The Meaning of Motor Activity:

Emotion, Temperament, Mood, and Laterality

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A Dissertation submitted to the Faculty of Graduate Studies
in partial fulfillment of the requirements for the degree of

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Department of Psychology
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The Meaning of Motor Activity: Emotion, Temperament, Mood, and Laterality

BY

Nancy A. McKeen

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree of Doctor of Philosophy

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Abstract

Individuals exhibit unique differences in the amount of motor activity that they exhibit as they go about their daily activities (Eaton, 1994). Theoretically, motor activity is salient to the emotional and arousal mechanisms thought to underlie temperament (Rothbart & Ahadi, 1994; Strelau, 1993, 1994, 1996). To test the theory empirically, two studies were conducted.

In Study 1, motor activity was assessed over a 24-hour period in 21 university students. Analysis of demographic and anthropometric variables showed that gender, limb length, and body size were not correlated with motor activity. Two objective measures of activity showed convergent validity, and both showed external validity with an Activity Diary. In Study 2, arousal, emotion, and mood correlates of motor activity were assessed in a sample of 84 university students. A factor analysis revealed a gender difference which showed that Negative Arousal was significantly negatively correlated with overall activity in females, but not in males.

A second focus of the dissertation was to examine the emotional and arousal correlates of within-individual lateral differences in limb movement. Emotion is asymmetrically processed with the right cerebral hemisphere specialized for negative emotional valence, and the left for processing positive valence (Davidson, 1995; Heller, 1993). Arm movement, controlled by the contralateral hemisphere (Carlson, 1991), was hypothesized to correlate with emotion; specifically, a left-arm bias in movement would relate to positive emotion, and a right bias would relate to negative emotion. Correlations revealed a gender difference, showing that in males, but not in females, greater right-arm activity was associated with the Positive Arousal factor. Thus, emotional arousal is associated with daily activity, but may be expressed differently by males and females.

The Meaning of Motor Activity: Emotion, Temperament, Mood, and Laterality

INTRODUCTION

Just as we take it for granted that people have different personalities, so too do we assume that they demonstrate different amounts of general motor activity in their everyday lives. In fact, when we are trying to describe the unique characteristics of others, we often comment on differences among people in their typical levels of motor activity. Consider the case of two friends. One prefers to be "on the go" for most of the day. Typically, her physical activity takes the form of biking to and from work, going for a walk at lunch time, and taking part in an aerobic work-out in the evening. The other friend usually drives her car to and from work, sits in the lounge at lunch, and spends her evenings in quiet activities, such as watching television. Each woman considers herself a friendly, sociable person, who enjoys the company of other people. However, their typical levels of physical activity remain rather different. This unique variation in the customary motor activity level displayed by individuals is easily recognized by others and commonly used in everyday parlance to describe character.

The omnipresence of motor activity makes it observable in all ages, from fetal life to old age. In fact, it is the very commonplace presence of general motor activity that makes it somewhat of a double-edged sword in terms of research. Yes, it is present and observable in all living beings. Yet, because of this very familiar presence, it tends to be ignored as a dimension of behaviour, unworthy of our notice. An individual engaged in motor activity may be doing any number of activities for any number of reasons. How can we derive meaning from something that occurs at all ages and in everyone to a greater

or lesser degree?

The question is, psychologically speaking, to what do the daily unique, but typical, individual levels of motor activity relate? Motor activity involves behavioural, affective, and cognitive components (Wankel, 1997). Behaviourally, motor activity is considered a dimension of temperament (Derryberry & Rothbart, 1988; Rothbart, 1986a; Strelau, 1983). It includes all of the movements we make, whether they are skilled and planned or unskilled and unplanned (Eaton & Enns, 1986). As a cognitive mechanism, we use our movement as a means with which to explore and interact with our environment (Campbell, Eaton, & McKeen, 2000). Emotion also plays a role in motor activity. We jump for joy. We strike out in anger. We freeze in fear.

Movement in general is a multifaceted behaviour, an important indicator of adaptability, sociability, and mental health (Bouchard, 1997; Chodzko-Zajko, 1997; Csikszentmihalyi, 1997). It is the behavioural and emotional components of motor activity that will be the focus of this dissertation. In it, I will address three aspects of motor activity. First, in a theoretical literature review, I will address the notion of motor activity and its relation to emotion and temperament. What are the emotional and temperamental correlates of individual differences in motor activity level? Secondly, I will examine intra-individual differences in motor activity. Are there differences in how much individuals typically move their right- and left- arms? What might asymmetric movements indicate about how individuals differ from one another in their temperament and in their experience and perception of emotion? Thirdly, I will address measurement issues in the study of motor activity, comparing the characteristics of two types of instruments designed to measure activity. To acknowledge the importance of ecologically valid

samples of data, I will measure the motor activity of individuals carrying out their usual activities throughout a typical day.

Concepts of Motor Activity

There are several different theoretical perspectives on motor activity available in the psychological literature. Although some of these are not central to the research proposed in this dissertation, they provide some insight into the importance and nature of motor activity in a variety of contexts. The literature described next characterizes the influence of motor activity on health and the quality of our psychic and social life.

Physical Activity, Fitness, and Health

The relationship of physical activity to fitness and health is an area of research linking motor activity to health outcomes associated with longevity. The health issues include weight control, bone density, blood pressure, blood fat levels, glucose metabolism, immune function, and the prevention of vascular disease. Fitness and health aspects of motor activity become particularly salient to the elderly, since projections are that about 15 percent of the population will be 65 years of age by the year 2000 (Bouchard, 1997). The percentage of elderly will grow to about 40 per cent of the adult population by the year 2075 (Turner, 1995). Researchers on one longitudinal study of Finnish men concluded that the physically active subjects lived about two years longer than their more inactive cohorts, even after accounting for age, smoking, blood pressure, serum cholesterol, and body mass index (Pekkanen, Nissinen, Marti, Tuomilehto, Punsar, & Karvonen, 1987). Researchers have estimated that three to four hours of exercise a week adds about 1.5 years to life (Paffenbarger, Hyde, & Wing, 1990). Thus, physical activity continues to be important to the quality of life over the lifespan (Bouchard, 1997).

Physical Activity, Psychic Energy, and Flow

Another approach to the study of activity addresses the spiritual aspects of physical activity (Csikszentmihalyi, 1997). The research is based on the idea that the activities one chooses shapes both the person who engages in them as well as the community at large. From this perspective, activity refers to any patterned, voluntary investment of attention. The investment of attention allows people to act, to think, and to have feelings about what they do. People select from a wide variety of possible activities. The study of these activities enables us to understand the pattern of choices that shape the physical and mental lives of individuals. Those activities in which people invest attention or psychic energy determine the content of individual lives, as well as the parameters of culture and social institutions (Csikszentmihalyi, 1997).

The average American worker spends about 42 percent of his or her waking life on the job (about 40 hours per week), but only about two thirds of this time is spent actually working. The other third is spent socializing, daydreaming, snacking, or on other nonproductive activities. Another 40 percent of time is spent in activities in the home. These activities include housework (about 8 percent), watching television (about 7 percent), resting (4 percent), hobbies (about 4 percent), reading (3 percent), eating and grooming (6 percent), and talking (2 percent). Other activities outside the home (18 percent of the time) include leisure activities such as sports, movies and restaurants (9 percent), shopping (3 percent), and transportation (6 percent) (Csikszentmihalyi, 1997).

Examination of the affective valence of various activities indicates that people report being happiest when they are involved with other people. They report being least happy when they take a nap, watch television, read, or do housework. Both work

activities and leisure activities can promote personal growth for an individual, as long as the activity is psychologically complex and provides what Csikszentmihalyi (1997) calls "flow." By *flow* he means the feeling of being so involved or absorbed in an activity that we no longer worry about irrelevant issues, and we forget ourselves to the task at hand. The flow experience can occur when challenges are high and personal skills are used to the utmost. The awareness of time disappears, and "the experience resembles a smooth, almost automatic movement toward an inevitable outcome (p. 75)." This experience is so enjoyable that the individual wants to repeat whatever activity has produced it. *Flow* tends to occur either while at work or during active leisure activities.

The opposite of *flow* is psychic entropy. Psychic entropy manifests itself as an inability to use energy effectively because of ignorance, lack of motivation, or conflicting emotions, such as fear, rage, or depression. Csikszentmihalyi (1997) might suggest that those who watch much television should be afflicted with psychic entropy, or atrophy of motivation. Watching television is an activity that is universally reported as involving no challenges, requiring no skills, and providing the least flow-like enjoyment. Yet people spend hours doing it every week. Csikszentmihalyi's explanation is that people seek to balance the psychic energy they must expend with the anticipated benefits. Television viewing provides little enjoyment, but it also requires little effort. Playing the piano or riding a bicycle are much more enjoyable, but require greater expenditures of energy.

When children are completely absorbed in their play, they spontaneously enjoy *flow*. However, in societies where there are few opportunities for flow experiences, Csikszentmihalyi (1997) suggests there is a progressive atrophy of the desire for complex activities. Children can lose their desire to explore new possibilities, become used to

passive entertainment, and no longer perceive the opportunities for action, if they are not exposed to complex activities when they are young.

The idea here is that habitual physical activity is an intrinsically psychologically rewarding experience, or at least has potential as a rewarding experience, if we begin at a young age and continue to be active throughout our lives. Csikszentmihalyi (1997) also implies that exposure to increased doses of physical activity will generate positive feelings of *flow*, which will in turn encourage us to be more active still. The emphasis is on the psychological benefits of physical activity and 'being all one can be' through active living.

Social and Communal Perspectives of Physical Activity

The Canadian government has initiated a program encouraging what they refer to as "active living." *Active living* is defined as a way of life in which physical activity experiences are valued and integrated into daily living (Fitness Canada, 1988, cited in Wankel, 1997). From this perspective, physical activity involves a societal or cultural dimension because it involves the collective valuing of being physically active and establishing norms for being active. It is the intention of the Canadian government to make regular physical activity a valued "cultural trademark" (Fitness Canada, 1986, cited in Wankel, 1997, p. 94) because it has recognized that active living is desirable for the well-being of individuals, as well as for the community at large.

Active living involves behavioural, cognitive, and affective components. The behavioural component is the engagement of individuals in regular physical activity. The cognitive component pertains to one's knowledge of how to be active and how to make activity an integral part of one's life. The affective component involves the positive valuing of physical activity and the positive feelings associated with being active (Wankel,

1997).

From this social perspective, the psychological aspects of physical activity involve the understanding of how to get people motivated to become involved, and how best to get them to stay involved in exercise and physical activity. Researchers have found, for example, that involvement in physical activity is positively associated with income, education, and occupational level, and negatively associated with age. Adults who are more likely to be physically active tend to perceive the health benefits of activity, are self-motivated, have the support of their spouses, and believe they have both time and access to facilities. Factors negatively affecting physical activity include being a smoker, being overweight, working in a blue-collar job, and experiencing mood disturbance. Environmental variables include disruptions in routine and the perceived discomfort of the physical activity (Dishman, Sallis, & Orenstein, 1985). Males and females are similar in their rate of participation in leisure-time physical activity, but males tend to participate at higher intensity levels than females (Stephens & Craig, 1990).

