletal effects. The questionnaire was initially designed specifically as a measure of anxiety; more recently, however, broader use of the questionnaire has occurred as research associates an increasing number of variables with autonomic perception.

Mandler et al. (1958a) found a positive relationship between autonomic activity and its perception. They found that subjects who revealed a higher awareness of autonomic activity revealed significantly more autonomic activity while under stress. Mandler et al. (1958b) replicated Mandler et al.'s (1958a) original findings.

Using the autonomic perception questionnaire, Johansson et al. (1982) found a further positive correlation between actual physiological arousal and perceived arousal among phobic clients.

Peunte et al. (1980) found that the autonomic perception questionnaire was predictive only of the responsiveness of skin conductance (SNS) to stressful stimuli. However, Peunte (1984) found that autonomic perception correlated with psychosomatic disorders, which Galin et al. (1977) and Stern (1977) associated with right hemisphere activity.

Thus, as logic dictates and as evidence supports, perception of autonomic activity correlates with autonomic activity.

The subjects were given the APQ to indicate the extent of their autonomic perception. The questionnaire is a self-report consisting of 21 questions regarding autonomic activity. The subject is required to indicate how aware he/she is of each of the listed autonomic functions, on a scale from 0 to 9. Zero indicates no awareness or no change, whereas nine indicates extreme awareness or change of that function, see Appendix 4.

The ANS, however, is composed of both the SNS (which is corresponds with NE secretion and right hemisphere activity) and the PSNS (which is corresponds with DA secretion and left hemisphere activity). Considering we are attempting to ascertain whether a correlation exists between the ANS and hemisphericity, and in particular, whether sympathetic perception is greater among those with a right hemisphericity, a second questionnaire is required that breaks the ANS down into its specific components.

Stress Audit

The first questionnaire, the APQ, addresses general autonomic perception. The second questionnaire clearly distinguishes between the sympathetic and parasympathetic systems, see Appendix 5. Two of the 14 sections in the Stress Audit (Miller et al., 1985) specifically concern the sympathetic and parasympathetic systems. For the purposes of our study, the administration of these two sections was modified. The Stress Audit instructs the client to indicate, on a scale from one to five, the stress that each of the autonomic symptoms causes him/her. In contrast, the subjects in this study were requested to indicate, on the same scale, the extent to which he/she experiences each autonomic symptom while experiencing stress, thus changing the focus from causal to experiential.

The stress audit is another self-report questionnaire concerning perception of autonomic activity (Miller et al., 1985). However, the stress audit separates autonomic activity into its two components, i.e., sympathetic and parasympathetic. This separation attempts to provide further understanding of the interaction between right hemisphericity, NE, and the autonomic systems, i.e., sympathetic. Are those with right hemisphericity more perceptive of the SNS (the autonomic system being related to NE)?

The original instructions direct the subject to determine how much stress is caused by each sympathetic and

parasympathetic symptom. Alternatively, we requested the subject to indicate how aware he/she is of each symptom while under stress. For the original purposes of the stress audit, the sympathetic and parasympathetic components have an internal consistency reliability between .81 and .88 (Miller et al., 1985). The parasympathetic and sympathetic components, each consisting of 10 questions, have a test-retest reliability of .78 and .79 after one week.

Oldfield's Edinburgh Handedness Inventory

Oldfield's (1971) modified version of the Edinburgh Handedness Inventory provided a self-report measure of the subject's sidedness. The questionnaire consists of 16 questions regarding the use of the hand or foot in specific activities. The subject was requested to indicate a left, right, or neutral side preference for each activity.

Subjects

Volunteer subjects were recruited from SFU Psychology 101 classes. Brief presentations were made in each class explaining: the rights of volunteers; the expectations of each subject; insurance of confidentiality; and that volunteering would in no way effect their course grade.