The above research areas linking physical activity to areas of social concern provide a social context to understand the importance of motor activity. It is evident that the physical activity of the population at large has far-reaching consequences for long-term well-being. Especially noteworthy for my research topic is that involvement in regular physical activity is associated with desirable psychological outcomes. People report that they feel healthier, have reduced anxiety and depression, and have an enhanced sense of self-esteem, enjoyment, and satisfaction in life (Wankel, 1997). Psychological maladies, such as depression, anxiety, and psychosocial stress are three areas of particular interest to researchers studying the relation between physical activity

and mental health (Spirduso & Mackie, 1995). Therefore, the concept of an active, healthy lifestyle has important implications for understanding emotional and psychosocial function. Importantly for the dissertation, however, is that there is a lack of evidence to indicate how physical activity mediates emotional function or psychosocial stressors (Wankel, 1997).

My research focuses on the role that motor activity plays in individual psychological characteristics, more than on the physical or social consequences of activity. Individuals show distinct differences in the amount of motor activity that they exhibit while going about their daily routines. One important aspect of psychological research into motor activity is to identify possible reasons for these individual differences of preference or inclination for activity. For instance, individual differences in the inclination to be active may be due in part to the arousal or pleasure associated with being physically active. It is this focus which is central to the studies presented in this dissertation.

In examining the psychological meaning of motor activity, I argue that the emotional characteristics of an individual's typical interaction in his or her day-to-day living will reflect differences in motor activity. I also assume that from early in life individuals use their motor activity or movement to optimize or regulate their emotional comfort levels in their interactions with others and by themselves. Operationally, I do not focus on the maintenance functions of motor activity, which presumably are similar in all people. Instead, I am focusing on the aspects of motor activity that show individual differences. Specifically, I will examine individual differences in motor activity and its emotional and temperamental correlates.

Emotions and motor activity may become integrated with each other early in life. The first basic component of sensorimotor action includes movement, perception, and feeling, and there is no sharp distinction between action and feeling (Fischer, Shaver, & Carnochan, 1990). This integration of action and emotion may continue into adulthood, so that motor activity continues to reflect an individual's emotional state. Since emotions provide a motivational basis for more stable temperamental differences among individuals, it is worthwhile reviewing theories of both emotion and temperament, and how they might relate, at least in theory, to motor activity.

Theories of Emotion

The common-sense view a hundred years ago was that emotional experiences produce bodily expressions of emotion. In contrast to that view, William James (1884; cited in LeDoux, 1989) thought that the perception of an event (by the sensory cortex) produces bodily changes (through the motor cortex). Perceptions of bodily changes then give rise to an emotion about the event. James's theory was criticized by Cannon (1927, 1931; cited in LeDoux, 1989) who argued that bodily changes were too non-specific and too slow to account for emotional experience. He thought that the brain possessed a special emotional system, of which the hypothalamus was the integrative structure. Papez (1937; cited in LeDoux, 1989) discovered such a functional circuit in the brain (the Papez circuit) which involved the relay of sensory input through the hypothalamus, anterior thalamus, cingulate cortex, hippocampus, and back to the hypothalamus. The flow of information through this loop Papez thought essential to normal emotional function. MacLean (1949, 1952; cited in LeDoux, 1989) postulated the existence of a visceral brain or limbic system. The limbic system consisted of phylogenetically old structures located

around the medial walls of the cerebral hemispheres as well as associated subcortical nuclei. The core of this emotional system is a mechanism for determining the affective significance of stimuli. In essence, research of the biological substrates of emotion has focused on autonomic changes that accompany emotion in humans and on the subcortical limbic system circuits that mediate emotional behaviours in animals (Davidson, 1995).

Functions of emotions

Emotions function in several useful ways. First, they provide survival value by preparing an organism to fight or flee dangerous situations by provoking the release of autonomic and endocrine responses in the body. Secondly, emotions are motivating. If a reinforcer is positive, the organism will work to obtain it. If the reinforcer is negative, the organism will work to avoid it or will reduce the response on which it is made contingent. Novelty, for example, may be positively reinforcing, encouraging curiosity and the desire to explore the environment. Thirdly, emotions promote social bonding by motivating animals and humans to communicate with each other. For example, emotions are an integral part of the ability of an infant to develop a bond of attachment to his or her mother. They also serve a cognitive function, by providing a mechanism for a current emotional state to facilitate the storage and recall of memories. For example, happy memories are more likely to be recalled when the individual is currently in a happy mood. This occurs because of the increasing strength of active synapses in associative neuronal networks. It is likely that some of the input axons from an experienced event carry information about the current emotional state, as well as about the event itself. The happy event will be recalled best when the memory closely resembles the pattern of modified

synapses (Rolls, 1990).

Panksepp's Theory of Emotion

Panksepp's (1982) theory of emotion set out four primary emotive neural circuits in the brain in animals. In the mammalian brain, these four subcortical circuits pass between midbrain, limbic system, and basal ganglia, and they elicit well-organized behavioural sequences that Panksepp labels the ***expectancy***, ***rage***, ***fear***, and ***panic*** circuits. All four circuits show reciprocal inhibitory relations. In other words, the action of one inhibits the action of the other. The expectancy circuit mediates anticipatory exploratory or approach behaviour and is responsible for producing motor arousal that leads to movement. The rage circuit generates an 'affective' attack involving growling and biting when the animal is restrained or irritated. The fear circuit elicits escape or freezing behaviours in response to environmental threats. The panic circuit mediates distress vocalizations and agitated behaviour in situations that would encourage increased social cohesion and caregiving behaviour (Panksepp, 1982).

In later work, Panksepp (1989) brought in the notion of hierarchical control of emotions in which he emphasized the robust influence of the subcortical processes over cortical processes in humans. He makes the point that our personality structures may be molded by the nature and vigour of our emotional circuits and by the habitual arousal of an emotional system during the early phases of development. He also suggests that in humans the laterality of various basic processes in the animal brain may be the source of emotional specialization of the two hemispheres of the brain. Asymmetries in emotional control may emerge from the manner in which the relatively symmetric subcortical processes are elaborated by the two sides of the brain (Panksepp, 1989).

With modern methods available, recent research on emotion has focused on how the subcortical and cortical areas of the brain are functionally integrated (LeDoux, 1989). Much work has been done on the means of expression of emotions and on the role that various cortical regions play in the regulation of emotion (e.g., Borod, 1993a, 1993b; Davidson, 1992b, 1992c, 1993a, 1995; Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Fischer et al., 1990; Fox, 1994; Heller, 1993; LeDoux, 1989; LeDoux, 1995). In particular, the focus is on the anterior and frontal cortical areas, which have extensive anatomic reciprocity with both subcortical areas and the posterior cortex, all implicated in emotional behaviour. These areas are also linked to motor function (Fuster, 1989). Asymmetries of the anterior cortex have been implicated in different forms of emotional behaviour (Davidson, 1995). In this dissertation I intend to examine asymmetries of motor activity along with various emotional behaviours.

Approach-Withdrawal

One of the recent key concepts in emotion theory is the behavioural consequences of the emotional experience. The decision to approach or withdraw is the most fundamental adaptive decision made by any organism, and individuals differ in their tendency to approach or withdraw from new situations (Davidson, 1992a). Responses are accompanied by changes in motor tension and the cardiovascular system, probably produced by the limbic system. There are also individual differences in the threshold at which approach and withdrawal behaviour occurs. For example, some individuals require high levels of fear stimuli to initiate withdrawal behaviour. Others start to withdraw at lower levels of intensity (Strelau, 1994).

Emotions and Motor Activity

How does all of this relate to motor activity? Leventhal's (1979) perceptual-motor theory of emotions helps make the connection between emotions and motor activity. He maintains that the central nervous system (CNS) uses the peripheral motor system to construct emotional reactions. He suggests that activation of the autonomic nervous system (ANS) and an increased level of arousal of the CNS are concomitant with the production of the expressive motor reactions controlled by a central motor mechanism (Gainotti, 1989). In infancy, innate motor programs express emotion in an innate reflex-like manner. With age, and more complex and variable experiences, external stimuli are associated with internal representations and memories of past emotional experiences. Gradually, emotionally expressive motor programs are incorporated into the individual's set of communicative skills and interpersonal interactions (Gainotti, 1989). Gainotti suggests that these expressive movements can include facial expressions and vocal activity. I suggest that motor activity might also be one of those expressive movements reflecting individual differences in emotional expression.

Support for this suggestion comes from several theoretical and empirical sources. The theory of Henri Wallon (1879-1962; cited in Van Der Veer, 1996) lends some support for this hypothesis. Wallon believed that children go through different stages of emotional development, similar to Piaget's stages of cognitive development. It was his view that muscle tone or muscle tension is a prime factor in emotional behaviour, and provides an accurate idea of the affective state of the infant. Wallon saw both laughing and crying as resolutions to a gradual build-up of hypertonia. For example, laughing releases tension through spasms of the skeletal muscles (Van der Veer, 1996). This notion of the close

connection between affect or emotion and motor activity has received some support from an empirical study (McKeen, 1995) and is a tenet or assumption of most emotion and temperament theories (e.g., Gainotti, 1989; Gray; 1991a; Strelau, 1983).

Theories of Temperament

While individual differences in emotion is a key issue of many studies of temperament, it is often not easy to study empirically. The concepts are either vaguely defined or too specific to animal research to be useful with humans. Temperament provides a more 'user friendly' way to examine emotion in that it is a higher-level construct and often relies on self-reports of typical responses to emotional situations found in daily life. In the following discussion, I define temperament, and further describe various theoretical perspectives related to individual differences in temperament and motor activity.

Temperament from a Neo-Pavlovian Perspective

The neo-Pavlovians emphasize the physiological basis of temperament. From Pavlov's initial work on conditioned responses in dogs, he and others of the school based the notion of temperament on the dynamics of excitatory and inhibitory nervous processes thought to underlie observable individual differences in humans. As defined by Strelau (1993), temperament

> refers to basic, relatively stable personality traits which apply mainly to the formal aspects of reactions and behavior (energetic level and temporal characteristics). These traits are present since early childhood and they occur in man and animals. Being primarily determined by inborn physiological mechanisms,

> temperament is subject to changes caused by maturation and by some environmental factors (p 117).

By stability, Strelau means that temperament is relatively stable over time, but that changes can and do occur. These are mainly due to developmental and lifespan maturational changes in the physiological mechanisms that underlie temperament. By formal traits, Strelau means those characteristics that may be described in terms of energy and tempo (Strelau, 1996). He is thus emphasizing that any behaviour may be described in terms of its intensity or magnitude, as well as by its speed or duration. According to the neo-Pavlovians, the main fundamental features of the nervous system type are defined as the strength, mobility, and equilibrium of the nervous system processes (Mangan & Paisey, 1983; Strelau, 1983).