Volunteer forms, were distributed in each class, with a brief explanation regarding the right to terminate their participation at any time (which three did) and the expectations of each subject. Space was provided at the bottom of the form for name and phone number, see Appendix 1. Attempts to contact all students were made via

telephone. Sixteen declined cooperation leaving a total of 269 subjects. These subjects were given an opportunity to decide the day and the time they wished to participate in the study. After eliminating the left handers and those with ambihemisphericity, a total of 196 subjects remained consisting of 64 males and 132 females.

Conjugate Lateral Eye Movement (CLEM) Test

The room used to administer the CLEM test, was similar to the CLEM rooms used in Part One. The same CLEM questionnaire used in Part One was used in Part Two, see Appendix 3.

Procedure

Each subject was met at the CLEM room, and asked to sign the protocol and consent form, see Appendix 2. The same CLEM test procedure, as noted in Part One, was used for Part Two.

The CLEM test was administered in a separate room and prior to the self-report questionnaires. The second room was made available so that the subjects were able to spread out their questionnaires and relax while completing them. Thus upon completion of the CLEM test, the subject was taken into the second room. She/he received instructions for completing each questionnaire, was asked if there were any questions, and then was requested to complete same. Upon completion, each subject was asked if there were any questions, and if so, given honest answers. Again, if told the true nature of the CLEM test, the subject was requested

not to reveal any information to others as the knowledge would eliminate potential volunteers.

Results

A total of 269 subjects volunteered for this second study, consisting of 96 males and 173 females. In keeping with Part One and other research based on either hemispheric asymmetry and/or hemisphericity, left handers and those subjects falling in the ambihemisphericity group were eliminated. This left a total of 196 subjects consisting of 64 males and 132 females. Subjects identified their age according to categorical groups which revealed that 52% of the subjects were under the age of 20.

The CLEM test was recorded in the same manner as experiment one, and again, subjects indicating bihemisphericity were eliminated. The hemisphercity results were skewed. Overall, seventy-three percent of the subjects revealed a right hemisphericity while twenty-seven percent revealed a left hemisphericity. Seventy percent of the males and seventy-five percent of the females revealed a right hemisphericity as measured by the CLEM test. See TABLE 5.

TABLE 5

SUBJECT NUMBERS

HEMISPHERE DOMINANCE	RIGHT HEMISPHERE	LEFT HEMISPHERE	TOTAL
NUMBERS	144	52	196
PERCENTAGE	73.5%	27.5%	100%

DOMINANCE + SEX	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
NUMBERS	45	99	19	25	64	132
PERCENTAGE	70.3%	75.0%	29.7%	25.0%	32.7%	67.3%

Although the hemispheric skewedness exists, other studies carried out by the same researcher, within the same academic institution, revealed hemispheric symmetry among the volunteers. The only difference between the CLEM aspect of the studies is the orientation of the participants in the rooms (i.e., previously a North-South orientation, as opposed to the current East-West orientation). However, this variable has never been a consideration in previous CLEM research, although it may merit possible future exploration.

Correlational Analysis

The correlational analysis computed between hemisphericity (i.e., using the CLEM measure) and autonomic awareness (i.e., using the responses from the autonomic questionnaires) for experiment two failed to find significant correlations for males and females either together or separately.

ANOVA Results

As with experiment one, two groups were created for
ANOVA analysis, the right and left hemisphericity groups
(the left and right movers, respectively). Additionally,
the sex variable allowed for a 2x2 analysis. The ANOVAs
were used to determine if the autonomic measures were
significantly different between the hemisphericity groups
and/or between the sexes. The dependent variables included
the autonomic perception variables: the APQ, the
sympathetic, and the parasympathetic questionnaires.
Analysis of the APQ variable revealed a significant
difference between the sexes but not the hemisphericity
groups, and no interaction between sex and hemisphericity.
Analysis of the sympathetic and parasympathetic variables
revealed main effects but no interaction for hemisphericity
and sex.

Autonomic Perception Questionnaire (APQ)

Analysis of the APQ variable revealed a significant
main effect for sex, but failed to reveal either a
significant main effect for hemisphericity or a significant
interaction between the two grouping variables.

TABLE 6

TWO-WAY ANOVA FOR THE APQ

APQ MEANS SEX HEMISPHERICITY	MALE RIGHT	MALE LEFT	FEMALE RIGHT	FEMALE LEFT	TOTAL
	87.71	84.31	99.22	104.30	95.99

SOURCE	SS	DF	MS	F	TAIL PROB
SEX (A)	8608.06	1	8608.06	9.53	0.0023
HEMISPHERICITY (B)	24.65	1	24.65	0.03	0.8690
AXB	623.34	1	623.34	1.69	0.4072
ERROR	173463.43	192	903.46		

The above two-way ANOVA revealed a significant main effect for sex, $F(1,192) = 9.53$; $p < 0.01$. The cell means further indicate that females are more aware of their general autonomic reactions than males.

Thus, the APQ failed to reveal a significant main effect for hemisphericity or an interaction between sex and hemisphericity. Considering that the autonomic system consists of both the sympathetic and the parasympathetic systems, further analyses were made to separate the two systems. The following analyses utilized the same grouping variables, i.e., hemisphericity and sex, but made use of the separate sympathetic and parasympathetic data collected from the modified Stress Audit questionnaire.

Sympathetic Questionnaire

As noted previously, the sympathetic component of the autonomic system is often referred to as the arousal system or the fight/flight system. A two-way ANOVA was used to analyze self reports of sympathetic awareness among the subjects, grouping the subjects according to their hemisphericity and their sex, see TABLE 7. The ANOVA revealed a significant main effect for sex, a non-significant main effect for hemisphericity, and no interaction.

TABLE 7

TWO-WAY ANOVA FOR THE SYMPATHETIC VARIABLE

SYMPATHETIC MEANS SEX HEMISPHERICITY	MALE RIGHT	MALE LEFT	FEMALE RIGHT	FEMALE LEFT	TOTAL
	18.00	20.63	22.63	23.88	21.77

SOURCE	SS	DF	MS	F	TAIL PROB
SEX (A)	434.10	1	434.10	11.15	0.0010
HEMISPHERICITY (B)	82.53	1	82.53	2.12	0.1470
AXB	2.91	1	2.91	0.07	0.7848
ERROR	7472.31	192	38.92		

The two-way ANOVA for the sympathetic variable revealed a significant main effect for sex, $F(1,192) = 11.15$, $p < 0.01$, a non-significant main effect for hemisphericity $F(1,192) = 2.12$, $p = 0.15$, and a non-significant interaction

F(1,192) = 0.07, p = 0.785. The cell means indicate a greater awareness of sympathetic functioning among females compared to males; and an insignificant trend in the direction of greater sympathetic awareness among the subjects with left hemisphericity.

Parasympathetic Questionnaire

A similar analysis of the parasympathetic variable is shown in TABLE 8.

TABLE 8

TWO-WAY ANOVA FOR THE PARASYMPATHETIC VARIABLE

PARASYMPATHETIC MEANS					
SEX HEMISPHERICITY	MALE RIGHT	MALE LEFT	FEMALE RIGHT	FEMALE LEFT	TOTAL
	16.93	19.26	20.69	22.18	19.94
SOURCE	SS	DF	MS	F	TAIL PROB
SEX (A)	387.42	1	387.42	9.29	0.0026
HEMISPHERICITY (B)	126.25	1	126.25	3.03	0.0834
AXB	6.19	1	6.19	0.15	0.7003
ERROR	8004.30	192	41.69		

The analysis of parasympathetic awareness revealed a main effect for sex, F(1,192) = 9.29, p < 0.01. The hemisphericity effect was not significant at the 0.05 level though it approaches significance (p = 0.083). The cell means reveal that females have greater parasympathetic perception than males. Subjects with left hemisphericity tend to be more aware of parasympathetic functioning than

those with right hemisphericity though this effect is not statistically significant.

Summary

In summary, the APQ findings failed to reveal a significant hemispheric difference, but did reveal a significant sex difference indicating greater autonomic awareness among females.

The analysis of variance for the sympathetic variable revealed a significant main effect for sex and a non-significant main effect for hemisphericity. The results indicated that females claim greater sympathetic awareness than males.