Strength of the nervous system. The strength of the nervous system is determined by the reactivity of the individual's excitatory response system. A strong nervous system is the result of low reactivity or sensitivity. A weak system is a consequence of high reactivity or sensitivity (Mangan & Paisey, 1983). Two neo-Pavlovians, Teplov and Nebylitsyn, considered the strength of the nervous system as a bipolar trait that can be designated either as endurance (or efficiency) at one extreme or sensitivity at the other, the correlation between the two being about 0.7 (Strelau, 1983). Nebylitsyn (1972; cited in Mangan & Paisey, 1983) also interpreted electroencephalographic (EEG) evidence as indicating that there are two physiological factors influencing the strength of the nervous system. One factor is responsible for sensory reactivity. The other is an independent factor responsible for motor activity. The implication of this finding is that the strength characteristics of the nervous system may be related to individual differences in both

sensory reactivity and motor activity (Mangan & Paisey, 1983).

Mobility of the nervous system. The capacity of the biological system to react quickly to changes in the environment, the neo-Pavlovians call the mobility of the nervous system. Adaptiveness, or functional speed of the nervous system is central to this idea of mobility. Speed is also closely related to the idea of lability and dynamism of nervous system processes. Although mobility may be a more important concept for learning and intelligence than for temperament (Strelau, 1983), mobility also may relate to motor activity. Individuals who are highly mobile are likely to be involved with more than one activity at a time, and enjoy the hustle and bustle of daily living and of novel occasions. Therefore they are likely to be more physically active.

Equilibrium. Equilibrium of both excitatory and inhibitory processes involves the balance of nervous processes (Mangan & Paisey, 1983). According to Strelau (1983), Nebylitsyn hypothesized that the balance of excitation and inhibition is a function of both the activating influence of the reticular structures of the subcortex and the inhibitory influence of the cortex. Strelau himself (1972) has defined it as the ratio between strength of excitation and inhibition.

These fundamental neo-Pavlovian concepts involving nervous system processes are very much related to basic physiological processes (Strelau, 1983). The work done by these researchers was experimental in nature and involved physical response measures such as galvanic skin responses (GSR), EEG responses, as well as visual, auditory, and other sensory, and reaction time responses. Many of the theoretical physiological concepts derived from the neo-Pavlovian studies in the 1950's and 1960's still hold today, their meanings perhaps taking on new emphases in the process. For example, the concept

of the strength of the nervous system is typically referred to in the Western literature as the arousal or activation of the nervous system. Although these Western concepts are not solely related to neo-Pavlovian theory, they are important to the theory and are discussed more fully here. Various components of arousal have been put forth. I will describe several of these and their relation to emotion and motor activity next.

Arousal

Immanuel Kant (1724-1804) developed the idea that temperament can be characterized as 'life energy' (*Lebenskraft*). According to him, our life energy ranges from excitability to drowsiness (Kant, 1912). Later in the century, Pavlov introduced the concept of strength of excitation in the cortex and subcortex, which he thought underlies the notion of arousal. He thought that individual differences in the intensity of these excitatory processes could explain individual differences in arousability (Pavlov, 1951, 1952; as cited in Strelau, 1994). Duffy (1951, 1957; as cited in Strelau, 1994) considered arousal or activation as an undifferentiated intensity dimension underlying temperament. Individuals differ in the level of arousal and responsiveness to stimulation. Arousal she defined as the release of potential energy for use in activity or response, which is determined by physiological factors. Energy release can take various forms, such as EEG activity, skeletal muscle tension, electrodermal activity (EDA), or activity of the ANS (Strelau, 1994).

Hebb (1955; as cited in Strelau, 1994) distinguished two main roles that stimulation plays in temperament. One function is as a cue, guiding the direction of behaviour. The other is an arousal or vigilance function, referred to the energetic background of behaviour. Hebb suggested that arousal is synonymous with 'general drive

state,' which he conceptualized as an energizer. He described arousal as an engine that is running, but which has no steering wheel. Hebb also related performance to the concept of the inverted-U-shaped curve relation that occurs between intensity of stimuli and the speed of learning (Yerkes & Dodson, 1908). At low levels of arousal, an increase in drive intensity may be rewarding, whereas at high levels, an increase in intensity may be distressing. An increase of arousal to the optimal level is accompanied by positive emotions (and high levels of performance), but beyond that, arousal is a source of negative emotions (and reduced levels of performance).

Since the discovery of the reticular activating system (RAS), arousal is also considered a neurophysiological construct. When the RAS was initially described (Moruzzi & Magoun, 1949), it was assumed to serve as a generalized arousal mechanism, which responded to sensory input and energized behaviour. It also activated EEG waves and the sympathetic nervous system. Since that time several researchers (e.g., Lacey, 1967; Pribram & McGuinness, 1975; Routtenberg, 1968) have postulated that there are two arousal systems in the brain, the RAS and the limbic system. The function of the two systems is reciprocal. That is, each suppresses the activity of the other, and organisms regulate their behaviour by maintaining a balance of activity between the two systems (Routtenberg, 1968).

The RAS functions to regulate arousal, which is designated as a phasic, short-lived response to stimuli. It reflects an individual's responsiveness to specific stimuli. The limbic system is an activation system, which maintains a tonic readiness to respond with action (McGuinness & Pribram, 1980; Tucker & Williamson, 1984). This tonic readiness can be considered as the individual's typical baseline or set-point of arousal.

By means of the arousal system, facilitated by the posterior cortex, the brain orients to novel input. The arousal system is thought to be a reward system, important in the integration of response mechanisms necessary for reinforcement. Approach responses (and expansive cognition) are positively reinforcing. Withdrawal responses (and constricted cognition) are negatively reinforcing (Routtenberg, 1968). Thus, through its reinforcing of reward, arousal is thought important to emotion (McGuinness & Pribram, 1980). Arousal is augmented with increasing novelty or complexity of stimuli, but repetitive stimuli soon produce habituation. The neurotransmitter substrates of arousal are the norepinephrine and serotonin pathways that proceed from the brainstem to innervate widespread areas of the brain. These substances regulate the sleep/wake cycle. They also sensitize the individual to novel, environmental stimuli, and perhaps filter out irrelevant stimuli. Thus, arousal is responsible for wakefulness, sleepiness, alertness, and the typical level of responsivity to sensory perceptual input (Carlson, 1991; Tucker & Williamson, 1984). It is a concept closely connected to both emotional behaviour and motor activity.

Activation

Activation is a second concept closely related to the notion of arousal. Activation refers to a state of tonic excitation regulated primarily by the basal ganglia of the extrapyramidal system. Activation is integral to motor operations, supporting postural readiness and motivationally directed action. As such, it is associated with vegetative activities (Routtenberg, 1968) and with intentional movement (Heilman & Watson, 1989). Activation directs the individual's attention inwardly, a characteristic more of wariness than of outward orienting to novelty (Tucker & Williamson, 1984). Activation is also important in providing a motivation to act (McGuinness & Pribram, 1980).

The dopamine pathways from the brainstem substantia nigra combine with cholinergic neurochemical influences on the basal ganglia and facilitation from the dorsolateral frontal cortex, to regulate activation (McGuinness & Pribram, 1980). Dopamine activation is implicated in the augmentation of motor control. Spontaneous locomotion depends upon an intact dopamine network, and research indicates that spontaneous motor activity correlates more closely with changes in dopamine levels than with norepinephrine. Dopamine causes an active, vigilant attentional mode, which is essential for avoidance behaviour and tied to motor readiness. However, rather than a simple, positive correlation with motor activity, dopamine regulation paradoxically facilitates a tight control of behaviour. In animals, high levels of dopamine restrict the range of behaviour, producing repetitive, highly stereotyped motor responses. Low levels of dopamine impair the ordered, sequential organization of behaviour. Individuals with clinically low levels of dopamine are unable to move their limbs normally, and have particular trouble in initiating motor activity (Tucker & Williamson, 1984).

Of course, in a normal, adaptive environment individuals maintain a balance of control in both external arousal and internal activation. Too much arousal would produce a behavioural response to every stimulus, resulting in behaviour that is random, distracted, and disorganized. An optimal amount of arousal may encourage curiosity and interest in one's surroundings. Too much activation would produce behaviour that is repetitive and redundant. An optimal amount of activation would provide a regulatory substrate for motivation facilitating habit formation (Tucker & Williamson, 1984).

A key point here is that, in theory, levels of arousal and activation should relate to both emotional state and to motor activity. Arousal should be related to emotional

feelings and to observable motor responses in new situations. Activation should be related to the individual's typical level of motor activity and to an internal motivation to move.

The neo-Pavlovian approach to temperament and the concepts of arousal and activation focus on very general underlying physiological processes that can be applied to any number of behaviours, including motor activity. It is useful to examine how this approach makes specific reference to activity level.

A neo-Pavlovian Account of Motor Activity.

Strelau's theory (1983; 1985a; 1985b; 1986a; 1986b;1987; 1989; 1994; 1996) contains several concepts that relate to motor activity. Strelau (1989) maintains that individuals have a tendency to react to situations with characteristic energy and tempo. Individual differences in the energy level of behaviour are the result of the two basic dimensions of biologically-based temperament, reactivity and activity. Strelau's reactivity closely resembles the neo-Pavlovian concept of strength of the nervous system. Because most behaviours involve an emotional context, the emotional state accompanying an action comprises the excitation-inducing factor or reactivity (Strelau, 1989). Tempo or briskness is the tendency to react quickly, or to keep up a high tempo of activity. It also refers to the ease with which an individual shifts behavioural responses according to changes in the environment (Strelau, 1996).

Strelau (1983; 1993) discusses activity in terms of its function. It is conceptualized as the tendency of an individual to undertake behaviour of high stimulative value, and therefore it is the way in which an individual typically controls and maintains a personal optimum level of stimulation or of activation. The amount of stimulation needed for an optimal level of activation differs according to the reactivity of the individual. Motor

activity can, in effect, "organize" the sources of stimulation into stimulation-seeking and stimulation-avoiding activities, depending on whether the individual is a 'low-reactive' or a 'high reactive.' For example, 'low-reactive' individuals tend to prefer highly stimulating activities to maintain an optimal level of arousal (Strelau, 1985b; 1989). 'High reactive' individuals prefer less stimulating activities to maintain their optimal level of arousal.

According to Strelau then, individuals will show a preference for a typical level of activity, which functions for them to maintain an optimal level of arousal. The individual's activity will be the result of efforts to either avoid or engage in a more or less stimulative environment. Emotional arousal or affect participates in the regulation of the individual's optimal level of arousal by providing motivation to act.

Many of the empirical temperament data come from correlational studies, in which researchers use questionnaire methods and ask about the occurrence of specific behaviours. A questionnaire has been developed (Newberry, et al., 1997a) which integrates neo-Pavlovian concepts of arousal with Western psychobiological views on temperament. I briefly describe this scale, called the Pavlovian Temperament Survey (PTS), a self-report measure used in Study 2 of the dissertation.

The PTS (formerly called the Strelau Temperament Inventory-Revised) contains three subscales reflecting the three definitional facets of the temperament dimensions. The subscales are named the Strength of Excitation (SE), Strength of Inhibition (SI), and Mobility of Nervous Processes (MO). The SE facet includes questions about emotional composure, perseverence in the face of danger, susceptibility to distractions when working, and resistance to fatigue. The SI facet includes questions about the ability to delay speaking, tolerance of delay in beginning projects, self-control for the benefit of

others, and the ability to suppress expression of feelings. The MO facet includes questions related to the ability to adapt to changes in working conditions, the speed with which emotions change, tolerance for the unfamiliar or unexpected, and the liking for being involved in multiple activities.

There is another theory of temperament developed by Gray (1991a), which appears to be salient to both emotional temperament and motor activity. This theory, and its implication for motor activity are described next.

Temperament from an Activation/Inhibition Perspective

Gray's theory of brain function and behaviour has been particularly influential in the area of temperament and personality research. He maintains that any psychological function depends upon the activity of the brain, so that if there exists a psychology of temperament, then there is also a neuropsychology of temperament (Gray, 1991a). He assumes that temperament is what remains of individual differences once the effects of general intelligence, visuospatial, verbal ability, or other cognitive functions have been removed (Gonzalez, Hynd, & Martin, 1994). Hence, his neuropsychological model of temperament concerns the neural substrates of emotional behaviour. Emotions are states of the CNS elicited by reinforcing events.

Gray (1991b) assumes that differences among individuals in temperament reflect differences in their predispositions towards different kinds of emotional responses to reinforcing events (Gonzalez, et al., 1994). Gray's model describes three emotional subsystems which respond to three fundamental emotion systems of the cortex and subcortex. The three emotional systems are referred to as the behavioral inhibition system (BIS), the behavioural approach or activation system (BAS), and the fight-flight system

(FFS) (Gray, 1991b).

Behavioural inhibition system (BIS). Activity in the BIS is elicited by conditioned stimuli that are associated with punishment, termination of reward, or novel stimuli. The stimuli activating the BIS cause an interruption, or inhibition of ongoing behaviour, and an increase in arousal and attention. By increasing arousal and attention, the system modulates exploratory behaviour. The BIS inhibits behaviour that may lead to negative or painful outcomes. The subjective state that accompanies activity in the BIS is anxiety (Gray, 1991a). Therefore, BIS activation exhibited as anxiety may be responsible for feelings of fear, anxiety, frustration, or sadness. The BIS is thought to involve neural activity in the septo-hippocampal system, a part of the limbic system.The links between the septo-hippocampal system and both the basal ganglia and cerebellum provide a means for the limbic system to communicate with the motor system, and thus a means for generating overt behaviours associated with emotions. The prefrontal cortex also modulates motor behaviour (Steinmetz, 1994).

Behavioural activation system (BAS). The BAS is a positive feedback system activated by stimuli and associated with reward, or with the termination or omission of punishment. It is an approach system that functions to increase the spatiotemporal proximity of stimuli, and is therefore considered a motor programming system (Gonzalez et al., 1994). The key components of this motor system are the basal ganglia, the dopaminergic fibres that ascend from the mesencephalon to the basal ganglia, the thalamic nuclei linked to the basal ganglia, and neocortical areas linked to the basal ganglia. These components form two interrelated subsystems. The first is the caudate motor system, a non-limbic cortico-striato-pallido-thalamic-midbrain circuit. This system

seems to be important in regulating the inhibition of motor activity. The second is the accumbens motor system, which is a limbic cortico-striato-pallido-thalamic-midbrain circuit. This system switches between steps in a motor program, interacting with the septo-hippocampal system, and monitoring the routine operation of a motor program. Gray postulates that the BAS underlies pleasurable states, such as anticipation or happiness (Gonzalez et al., 1994).

Fight or flight system (FFS). The third emotional system, the FFS, is specialized to respond to either unconditioned punishing stimuli or the termination or omission of reward (Gray, 1991b). With an activated FFS, the individual responds to aversive stimuli with defensive aggression or escape behaviour. The anatomical structures that appear to function in support of this system include the amygdala, which inhibits the medial hypothalamus, which in turn inhibits the final common pathway in the central gray of the midbrain. The system may be influenced by input from the BIS, probably by way of the septo-hippocampal system. No direct links to a corresponding human emotion has been found as yet with the FFS, although anger and terror are possibilities (Gray, 1991a).

It is the balance or interactions among these emotional systems that Gray hypothesizes results in human temperament or personality differences. Gray (1991b) suggests that his biological approach serves as a basis for other concepts of temperament and personality. He makes the case that theories of personality (e.g., Eysenck, 1967; Eysenck & Eysenck, M., 1985; Eysenck & Eysenck, S., 1969) and mood structure (e.g., Tellegen, 1985) are compatible with the BIS/BAS/FFS theory of temperament. Individuals will demonstrate different patterns of emotionality with different combinations of positive and negative affect. Thus, individuals who possess a more reactive septohippocampal BIS

are susceptible to threats of punishment and non-reward. They are anxious and introverted, more fearful and frustrated. Individuals who possess a more reactive medial forebrain bundle approach system (BAS) are susceptible to signals of reward or nonpunishment. They are extraverted, impulsive, and more susceptible to emotions such as relief and hope (Derryberry & Rothbart, 1988).

Within the BIS/BAS system, temperament reflects individual differences in predispositions towards particular kinds of emotions. How might the behavioural inhibition and activation systems produce individual differences in motor activity?

Motor Activity in an Inhibition/Activation (BIS/BAS) System.

Gray's theory of the approach and withdrawal mechanisms of the BIS/BAS have implications for motor activity. Because the BAS is an emotional system that has evolved to motivate a pleasurable engagement with the environment, it involves forward locomotion and search behaviour (Nelson, 1994). Individuals with a highly activated BAS would be more inclined to approach new situations, and want to be in the centre of whatever is happening. Therefore, motor activity would be higher generally in individuals with sensitive approach systems. On the other hand, individuals who have very active BIS systems tend to present more negative affect and withdraw from novel situations. Arousal of the BIS would inhibit rather than energize motor behaviour (Fowles, 1980).

There is some support in the literature for the idea that the BIS/BAS relates to motor activity. In studying children, Quay (1988, 1993) has used the BIS/BAS theory to suggest the underlying causes of behaviour disorders. He argues that an overactive BAS may be responsible for causing extreme responses to reward signals resulting in conduct disorders. An underactive BIS might be the cause of impaired inhibition in the face of

threatened punishment, resulting in attention deficit hyperactivity.

There are other factor analytic approaches to theories of temperament that almost exclusively make use of self-report questionnaires and include activity specifically as a dimension of temperament. Several of these are discussed next. Recent findings from biology, behaviour genetics, and personality theory confirm the prominence of motor activity as a dimension of temperament (e.g., Gonzalez, Hynd, & Martin, 1994; Gray, 1991a; Saudino & Eaton, 1991).

Rothbart's Theory of Temperament

There are other concepts and ways to define temperament. Rothbart is a key researcher and theorist in the area of temperament. She presents a psychobiological approach to personality development, maintaining that the "study of temperament is located at a level of analysis with physiology on one side and social interaction on the other" (Rothbart & Ahadi, 1994, p. 56). She and her colleagues define temperament as the "constitutionally based individual differences in reactivity and self-regulation" (p. 55). Over time, reactivity and self-regulation are influenced by heredity, maturation, and experience. The concepts of reactivity and self-regulation are important in the behavioural consequences of temperament.

Reactivity

Reactivity refers to the intensity and temporal aspects of psychobiological functioning of the somatic, endocrine, autonomic and central nervous systems (Rothbart, 1986b). It is defined more generally as the excitability, responsivity, or arousability of an individual's physiological and behavioural systems (Rothbart & Derryberry, 1981). Reactivity is also described as the anatomical and physiological mechanism responsible

for the release of stored energy. There are individual differences in the arousal mechanisms that determine reactivity. In high-reactive individuals, these mechanisms enhance or augment stimulation. In low-reactive individuals, the mechanisms reduce or suppress stimulation.

In its empirical measurement, reactivity has been operationalized into central and peripheral forms. Cortical reactivity is assessed by examining external sensory sensitivity (e.g., noticing room temperature), internal perceptual sensitivity (e.g., noticing stomach growling), and cognitive reactivity (e.g., ease of engaging in daydreaming, problem-solving, and visual images). Peripheral reactivity is assessed by examining individual differences in autonomic reactivity (e.g., sweating palms), motor tension (e.g., tension in shoulder muscles), and motor activation (e.g., feet tapping while reading) (Derryberry & Rothbart, 1988).

Self-regulation

Self-regulation refers to the individual's ability to actively control arousal and emotional responses. It is a process that serves to modulate the individual's reactivity, through cognitive orientation, attention, approach, and avoidance behaviours (Rothbart, 1986b). Behaviourally, it often refers to self-control, as is the case when one inhibits attending to irrelevant stimuli. It also refers to more subtle behaviour, as occurs when an individual can attend to one particular stimulus and ignore others. The result is that individuals can shift their attention toward a positive stimulus and away from a negative stimulus. In this way, they can attenuate or regulate their arousal and emotion (Ahadi & Rothbart, 1994; Derryberry & Rothbart, 1988).

Rothbart's Theory and Motor Activity

Rothbart (1986a; 1986b) includes activity as a central dimension of temperament. She presumes that motor activity is an underlying constitutional tendency of the individual to react in a typical manner or style across a variety of situations and to regulate his or her own responses. The development of temperament involves the addition of increasing regulatory control over initial patterns of reactivity or activation (Rothbart & Posner, 1985). Rothbart defines activity level in children as the level of the child's gross motor activity, including movement of arms and legs, and rate and extent of locomotor activity (Ahadi & Rothbart, 1994). Her recent temperament inventory, the Early Adolescence Temperament Questionnaire (EATQ; Capaldi & Rothbart, 1997) includes statements from the Activity subscale such as, *I hardly ever fidget or squirm around* and, *When I get excited I often feel like moving around.*

There are other ways to define temperament, but the examples above provide a flavour for the major concepts involved in defining temperament in the literature. The general concepts and definitions of temperament above emphasize the constitutional and biological bases of temperament. Rothbart is one of several researchers who specifically includes motor activity as a dimension of temperament. I will briefly discuss three other theories of temperament that also include the concept of motor activity as a dimension of temperament. These theories may provide clues about our individual differences in motor activity and what they reveal about our temperament.

Theories using Motor Activity as a Temperament Dimension

Through the New York Longitudinal Study, Thomas and Chess (1977) studied the social, emotional, and attentional characteristics of children, and determined those that

were predictive of later problems. They developed nine dimensions of childhood temperament, of which activity level was one. Thomas, Chess, and Birch (1968) define activity level as the amount of spontaneous movement in the child's behaviour and the daily proportion of active to inactive periods. They formulated dimensions of temperament based on the underlying acceptance of the notion that individuals differ in the way they behave. They maintain that temperament deals with how a response is made (fast or slow, mild or intense), rather than what the response is (affection, aggression etc.) (Strelau, 1983).

Buss and Plomin (1984) define activity in terms of frequency or rate, time spent in high-energy activities and persistence in continuing with such activity, the amplitude or vigour of the activity, the choice or preference for high-energy games or work, and the reaction to enforced idleness. For example, their EAS (Emotionality, Activity, and Sociability) Temperament Survey asks parents of children to rate statements such as, *child is always on the go* and *child is very energetic*, to obtain an overall measure of how active the child is. Buss (1991) defined it similarly as the expenditure of physical energy. He specifically excludes any cognitive effort (such as thinking, imagining, planning) and any arousal that accompanies emotional behaviour. For adults, he emphasizes the tempo or pace of action, vigour or intensity, and endurance of active individuals.