The analysis of variance for the parasympathetic variable revealed a significant main effect for sex. The results indicated that females claim greater parasympathetic awareness than males. There is an insignificant trend in the direction of greater awareness for the left hemisphericity group.

CHAPTER IV

DISCUSSION

General

The experiments reported in this dissertation were designed to address the problem of neurochemical asymmetry in the brain. The evolution of our understanding of CNS functioning has gone from an emphasis on electrical activity to a more complex dynamic based on neurochemicals, the role of receptors for specific neurochemicals, and brain localization with respect to the production and distribution of specific neurochemicals. The latest development in this progression is concerned with the role of hemispheric asymmetry of neurochemicals in a laterally asymmetrical nervous system. These neurochemical asymmetries may be seen as the molecular basis of the functional hemispheric asymmetries of the brain which have been observed since the time of Broca (Gainotti et al., 1982; Glick et al., 1982; Tucker et al., 1984; Glick et al., 1985; Flor-Henry, 1985). Neurochemical asymmetry in the brain has been shown to be related to a wide variety of psychological functions in areas such as arousal, attention, sexual function, psychopathology, cognitive functions, turning behaviors, immune response, handedness, vestibular functions and visuospatial functions (Previc, 1991).

The present studies aim to extend the lateralized neurochemical approach to the concept of hemisphericity.

Hemisphericity refers to an individual difference approach to hemispheric asymmetry which assumes that individuals differ in the hemispheric organization of the brain in a way which leads to individual differences in relative hemispheric preference. With this approach individuals are said to be relatively right hemisphere dominant or relatively left hemispheric dominant with respect to cognitive, affective, and other areas of functioning. The hemisphericity approach is related to the functional hemispheric asymmetry approach in that the behavior of a relatively right hemisphere dominant individual is expected to show a similarity to right hemisphere functioning and a relatively left hemisphere dominant individual is expected to show a similarity to left hemisphere functioning. This approach has led to an extensive literature which generally supports these expectations (Bakan, 1978; Ehrlichman et al., 1978; Charlton et al., 1989).

Experiment One

The first study reported in this dissertation represents the first attempt to look for differences in blood plasma levels of neurochemicals between subjects classified on the basis of hemisphericity. The neurochemicals chosen, namely norepinephrine (NE) and cortisol (C) were associated with evidence of brain asymmetry in the literature but not with hemisphericity. Evidence of greater plasma NE in the right than the left hemisphere has been reported in several studies (Oke et al.,

1978; Rosen et al., 1984; Denenberg et al., 1985; Glick et al., 1985; Robinson, 1985; Robinson et al., 1985). Similarly there is support in the literature for a relationship between C and the left hemisphere (Glick et al., 1979; Glick et al., 1982; Groves, 1983; Glick et al., 1985).

In view of an NE/right hemisphere relationship and a possible C/left hemisphere relationship, it was predicted that individuals manifesting right hemisphericity would have a higher level of NE than individuals manifesting left hemisphericity, and that individuals with left hemisphericity would have higher levels of C than those with right hemisphericity. The measure of hemisphericity used was a measure of the lateral direction of conjugate eye movements (CLEM) devised for this purpose by Bakan (1969).

The results of experiment one supported the prediction of a positive relationship between the plasma NE level and right hemisphericity and a positive relationship between the plasma C level and left hemisphericity. Thus individuals who differ in the direction of their eye movements, right or left, as they begin to reflect or think about the answer to a question, also differ with respect to the relative blood levels of the two neurochemicals in question.

On the basis of this difference it is reasonable to expect that within individuals there should be a negative correlation between plasma levels of NE and C. This

expectation was confirmed by a trend to negative correlation between NE and C plasma levels.

The NE and C relationships to hemisphericity were supported by two different statistical analyses, correlation and ANOVA. For the correlational analyses all subjects in the sample were used. For the ANOVA analyses two groups were defined, a right hemisphericity group and a left hemisphericity group, thus reducing the number of subjects since those who did not meet the criterion for right or left hemisphericity were not included in this analysis. Despite the reduction in numbers, the ANOVA result for hemisphericity was significant at the 0.03 level for NE and at the 0.006 level for C.