Eaton (1994) defines activity level simply as the individual's customary level of energy expenditure through movement. This definition captures the essence of the theoretical definitions without restricting it to any one particular theoretical approach. This definition also links motor activity to the notion of energy expenditure used in biology and medicine. There is no requirement for activity to be goal-directed for example, nor are

causal antecedents implied. Energy can be expended to maintain body temperature and to grow, but the notion of activity level is restricted to movement-based calorie costs. Such an approach allows for practical measurement, but is broad enough to encompass the more theoretically-based definitions.

Theoretical matters of importance when trying to operationalize or develop hypotheses about motor activity revolve around psychobiological and temperamental issues of individual style of behaviour. Although we understand many facts about the way the motor system is organized physically, motor activity level as a psychological concept is not well understood. When I refer to activity level here, I am referring to Eaton's (1994) definition, which I will be using for the purposes of this dissertation. This conceptualization of motor activity as a dimension of temperament focuses on the way that individuals typically act or interact with their environment. The definition does not refer exclusively to skilled motor activity, but it does include it. It also includes unskilled motor activity. From this perspective, motor activity is an ecologically based psychological concept, that describes individual differences in susceptibility to stimuli and initiation of behaviour.

Theory of Mood

Although not studied from a biological perspective, mood is nonetheless a psychological construct involved in concepts of emotion and arousal. The following theory of mood is interesting because it includes a consideration of energy as it relates to positive and negative emotion and physical activity.

Thayer (1989) argues that there exist two mood systems which work to arouse feelings of mood. The energetic arousal system is recognizable by subjective sensations of

energy, vigour, or peppiness. If the mood is one of energetic arousal, the individual is predisposed to move and be physically active. Declines in the energetic mood system incline an individual to feel tired, and to rest or be physically inactive. The second mood system is the tense arousal system. It is associated with feelings of tension, anxiety, or fearfulness. With activation of the tense arousal system, a preparation for action is present, but also restraint or inhibition to act.

The two mood systems interact together to produce various moods. High energy and low tension are associated with feelings of calmness, optimism, happiness, and pleasurable feeling, which is called a *good* mood. Low energy and high tension produce an unpleasant feeling, often labelled as a *bad* mood (Thayer, 1989). Anything that increases feelings of energy and decreases feelings of tension (e.g., caffeine, cocaine, tranquilizers, exercise, sleep) encourages positive feelings and puts an individual in a good affective state or mood. The addictive attraction of attaining a positive mood is a key motivation in the use of various psychoactive drugs. The often immediate positive effects of exercise, Thayer (1989) attributes to the effects of energetic arousal on mood.

Relations among Emotion, Temperament, and Mood

Although the concepts of emotion, temperament, and mood come from different theoretical backgrounds, it is useful to discuss how they relate to each other. One way to explain the relationship among emotion, temperament, and mood is to apply them along a temporal dimension. Temperament lasts longer than mood and is the most stable or consistent (Strelau, 1986b). Mood lasts longer than emotion. Emotions are often described as transient feeling states. Moods are usually defined in terms of states of mind or attitude predisposing the individual to some action. Moods and emotions can

contribute to temperament if they are consistent enough over time (Thayer, 1989).

People usually describe moods as subjective, background feelings that last for a time and may or may not have an identifiable cause. Mood is sometimes seen as an assumed tendency or inclination to act under certain circumstances (Thayer, 1989). However, it is also considered a biopsychological concept in which affect is not so much the response to biochemical, psychophysiological, or cognitive bodily processes, but an interaction process (Thayer, 1989). In this way, thoughts, subjective feelings, life events, and biological processes are all necessary for moods to occur.

Another way to explain the relationship between emotion, temperament, and mood is in terms of their historical origin. Emotion comes from the experimental animal literature, and thus, empirically, often its concepts deal with basic neurobiological processes of emotion attributed to animals. Emotional concepts therefore come from the *bottom up*. Temperament and mood are considered *top down* approaches, coming as they do from the self-report methodology of the adult personality literature. As well, emotions tend to be more intense than mood (Thayer, 1989).

I dwell on the concepts of temperament, mood, and emotion for two reasons. First, emotion theorists use neurobiological or psychobiological approaches on which to base their theories. These lower-level theories are then used to explain the biological basis of higher-level concepts or theories of temperament, or mood, which I will be assessing in this dissertation. Secondly, I shall be examining the literature on the hemispheric lateralization of emotion. This literature consistently refers to the concept of emotion, rather than to the concepts of mood, presumably because of the stronger biological advances made in the name of emotion. I therefore want to include both in the general

theoretical discussion.

Summary

The neo-Pavlovian concepts of arousal, excitation, and inhibition are not inconsistent with Gray's (1991a, 1991b) notion of the approach-oriented activation system, and the withdrawal-oriented inhibition system. Both systems are thought to underlie the experience of behaviour and emotion. The excitation and inhibition systems can be assessed empirically using the BISBAS scale developed by Carver and White (1994). Neo-Pavlovian concepts of arousal can be assessed using the Pavlovian Temperament Survey (PTS; Newberry et al., 1997a). Mood can be assessed using a brief self-report measure (PANAS; Watson, Clark, & Tellegen, 1988). In addition, the Affect Intensity Measure (AIM; Larsen & Diener, 1987) can be used to measure both arousal and affective valence characteristics. These instruments describe the tendency and tone with which individuals interact with others and the world around. It should be the case empirically, that arousal is related to an individual's typical level of motor activity. In this dissertation, I am using these self-report instruments to examine the temperamental and emotional correlates of motor activity.

The underlying assumption of the research discussed above is that motor activity is a unified entity present to a greater or lesser degree in all living animals. However, another way to explore the meaning of motor activity is as a lateral phenomenon. Corballis (1989) speculates that asymmetries in humans make efficient use of neural space and are evolutionarily advantageous. Further, Davidson (1992a) suggests that the decision to approach or withdraw speedily is adaptive when it comes to fleeing danger, for example. In any life or death situation, one would want to be able to move decisively

away from, rather than toward an enemy! He argues that at the point of taking action, we must choose whether to go left or right. Davidson (1992a) also suggests that it might be evolutionarily advantageous if these lateral movements were associated with our emotions, providing motivation to move. Thus, the possibility exists that asymmetric motor activity relates to the emotions.

In the next section, I discuss the literature on lateral asymmetries and how they relate to emotions. Further, I will attempt to draw together the literature on hemispheric lateralization to make the case that lateral biases in movement should relate to emotional experiences or perceptions.

Concepts in Laterality Research

In the psychological literature, lateral asymmetries in behaviour are explained from a neuropsychological perspective. This tradition developed out of the clinical literature, which emphasizes the importance of asymmetries in the function of the CNS. Although the initial impetus for much of the neuropsychological functional and physiological laterality research has been based on clinical pathology, there is now an extensive base of data and methods on which to draw for research of a non-clinical nature. In fact, various neuropsychological methods, behavioural responses, and observations provide options for collecting relatively ecological data outside of the laboratory setting. One of the goals of this dissertation is to collect an ecological sample of motor activity to explore its relation to individual differences in the domains of temperament, emotion, and other lateral motor asymmetries, such as handedness, from a neuropsychological perspective. In order to understand this perspective, I will describe next several key theoretical issues in laterality research and how they relate to motor

asymmetries.

An examination of the neuropsychological literature on lateral asymmetries reveals many right-left differences in behaviour. These asymmetries are important because they are thought to represent underlying asymmetric processes in brain function in both adults (Bradshaw & Nettleton, 1981; Galaburda, Rosen, & Sherman, 1990; Geschwind, 1979; Geschwind & Galaburda, 1985a, 1985b; Hellige, 1993; Iaccino, 1993; Kinsbourne & Hiscock, 1983; Zaidel, 1983) and in children (Best, 1988; Koenig, 1990; Kolb & Fantie, 1989; Levy, 1981; O'Leary, 1990; Witelson, 1977; Young, 1990a). Lateralization in neural control involving either motor performance or motor preference is evident in various functional perceptual and cognitive abilities. For example, lateral asymmetries are evident in preferences involving motor function, such as handedness (Annett, 1992; Gottfried & Bathurst, 1983; Provins, Milner, & Kerr, 1982; Young, 1990b) and footedness (Levy & Levy, 1978; Peters, 1988). There are other abilities and preferences in the area of kinesthetics (Pipe, 1991), touch (Flanery & Balling, 1979; Moreau & Milner, 1981; Rose, 1984), earedness (Bryden, Free, Gagne, & Groff, 1991; Davidson & Hugdahl, 1996), and eyedness (Bourassa, McManus, & Bryden, 1996). Cognitive functions such as visual perception (Hellige, et al., 1994), spatial function, thinking, and language (Bates, O'Connell, Vaid, Sledge, & Oakes, 1986; Goldberg & Costa, 1981; Gottfried & Bathurst, 1983; Levy & Reid, 1978; Shucard & Shucard, 1990; Witelson, 1977), also show lateralized differences. However, the particular focus in this dissertation is on the lateralization of emotions and the relationship of emotional expression to lateral asymmetries in motor activity. Both emotional expression and emotional understanding have been shown to be lateralized in normal individuals

(Davidson, 1993a, 1995; Borod, 1993a; Heller, 1993; Kinsbourne & Bemporad, 1984; Tucker & Frederick, 1989).

Although many of these lateral behaviours involve motor activity, what we do not know is the relationship between spontaneous motor activity and other lateralized behaviours. Among the multitude of studies on various lateralized behaviours, none has explored motor activity as a lateralized behaviour. Insights into the relationship between behaviour and brain function have been revealed through studies on lateral asymmetries in cognition and emotional function. Could it also be the case that lateral asymmetries in motor activity and emotional function reflect a relationship between behaviour and brain function? This gap in the literature will be addressed in this dissertation. I will examine how asymmetries of motor activity relate to an individual's emotional behaviours, temperament, and other lateral preferences.

Many asymmetries are fairly easy to observe in normal individuals. There are several key concepts that offer explanations for why we see asymmetrical behaviours. These concepts include the notion of hemispheric specialization, and hemispheric lateralization. Both hemispheric lateralization and hemispheric specialization are terms that often are used interchangeably in the psychological literature, and both are of particular relevance to understanding the theoretical basis of the proposed study. These terms and the issues they engender are therefore described in more detail below.

Hemispheric Specialization and Lateralization

Hemispheric specialization refers to a theoretical concept involving the functional organization of higher mental functions (e.g., verbal, visuo-spatial, emotional understanding and expression) in the brain. The term refers to the localization or focusing

of crucial component processes in one hemisphere of the brain, resulting in what is referred to as lateralization (to the left or right hemisphere) of the function. In the literature, both hemispheric specialization and lateralization are used with slightly different meanings, depending upon the context. Either term may refer to the specificity of the task of one hemisphere's role in mediating cognition, to the competence of the hemisphere in processing a particular task, or finally, to the hemisphere that is relatively more involved in processing a specific task (Witelson, 1987). Often the assumption is that for any particular function, the hemisphere that is relatively more involved will also be the more competent.