Some of the implications of the newly discovered relationship between hemisphericity and two important neurochemicals will be spelled out, but this discussion must be limited at this time to the female sex. The study made use of an already existing data base of biochemical measures collected from a female sample (Long 1986a, 1986b). These subjects were then recalled for the measure of hemisphericity later on. Therefore the results of experiment one are based on a female sample. To the extent that there may be sex interactions with the neurochemical/hemisphericity dimension the results of this study and its implications need to be limited to females. Findings of sex differences with respect to functional hemispheric asymmetry results (McGlone, 1980) certainly

suggest the possible importance of sex in the field of hemisphericity.

A major implication of the results of experiment one is that it provides important support for the concept of hemisphericity. Historically speaking the concept of hemisphericity is young and has already attracted some criticism (Ehrlichman et al., 1978). The demonstration that "hard" physiological variables at the neurochemical level are significantly related to the CLEM indicator of hemisphericity goes a long way to answering the critics of hemisphericity and the CLEM indicator of hemisphericity. Furthermore the results indicate that in studies where the primary interest is in measures of neurochemicals such as NE and C, experimental designs that take into account hemisphericity variance would reduce error terms and add the possibility of studying interactions.

Another implication of the results is that they suggest a more analytic approach to the study of stress. Both NE and C are associated with stress and increases in these chemicals have been demonstrated with stress. Their negative correlation, and inverse associations with the hemispheres raises the possibility that different kinds of stress may activate two different stress systems, an NE/right hemisphere system and a C/left hemisphere system. Such a view is consistent with the statement by Kirschbaum et al. (1989) to the effect that "suspenseful anticipation (as a consequence of ego-involvement) was associated with

increases of cortisol...while tension alone did not evoke

secretion of cortisol." Interaction between a personality

variable, and C response is also suggested from a study of

children watching a film where it is reported that

> "cortisol patterns were indistinguishable between
> stress and control film when all subjects were
> treated as a single group. However, a distinct
> cortisol response was observed separating children
> with high scores on a trait anxiety scale from
> children with low scores. The latter group had
> decreasing salivary cortisol levels in response to
> both films and the opposite picture emerged with the
> high anxiety subjects" (Kirschbaum et al., 1989)

This kind of interaction between a personality variable and

C responses suggests that similiar interactions between C

and NE responsiveness might be found with hemisphericity as

a variable.

Experiment Two

The second experiment was designed to further explore

the relationship between hemisphericity and NE, by using an

experimental, psychological variable as the dependent

varible as a proxy for the physiological variable of plasma

NE. If right and left hemisphericity subjects differ in

plasma NE levels, as was shown in the first experiment, do

they also differ in their perceived experience of autonomic

responses in general or in sympathetic/parasympathetic

responses in particular?

The logic for a specific predictor that subjects with

right hemisphericity would be more aware of sympathetic

nervous system (SNS) response was based on the following

reasoning. Right hemisphericity is associated with higher

levels of NE; NE is associated with SNS activity; SNS
activity is associated with perception of such activity;
therefore those with right hemisphericity should be more
aware of sympathetic activity. To determine whether this
was limited to sympathetic activity, measures of overall
autonomic activity and a measure of parasympathetic
perception were included. Furthermore experiment two was
desinged to have sex as a variable so that possible
differences between males and females could be explored.

The predicted result was not obtained. In the study of
overall autonomic perception there was no significant
difference due to hemisphericity. Nor were there
statistically significant effects for either sympathetic nor
parasympathetic perception. Though statistically
insignificant, the directional trend for both sympathetic
and parasympathetic perception was such that left
hemisphericity subjects were more aware of both sympathetic
and parasympathetic responses on the Stress Audit. Such a
difference was not reflected in the general Autonomic
Perception Questionnaire (APQ).