The term lateralization or laterality, usually describes the behavioural evidence or observable asymmetries predicted by the notion of hemispheric specialization or hemispheric lateralization, which is a theoretical construct (Kinsbourne & Hiscock, 1983). Thus, although they are often used interchangeably, hemispheric specialization refers to the competency or specificity of a cognitive task on one side of the brain, while lateralization describes the involvement or degree of asymmetry without respect to the direction of the asymmetry (Collins, cited in McManus, 1991).

Each hemisphere is thought to be specialized or uniquely suited to carry out some functions or tasks better than others. The specialization of the two hemispheres has often been described in terms of dichotomies, with the left side said to be best at verbal, analytic, serial, focal tasks, and the right hemisphere best at nonverbal, holistic, associative, and diffuse tasks (Kinsbourne & Hiscock, 1983). More specifically, the left hemisphere is thought to be specialized for tasks involving time-dependent and sequential functions, such as speaking and the finely tuned, discrete movements involved in writing.

The right hemisphere is thought to be specialized for tasks that involve spatial relationships and the recognition and production of emotional communication. For example, the more holistic process of synthesizing individual features involved in face recognition is considered a right hemisphere task, as are the manipulo-spatial tasks involved in map-reading and understanding braille (Bradshaw & Nettleton, 1981). Although it may appear that the tasks performed best or controlled by each hemisphere are clearly defined, the literature on the topic is far from complete.

It is very much a matter of tradition and supposition how the cognitive processes or functions ascribed to the two hemispheres are labelled and described. We develop psychological constructs to try to describe cognitive functions, but they may be inadequately defined (Bradshaw & Nettleton, 1981). To go beyond description and try to understand *why* the two hemispheres are most competent at different types of tasks, researchers are trying to identify more precisely the underlying cognitive mechanisms used to carry out each of the tasks. For example, the basic mechanism underlying the exquisite timing and sequential motor functions ascribed to the left hemisphere are variously identified as an ability to inhibit behaviour, and/or to carry out intentional action, and/or maintain vigilance (Pribram & McGuinness, 1975; Tucker, Vannatta, & Rothlind, 1990; Tucker & Williamson, 1984), or to support motor readiness for the 'fight or flight' response (Tucker and Derryberry, 1992). The cognitive mechanisms attributed to the right hemisphere are identified as a tendency to impulsive action and/or attentional activity (Bradshaw & Nettleton, 1981; Verfaellie & Heilman, 1990), especially orienting to novel events (Tucker, 1989), and being particularly skilled in the comprehension and perception of visuospatial and tactile experiences (Deutsch, Bourbon, Papanicolaou, &

Eisenberg, 1988; Witelson, 1976).

Semmes (1968) and Gur et al. (1980) suggest that each hemisphere is uniquely suited for different functions because there is more grey matter in the left hemisphere and more white matter in the right hemisphere. Grey matter is composed of nerve cells and unmyelinated fibres suited to short-distance intra-hemisphere function, while white matter is composed primarily of myelinated nerve fibres suitable for cross-region inter-hemisphere transfer. On the basis of such asymmetrical neuroanatomical organization, Goldberg and Costa (1981) suggest that the right hemisphere has a greater capacity to deal with complex, multi-modal diffuse information, gathering and integrating information from different areas of the brain. The left hemisphere has a greater capacity to deal with unimodal focally represented information, such as is necessary for discriminating fine differences in language and making fine oral movements in speech.

Dichotic listening. One technique for behaviourally assessing hemispheric asymmetries is to administer a dichotic listening (DL) task (Kimura, 1967). In this procedure individuals listen to two competing messages delivered to each ear by stereophonic headphones. The key to this task is to present information to both ears at the same time, and to provide more elements for processing at any one moment than the brain is capable of processing (Hugdahl, 1995). This simultaneous exposure to each ear, of more stimulus components than can be consciously analyzed, in effect, ensures that information is presented to each hemisphere separately. Greater accuracy in reporting stimuli presented to one ear is interpreted as reflecting the specialization of the contralateral hemisphere for the task (Kinsbourne & Hiscock, 1983). A right-ear advantage (REA) has been associated with a left-hemisphere specialization for identifying

language (digits, words, and consonant-vowel syllables). A left-ear advantage (LEA) has been associated with a right hemisphere superiority for the reporting of musical notes, emotional stimuli, and environmental sounds (Hahn, 1987; Koenig, 1990). In this dissertation, I am assessing hemispheric specialization for language and emotional perception by means of a DL task. I expect that most individuals will show a REA for language, and a LEA for emotional stimuli, but how the ear advantage will relate to lateralized motor activity, I cannot predict.

Thus, the current level of understanding and knowledge about how the brain functions is developing into more than just a descriptive list. However, linking brain function to specific, observable behaviours is a difficult task. The existence of intra-individual variations may account for some of the inconsistencies or contradictions in the findings in the empirical literature on lateralities (Gur & Reivich, 1980; Nestor & Safer, 1990). Nevertheless, much is known about typical asymmetries in motor control and the nervous system. These functions and processes are discussed next.

Development of Asymmetries in Motor Function

Peters (1983) and others (Govind, 1989; Guth & Yellin, 1971, cited in Peters, 1983) make several points of interest to a discussion of the development of hemispheric function and motor activity. They have suggested specifically that an increase of activity on one side will produce a differentiation of the muscle fibres into the slow type on that side. Peters (1983) also speculates that any early bias in the amount of movement in an arm or leg is liable to result in different rates of differentiation. Therefore, even an initial, mild but consistent bias in activity can result in a strong asymmetry later on. If a mild movement bias early in life amplifies later structural changes involving modifications in

both form and function, the results are relevant to a developmental view of hemispheric specialization and lateralities. Early differential right-left motor activity should influence later lateral motor activity, and consistency of lateralized practice should promote more precise motor control. Thus, an early bias in lateral behaviour might lead eventually to later right-left differences in manual skill and/or hand preference (Peters, 1983).

Motor Control and Asymmetries in the CNS

For normal motor functioning, both cortical and subcortical structures are important. In the cerebral cortex, the parietal and frontal cortex, and their interconnections are considered key in motor control processes (Haaland & Harrington, 1990). The subcortical sites that most directly influence movement are the basal ganglia, the thalamic relays and the cerebellum. The complete motor circuit consists of the supplementary motor area (SMA), primary motor, and somatosensory areas in the cortex, and the putamen, globus pallidus, and thalamus in the subcortex (Haaland & Harrington, 1990). The SMA participates in the planning of motor routines. The premotor area participates in non-routine, voluntary movements, dependent upon sensory information. The primary motor area controls voluntary motor functions. Subcortical areas participate in the planning and execution of voluntary movements (Roland, 1984).

Physiologically, Geschwind and Galaburda (1985a) hypothesize that there are two motor pathway systems and that these systems control the ability or ease with which an individual learns different types of motor movements. The first system is the ***pyramidal*** or corticospinal pathway that controls complex sequences of fine motor movements and independent motor control of the fingers. The second system is the ***extrapyramidal*** or ***axial*** pathway controlling the ability to coordinate whole limbs and proximal body

movements, such as those involved in posture and large motor movements.

Peters (1983) suggests that the two motor systems, the pyramidal and axial systems, are functionally interrelated. For example, he speculates that in executing a skilled movement, the guidance of the movement is controlled by the axial system, but that the formation of the intention to move and the initiation of movement is carried out by both systems, providing a greater resolution of precise movements. Of particular interest here is that asymmetries in motor activity are a function of the system that initiates and terminates movements rather than in the guidance of a skilled movement.

Most, but not all individuals have distinct anatomical brain asymmetries. In about 65 per cent of the population, the areas of the brain thought to be important in language function are larger on the left side. In about 24 per cent of the population these areas are about equal in size, and in the remaining 11 per cent, the right hemisphere appears larger (Geschwind & Levitsky, 1968). Similar biases in the same proportions have been reported for the brains of both children and adults (Geschwind & Galaburda, 1985a) with normal language development.

The empirical finding of left hemisphere superiority for language appears to be in fact, a left hemisphere superiority for learning sequences of movements, including sequences of articulatory movements of the mouth and tongue and limb posture (Kimura, 1977; Kolb & Milner, 1981, cited in Hellige, 1993). Thus, left hemisphere superiorities derive from an asymmetry of left-hemisphere superiority for motor control (Hellige, 1993).

Although much of the theoretical and empirical literature deals with the lateralization of various cognitive functions, less is said about the lateralization of general

motor activity, especially spontaneous, unskilled motor activity and limb movement. Behavioural evidence of motor asymmetries is varied in nature. The asymmetries may include facial expressions (Kinsbourne & Bemporad, 1984), limb preferences in the form of handedness (Annett, 1972; Henninger, 1992; McManus & Bryden, 1992; Steenhuis & Bryden, 1989), footedness (Peters, 1988), and rotational and turning biases (Glick, 1993). Eye preference (Bourassa et al., 1996) and earedness (Davidson & Hugdahl, 1996; Kimura, 1961a), while not predominantly motor in nature, are conceptually related. For example, it is conceivable that the hemisphere dominant for language may be related to motor asymmetries through attentional or perceptual asymmetries.

As far as having a direct effect on limb movement, it is likely that asymmetries of the peripheral nervous system (PNS) would be involved. Some of the key asymmetries of the PNS are described next.

Motor Control and Asymmetries in the PNS

Two main motor nerve pathways connect the cortical areas of the brain to the subcortex and the muscles of the skeletal system. The direct corticospinal (pyramidal) tract originates in the precentral gyrus of the cortex and passes down through the internal capsule. The pyramidal tract contains fast conducting neurons (Martinez, Lamas, & Canedo, 1995) and is critical for the development of fine manual skills, such as those involved in precise individual finger movement (Hofsten, 1989). About 90 percent of the nerve fibres cross to the opposite side (decussate) at the level of the medulla and terminate in the spinal cord to form the lateral corticospinal tract. Axons of this lateral tract originate in the region of the primary motor cortex controlling the motor neurons which control the distal limbs, those that move the arms, hands and fingers. The

remainder of the fibres descend through the ipsilateral spinal cord forming the ventral corticospinal tract (Carlson, 1991). Decussation of the nerve fibres means that the right motor cortex exercises control over the left side of the body, and the left motor cortex exercises control over the right side of the body (Bigler, 1988).

The extrapyramidal tract passes from the brain to the spinal cord. It includes the basal ganglia (the caudate nucleus, globus pallidus, putamen, nucleus accumbens septi, and olfactory tubercle) and an array of brainstem nuclei (subthalamic nucleus, substantia nigra, red nucleus, reticular formation, and various cerebellar nuclei). The caudate and putamen form the striatum (also called the neostriatum) (Afifi, 1994a, 1994b). The striatum of the extrapyramidal tract interconnects with the dopamine-rich centres of the nigrostriatal system to arouse the motor system and control background movement, such as posture. In general, the extrapyramidal system controls the muscles of the trunk and proximal limbs, and is involved in controlling activities such as walking. Parts of the striatum are connected to the limbic system, so physiologically, an association can be made between the cortex, motor, and emotional systems.

Anatomically, the contralateral neuronal pathways between the cortical hemispheres and the hands are larger than the ipsilateral ones, and those linking the left hemisphere with the right hand are the largest. Asymmetries exist in the number of pyramidal fibres that cross from one side to the other at the level of the medulla in about 40 per cent of human nervous systems studied. The decussation is more complete for the pyramidal path arising from the left hemisphere than it is for the one arising from the right (Geschwind & Galaburda, 1985a). The implication of this anatomical arrangement is that in most people the motor connections between the left hemisphere and right hand are

dominant over those of the right hemisphere and the left hand and over the ipsilateral pathways. Functionally, however, the left hemisphere in particular, is thought to be dominant in the control of motor processes (Brinkman & Kuypers, 1973; Peters, 1983).

In terms of motor control asymmetries, various researchers (e.g., Haaland & Harrington, 1990) have proposed that the left hemisphere is dominant for controlling what they call open-loop movements. These movements are rapid, ballistic type movements that are performed with little modification by sensory input. No evidence has been found for hemispheric asymmetry in controlled, closed-loop movements, which are slower and modified from moment to moment by sensory feedback. However, right-hemisphere injuries have produced impairments in initiating a closed-loop movement toward a visual target, and left-hemisphere injuries have produced impairments in the final stages of guiding movements to a target (Hellige, 1993). Thus, each hemisphere may have specific roles in the speed of motor control.

Individual finger movements are controlled contralaterally, as are whole arm and leg movements (proximal and distal). Proximal movements (e.g., movement of the arm at the shoulder) of the limbs are controlled ipsilaterally (Brinkman & Kuypers, 1973; Mack, Gonzalez, Rothi, & Heilman, 1993). Thus, for most motor activities involving only one side of the body, the left hemisphere controls the limb movements of the right side of the body, and the right hemisphere controls movements of the left side.

Asymmetries of Limb Size

In addition to asymmetries in various areas of the CNS and PNS, there are physical asymmetries in the limbs. For example, anatomical asymmetries have been found in both upper and lower limbs. In one study of adult righthanders, 85 per cent had

longer and heavier left legs, but longer right arms (von Bonin, 1962). However, between the ages of six and 20 years, both right arms and right legs were longer. In another study, Ingelmark (1947) found that lefthanders between ages six and 20 all had longer left arms.

Since it is conceivable that asymmetries in the limb size could influence lateralized differences in motor activity, I am assessing the relation in this dissertation. In the next section, I begin a discussion on asymmetries thought related to motor behaviours.

Lateral Asymmetries Related to Motor Activity

Theoretically and empirically, it is the case that individual variation in brain asymmetry shows behavioural manifestations. A lateral asymmetry expressed in a sensorimotor activity is considered to be a behavioural expression of hemispheric specialization for the task. In motor behaviour, an asymmetry in the differential use or preference for one limb over the other for any number of tasks is considered the behavioural expression of lateralization or hemispheric specialization (Hellige, 1993; Henninger, 1992; Kinsbourne & Hiscock, 1983). A manual response that consistently favours either the right or left hand is defined as a laterality of hand preference. Laterality of hand preference is implicated in the hypothesized relationship between hemispheric function and manual control. For example, in the most common case, the asymmetrical use of the right hand for writing is thought to relate to a specialization for handedness in the contralateral left hemisphere. Similarly, a pedal asymmetry (or footedness) is the differential use of preference for one foot or leg over another in tasks that require differential roles for the two limbs (Peters, 1988). These functional asymmetries are evident across the lifespan. Some of the common functional lateralities are closely associated with movement either directly or indirectly (Hellige, 1993).

Handedness

There is no single accepted view on how to define handedness, nor on which motor behaviours can be considered key to the concept of handedness. For adults, Kolb and Wishaw (1990) define handedness as a consistent preference for the use of one hand in a variety of manipulations (p. 403).

McManus et al. (1988) distinguish between direction or preference and degree or skill in describing handedness. Direction of handedness refers to the left-right categorical assignment of manual laterality preference. Direction or preference reflects the fact that a right-handed individual will tend to use the right hand for a variety of different tasks. However, a hand preference does not necessarily imply greater skill relative to the non-preferred hand (Annett, 1972; Flowers, 1975). McManus et al. (1988) and others (e.g., Annett, 1972) suggest that a genetic factor might be responsible for the preference. A directional preference begins to develop between 5 and 8 months of age (Ramsay, 1984), but does not appear to be consistent until between age three to age five for both right- and left-handers (McManus et al., 1988).

Degree of handedness refers to the extent to which each hand is used consistently for particular tasks. It is a measure of the relative use of both hands, and it is a continuous variable. Because it involves practice in manual skills (i.e., in that one hand is used consistently for particular tasks), degree of handedness implies a relatively better dexterity in speed or accuracy of fine hand and finger movements for one hand over the other. There is no familial trend in degree of handedness, and it appears to be influenced by the individual's usage and cognitive strategies of motor control. Degree of handedness continues to develop until age seven (McManus et al., 1988).

Steenhuis and Bryden (1989) focus on the skill level required to execute a task, but also consider the influence of other factors. The analysis of their questionnaire shows that salient factors of handedness include the skill required to carry out a manual activity, the size of the object manipulated, the strength required to use the object, and whether the activity is a one-handed or two-handed activity. The first factor included questions on drawing, writing, hammering, erasing, sewing, the use of a toothbrush, and cutting bread with a knife. About 70 percent of right-handers and 63 percent of left-handers always use their preferred hand for these activities. The second factor involved picking up objects, such as paper clips, marbles, pieces of paper, and pins. These activities tend to be less lateralized. In their study of 2000 individuals, only 19 percent of right-handers and 18 percent of left -handers indicate that they use one particular hand exclusively for these activities. The third factor involved the use of a bat and an axe. Ten percent of right-handers and 26 percent of left-handers use their left side for these activities. The fourth factor was a strength element, involving carrying heavy objects, and suitcases. For both right- and left- handers, these activities are performed about equally by both hands (Steenhius & Bryden, 1989).

Oldfield (1971) simply defines handedness as a preference for use of one hand in a set of habitual everyday acts. His widely-used Edinburgh Inventory is a questionnaire which assesses handedness based on the individual's preference for familiar one-handed and two-handed tasks such as writing, drawing, throwing a ball, brushing teeth, using a broom, dealing cards, and threading a needle (Oldfield, 1971). For the two-handed tasks, the hand used to manipulate rather than hold the object is the one considered to be the preferred hand. For example, when opening a jar with two hands, it is the hand that turns

the lid that is considered as the preferred hand rather than the hand that holds the jar (Oldfield, 1971).

Handedness and Hemispheric Specialization

In the most general way, handedness is considered a reflection of the greater capacity of one side of the brain to acquire the programs for particular skills (Liepmann, 1908; cited in Geschwind & Galaburda, 1985a). For example, hemispheric specialization in the left hemisphere for language has been linked to right-handedness (Witelson, 1987). One might be inclined to think then, that left-handedness must be linked to the right hemisphere for language. However, studies examining the occurrence of manual interference when adult subjects are given concurrent verbal and manual tasks indicate that manual activity is often controlled to some extent at least by the left hemisphere for both right- and left-handed tasks for both right- and left-handed people (Simon & Sussman, 1987).

In fact, in over 95 percent of the right-handed population and 70 percent of the left-handed population, both motor control and language are controlled by the left-hemisphere (Kinsbourne & Hiscock, 1983). Although the specific proportions vary according to the study, various researchers have concluded that in about 15 percent of left-handers, language and handedness are dissociated, typically with language controlled by the right hemisphere and motor control in the left hemisphere. A further 15 percent of left-handers have the functions bihemispherically controlled (Simon & Sussman, 1987). That is, they show no observable lateralization effects in tasks that usually show evidence of such. Therefore, about 30 percent of left-handers have a non-standard cerebral dominance for language and/or motor control. However, on average, a hemispheric

asymmetry for a group of left-handers can be expected to be in the same direction as right-handers, but with a smaller magnitude for the left-handers (Hellige, 1993).

Although it is a commonly assessed neuropsychological variable, there is not much in the psychological literature on the relationship between handedness and motor activity. The results of one recent study do show that handedness was not significantly related to either motor activity or lateralized motor activity. In this study, both right- and left- handers were more active on the left (Eaton et al., 1998). Similarly, in this dissertation study, I do not expect to find a relationship between handedness and lateralized motor activity. However, a check of handedness is in order. I will assess handedness with a brief 4-item questionnaire (Coren, 1993a).

Footedness

Structurally and physiologically, the functioning of leg and foot movements are the same as for the hands. However, footedness does differ from handedness somewhat because relative to the hands, the activities of the feet are less complex and less overlearned. Furthermore, there are more unimanual activities in day-to-day living than there are uni-footed activities (Gabbard & Hart, 1996). Most of the usual movements of the feet, such as walking and standing, involve both limbs. Peters (1988) suggests that the lateral bias in role differentiation in the lower limbs is not as compelling as it is for the hands because of these differences. Therefore, it may be that foot activity is functionally more bilaterally controlled than are hand movements (Aglioti, Dall'Agnola, Girelli, & Marzi, 1991). Footedness is still important though, as a lateralized behaviour, because it has been found to be a better predictor of direction and strength of language lateralization than is handedness (Searleman, 1980).

Peters (1988) defines footedness by emphasizing the role differentiation of the feet (and/or legs). The foot that is selected to manipulate objects or to lead off first is defined as the preferred or dominant foot. The foot used for support and power functions is defined as the non-preferred or non-dominant foot. In righthanders, the left foot (or leg) is most often used for support and power functions, and the right foot (or leg) is used to manipulate objects. Lefthanders as a group do not show a clear preference for either foot, although they show more left footedness than do righthanders.

Typical findings in several studies show that about 95 per cent or more of right-handed children use their right feet to kick a ball, while only between 50 and 84 per cent of lefthanders used their left feet (Annett & Turner, 1974; Peters & Durding, 1979; Peters, 1988). Left-handed children were almost as likely to be right footed as left footed, indicating that the lefthanders manifest less lateralized foot preference than right-handers. In one study, researchers found that 94 percent of right-handers were also right-footed, but only 41 percent of left-handers were also left-footed (Chapman, Chapman, & Allen, 1987).

The assessment of footedness is somewhat complicated by the interactions between hands and feet, such as those that occur in athletic performances, dancing, playing musical instruments, and in operating machinery. However, both preference and performance of foot and leg activities can be used in determining footedness. Kicking a ball, picking up pebbles with the toes, and stepping up onto a chair are tasks used to distinguish foot preferences. Foot performance measures include tapping speed, and tapping rhythms, tests of leg strength, and picking up and releasing small objects with the toes (Peters, 1988).

Although I do not expect a relationship between motor activity and footedness, footedness is a commonly measured laterality. I will assess footedness with the brief Coren (1993) questionnaire.

Eyedness

Just as handedness and footedness are manifestations of lateral dominance or sidedness, so too is there a dominant sighting eye. Although its functional significance is not fully understood (Bourassa et al., 1996; Porac, 1997), the dominant eye reflects a behavioural selection or preference for viewing when only one eye can be used. Sensory dominance occurs when monocular views are discrepant and must be coordinated, and acuity dominance refers to the eye that performs with better vision, but sighting dominance is most analogous to handedness or footedness (Porac & Coren, 1976).