In this study neither the hemisphericity as measured by
the CLEM test nor the associated higher levels of NE found
for the right hemisphericity subjects are reflected in the
predicted direction for perception of sympathetic responses.

There was a strong and consistent sex difference in all
three mesures of autonomic perception, the APQ measure of
general autonomic perception and the Stress Audit measure of

both sympathetic and parasympathetic perception. In all cases females showed a greater awareness of autonomic functioning. This finding is not relevant to the present study, especially since none of the sex by hemisphericity interactions either reached or approached significance. This difference is likely due to a greater sensitization of females to bodily signals of all kinds, possibly related to the course of bodily changes associated with menstrual cycle endocrinology.

<u>Summary</u>

In summary, experiment one revealed that hemisphericity as defined by Bogen and as measured by Bakan's CLEM test was associated with two important neurochemicals in a sample of 37 females, i.e., right hemisphericity females secrete significantly more blood plasma NE than left hemisphericity females and left hemisphericity females secrete significantly more blood plasma C than right hemisphericity females. These results provide empirical support for the concept of hemisphericity and are the first to provide empirical support for the relationship between hemisphericity and biochemistry.

Due to the relationship between right hemisphericity and both SNS activity and NE, experiment two attempted to support experiment one using perception of autonomic activity as a proxy for NE measures. Analyses revealed that hemisphericity was not significantly associated with autonomic perception. The results did however reveal that

regardless of hemisphericity, females report significantly greater autonomic awareness than males.

APPENDIX 1

Volunteer Form

To All Students,

I am conducting a study requiring your response to a short verbal questionnaire and 3 written questionnaires. All information will be coded numerically, thereby insuring complete confidentiality. It will take less than 30 minutes of your time and will be done at your convenience.

If you will print your name and phone number below, and hand in the form at the end of this class, I will contact you and make an appointment with you at your convenience.

Thank you for your cooperation.

Holly Prochnau

PLEASE PRINT

NAME_____

PHONE NUMBER_____

APPENDIX 2

Protocol and Consent Form

The study that you are about to participate in, WILL NOT invade your privacy. All information will be coded numerically, and your name will only appear below on this consent form. You will be asked to indicate your age and sex on one questionnaire, and if you are female, you will also be asked to indicate if you use oral contraceptives.

You will be required to answer 40 verbally presented questions, and to complete 3 written questionnaires. Please answer all questions truthfully.

As a volunteer subject, it is your right to terminate your participation at any point during the study.

If you are interested in obtaining the results you may contact Holly Prochnau.

Your participation is appreciated. Thank you.

Holly Prochnau

I understand the experimental procedure and agree to consent.

DATE_____

NAME_____

SIGNATURE_____ **Volunteer**

APPENDIX 3

CLEM

1. What is the meaning of the proverb: A watched pot never boils?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

2. What is the meaning of the proverb: It is an ill wind that blows no good fortune?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

3. Make up a sentence using two forms of the same verb.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

4. Tell me two verbs beginning with "N".
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

5. What is the meaning of the proverb: A poor worker blames his tools?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

6. Spell therapeutic.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

7. What is the meaning of the proverb: More than enough is too much?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

8. List two adverbs.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

9. What is the meaning of the proverb: Lend your money loose your friends?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

10. What is the meaning of the proverb: Call no many happy till he's dead?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12   1-3 4-6 7-9 10-12

11. List two prepositions?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

12. What is the meaning of the proverb: Words should be weighed
not counted?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

13. What is the meaning of the proverb: He is rich who has few
wants?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

14. Define inflation.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

15. What is the meaning of the proverb: A rolling stone gathers
no moss?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

16. Make up a sentence using two adverbs.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

17. Tell me two verbs beginning with "R".
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

18. What is the meaning of the proverb: What saddens a wise
man, gladdens a fool?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

19. What is the meaning of the proverb: The hardest work is to
be idle?
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

20. Defined the word economics.
1 2 3 4 5 6 7 8 9 10 11 12   1-6 7-12 1-3 4-6 7-9 10-12

APPENDIX 4

Autonomic Perception Questionnaire

Instructions: This questionnaire concerns your physical symptoms when you are feeling anxious. Think of a situation that causes you anxiety and circle the number indicating the degree to which you do or do not feel that particular symptom when feeling anxious.

1.   When feeling anxious, do you have an awareness of many bodily reactions?
Very Few 0 1 2 3 4 5 6 7 8 9 Very Many

2.   When feeling anxious, how frequently are you aware of those reactions?
Never   0 1 2 3 4 5 6 7 8 9 Always

3.   When feeling anxious, does your face become hot?
No Change   0 1 2 3 4 5 6 7 8 9 Very Hot

4.   When feeling anxious, do your hands become cold?
No Change 0 1 2 3 4 5 6 7 8 9 Very Cold

5.   When feeling anxious, do you perspire?
Not At All   0 1 2 3 4 5 6 7 8 9 A Great Deal

6.   When feeling anxious, does your mouth become dry?
Never   0 1 2 3 4 5 6 7 8 9 Always

7.   When feeling anxious, do your muscles become tense?
None   0 1 2 3 4 5 6 7 8 9 A Great Deal

8.   When feeling anxious, do get headaches?
Never   0 1 2 3 4 5 6 7 8 9 Always

9.   When feeling anxious, do you notice changes in your heart's action?
Never   0 1 2 3 4 5 6 7 8 9 Always

10. When feeling anxious, are you aware of increase in the rate of heartbeat?
No Change 0 1 2 3 4 5 6 7 8 9 Great Acceleration

11. When feeling anxious, are you aware of an intensity in your heartbeat?
No Change 0 1 2 3 4 5 6 7 8 9 Extreme Pounding

12. When feeling anxious, are you aware of changes in your breathing?
Never   0 1 2 3 4 5 6 7 8 9 Always

13. When feeling anxious, are you aware of your breathing becoming more rapid.
No Change 0 1 2 3 4 5 6 7 8 9 Very Rapid

14. When feeling anxious, does your breathing become more deep?
No Change 0 1 2 3 4 5 6 7 8 9 Much More Deep

15. When feeling anxious, does your breathing become more shallow?
No Change 0 1 2 3 4 5 6 7 8 9 Much More Shallow

16. When feeling anxious, are you aware of blood rushing to your head?
Never   0 1 2 3 4 5 6 7 8 9 Always

17. When feeling anxious, do you get a lump in your throat?
Never   0 1 2 3 4 5 6 7 8 9 Always

18. When feeling anxious, does your stomach become upset?
Not At All   0 1 2 3 4 5 6 7 8 9 Very Upset

19. When feeling anxious, are you aware of a sinking or heavy feeling in your stomach?
Never   0 1 2 3 4 5 6 7 8 9 Always

20. When feeling anxious, do you have difficulting in talking?
Never   0 1 2 3 4 5 6 7 8 9 Always

21. When feeling anxious, do your bodily reactions become bothersome?
Not Bothered 0 1 2 3 4 5 6 7 8 9 Very Bothered

A____   S____   P____

APPENDIX 5

Symptom Report

Directions: Think of a stressful situation that occurred in the recent past and note to what extent each of the following items effected you on the five point scale. Then think of a stressful situation that may occur in the next 6 months and again note to what extent each item may effect you on the five point scale. Please remember that every item requires an answer from 1 to 5 on your answer sheet.

Scale for Symptoms

NOT STRESSFUL 1 2 3 4 5 VERY STRESSFUL

Sympathetic

01. High blood pressure
02. Dizziness
03. Palpitations
04. Sweaty palms, increase perspiration
05. Cold hands or feet
06. Rapid heart beat
07. Sudden bursts of energy
08. Migraine headaches
09. Chest pains
10. Shortness of breath

Parasympathetic

11. Change in appetite
12. Nausea
13. Gas pains or cramping
14. Acid stomach, heartburn
15. Problems with urination
16. Constipation
17. Diarrhea
18. Frigidity or impotence
19. Dry mouth or throat
20. Difficulty in swallowing

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