Ninety-seven percent of the population consistently uses the same eye for various one-eyed sighting tasks, while about three percent show no consistent preference. Eye preference appears to be independent of age, sex, or cultural differences (Bourassa et al., 1996). However, there is an age effect apparent when the concordance between age and handedness is examined. Older people have a greater hand-eye association than young people by a ratio of 1.4 times per decade (Bourassa et al., 1996). In their recent meta-analysis of eye dominance and hand preference in over 50,000 people from 43 populations, Bourassa et al. (1996) found that a right-eyed sighting dominance occurs in about 64 percent, and a left-eyed preference occurs in about 36 percent of the population. Thirty-four percent of right-handers and 57 percent of left-handers are left-eyed. The overall incidence of left-eyedness in left-handers is 2.5 greater than that in right-handers. Thus, there is a small, but consistent association between handedness and eyedness.

This association between handedness and eyedness was confirmed in a later study of eye preference in a Canadian population that ranged in age from 18 to 94 years. Both right- and left-handers were more likely than not to display congruent eye preference. In the 18 to age 30 group, the odds ratio indicates that the occurrence of left eye preference increases by a factor of 4 if one is left-handed. In the age 55 to 74 group, the odds ratio is raised to a factor of 16, and in the 75 to 94 year age group, it is a factor of 18. Similar findings result from predicting eye preference from foot preference. Being left-footed increases the likelihood that an individual between ages 18 and 30 will be left-eyed by a factor of 6. That number is increased to a factor of 25 for the 55 to 74 age group and by a factor of 8 in the oldest group (Porac, 1997).

The association between eye and handedness is slightly greater when questionnaire methods are used (Bourassa et al., 1996). However, it is possible that the association is shaped over time by hand-eye practice effects. In this study, the assessment of eyedness is not a major feature. Therefore, assessing eyedness using a short questionnaire (Coren, 1993a) should be sufficient.

Earedness

Earedness is not exactly a motor asymmetry, but it is a commonly measured laterality. It is thought to represent more than just a preference for using one ear over the other for listening on the telephone. Asymmetries of perception in listening are considered evidence of underlying hemispheric specialization, hypothesized to relate to lateralized cognitive, emotional, or perceptual processes in cerebral hemisphere function (Hellige et al., 1994; Hugdahl, 1995).

In normal individuals, auditory information is transmitted from each ear to both

contralateral and ipsilateral cortical areas, particularly the areas responsible for language understanding and speech. Auditory stimuli travel from the cochlear nucleus in the ear (from the vestibulocochlear nerve) to reach the primary auditory cortex in the temporal lobe for language processing. Although signals from both ears reach the auditory cortex in both temporal lobes, the contralateral pathways are dominant and preponderant, probably due to the fact that they contain a greater number of fibres and transmit information faster (Hugdahl, 1995; Iaccino, 1993).

Earedness is a commonly measured lateral preference, and although I do not expect a relationship with lateralized motor activity, I will assess it briefly in the proposed study. Earedness as a preference for listening will be assessed in this dissertation study by means of the Coren (1993) questionnaire. I will also assess verbal and emotional perception using a dichotic tape task which I will discuss later (Bulman-Fleming & Bryden, 1994).

Motor Activity and Lateral Behavioural Preferences

Of the above functional asymmetries of preference, handedness and footedness are most likely to relate to motor activity. Eyedness and earedness do not so obviously involve peripheral limb movements. However, any hypothesized relation between a common lateral preference and motor activity must take into consideration the possibility that either perceptual habits or attentional biases may make any interaction complex in everyday activity. The typical right-hander's left-hemisphere bias for speech for example, might influence the amount of motor activity expressed by the right- or left- arms while an individual is speaking. Right-arm movement might be diminished during speech because the contralateral left hemisphere is absorbed with the cognitive task. On the other

hand, perhaps speech enhances right-arm (or left-arm) movement by contributing emphasis and meaning to the words. While I am not examining the effects of speech or other specific motor task on motor activity in this dissertation, these behaviours are no doubt an influence on the daily motor activity expressed by an individual.

Empirically, there is little research relating motor activity assessed in everyday context to lateral preferences or skills. In one such study, archival films of persons living in pre-literate cultures were examined for hand use (Marchant, McGrew, & Eibl-Eibesfeldt, 1995). The researchers concluded that hand use in the natural environment of the three cultures studied was consistently, but weakly, right-sided. Tool use however, was strongly right lateralized when a precision grip was involved.

In a longitudinal study of twins carried out in our laboratory (Saudino & Eaton, 1991), we have found that patterns of spontaneous movement changes with age. As measured with mechanical instruments over a two-day period, at the age of 6 months about 60 percent of the infants showed more left-armed motor activity. By the age of 3 years, about 96 percent of the same children showed more left-armed motor activity. By age 6, about 70 percent of the children showed more left-armed motor activity (McKeen, 1997). Because of the huge developmental trends evident at 3 years of age, when almost all of the children were more active with their left arms, we found no correlations with individual differences characteristics, such as handedness or motor skill level.

In another study carried out in our laboratory, we also examined arm movement in a natural setting. We used an instrumented measure of the frequency of arm movements of 70 university students over typical two-day periods. We used the 32-item Waterloo Handedness Inventory (Steenhuis & Bryden, 1989) to assess hand preference

on a variety of unimanual activities in right- and left-handers. We found that the participants' left arms made approximately 80 more movements per hour than did their right arms. This asymmetry reflected a generalized leftward shift in the distribution in the arm-movement frequency. It was not due to a few extreme individuals. However, to our surprise, the observed sinistral bias was not related to direction or degree of hand preference. Seventy-two percent of right-handers were left-biased in movement frequency, whereas 59% of left-handers were left-biased, a non-significant difference (Eaton et al., 1998). These percentages in the adult sample are very similar to those we found in the 6-year-old sample, in which 70 percent showed more left-armed activity.

Other empirical evidence relating asymmetric motor activity to lateral preferences is virtually non-existent in the literature. Because we (Eaton et al., 1998) unexpectedly found no relationship between handedness and lateralized motor activity, I do not expect a relationship to emerge in this study. However, if the lateral asymmetry of motor activity emerges, I shall assess it in relation to the other customary lateralities. Thus, in the dissertation studies, I am assessing handedness, footedness, earedness, and eyedness, and their relation to lateral differences in motor activity.

It is one thing to find empirical evidence of lateral differences in motor activity. It is another thing to discover to what they relate. It is conceivable that they are meaningless, simply *evolutionary junk* left over from our primordial past. More optimistically, asymmetries in motor activity may provide a link between brain and observable behaviour, as intriguing as the link between handedness and lateralization. While many of the hand activities that we accomplish are bimanual to a greater or lesser degree, the few empirical results we have seem to indicate a consistent left-biased motor activity in

everyday activities. As discussed above, this activity bias does not seem to relate to handedness in either children or adults. To what might the asymmetry relate? I suggest that lateral differences in motor activity among individuals relate to differences in their temperament, emotion, or mood. In the next section, I discuss the recent empirical evidence for the lateralization of emotion and its possible relation to motor activity.

Lateralization of Emotion

Earliest evidence of emotional lateralization comes from reports of the affective consequences of brain damage. Negative affect and catastrophic reactions were reported in patients with left-hemisphere damage. Patients with damage to the left frontal regions of the cortex tend to be apathetic, experience a loss of interest and pleasure in life, and have difficulty initiating voluntary action, all symptoms we describe as reflecting depression and sadness (Davidson, 1995). In patients with right-hemisphere damage, indifference, joking, or euphoria predominate (Davidson & Fox, 1988). Similarly, in epileptic patients, pathological crying occurs more frequently with left-sided lesions. Pathological laughter occurs more frequently with right-hemisphere lesions (Sackeim, Greenberg, Weiman, Gur, Hungerbuhler, & Geshwind, 1982).

In a normal population, researchers have used facial expression and electrophysiological procedures to make inferences about patterns of activation. For example, studies using EEG data have found greater right-sided anterior activation (in the frontal and anterior temporal areas) during facial expressions of disgust than during happy facial expressions in adults (Davidson, 1992b). Facial signs of disgust related to the taste of citric acid were also present in newborns and also associated with greater right-sided frontal activation. From studies such as these, researchers conclude that an early

differential anterior lateralization for emotion is present from birth (Davidson, 1992b).

Researchers (e.g., Lee, Loring, Dahl, & Meador, 1993; Sackheim et al., 1982) have suggested an inhibition-disinhibition brain mechanism to account for the rather contrary findings between the clinical and normal populations. They hypothesize that under normal circumstances, each intact hemisphere inhibits the emotional tendency of the contralateral one, creating a balance of emotional expression. Thus, the activation of the right hemisphere during negative emotions that occurs in normal individuals is inhibited somewhat by the effect of the left hemisphere control. In those with left hemisphere lesions, that inhibition no longer occurs. The idea is that damage to the left hemisphere interferes with its normal ability to inhibit the natural tendency of the right hemisphere to produce negative emotions. Negative emotions occur more frequently in those with left hemisphere clinical conditions. The result is a production of excessive negative affect in those with left hemisphere lesions. The results of the Lee et al. (1993) study support the conclusion that the intrinsic emotional tone of the left hemisphere is positive (producing euphoria, elation, and laughter), and the intrinsic emotional tone of the right hemisphere is negative (producing sadness, depression, and crying).

In terms of individual differences in temperament, behaviourally inhibited children show significantly less left-sided frontal activation compared to their age-peers (Fox, 1989). Inhibited children are described as shy, fearful, or introverted. They also appear more anxious and more distressed by mildly stressful events. The pattern of left frontal EEG hypoactivation displayed by the inhibited children is similar to that observed in adults who are depressed (Davidson, 1992b). The point here is that there are individual differences in emotional reactivity, expression, and lateralization in normal children and

infants. These differences in laterality and emotionality may represent individual differences in the thresholds for affective responsivity and thus to individual differences in temperament (Davidson, 1995; Davidson & Tomarken, 1989) that occur early in life.

One important aspect of the research on emotional lateralization and affect in infants is that they have not yet learned to regulate their emotional expressions and reactivity to emotion-producing stimuli (Davidson, 1992a). It is thus easier to examine the production of emotion in infants. One such study demonstrates some of the lateral asymmetries in emotional reactivity as shown by changes in facial expressions. Facial expressions, it should be mentioned, are essentially motor responses of emotion. Fox and Davidson (1988) found that among normal 10-month-old infants, those who cried in response to a one minute separation from their mothers had greater right-sided frontal activity during a prior baseline measure. None of the infants appeared to differ in facial expression during the baseline assessment. When the mothers returned and approached their infants, those infants who exhibited joyful expressions showed greater activation in the left frontal hemisphere. During the study procedures, infants who exhibited sad facial expressions showed greater right hemisphere activation, if they later cried. They showed greater left hemisphere activation if they appeared sad, but did not cry. Anger with crying was associated with significantly more right frontal activation, but anger in the absence of crying was associated with left frontal activation (Fox & Davidson, 1988).

In the study above (Fox & Davidson, 1988), individual differences in baseline measures of frontal asymmetry were related to the intensity of both positive and negative affective responses to study procedures. That is, rather than indexing some kind of generalized emotional reactivity, the anterior asymmetry was valence specific. It primarily

indexes the individual's relative balance of positive and negative affective response tendencies (Davidson & Tomarken, 1989).

However, Fox and Davidson (1988) further interpreted the asymmetries in frontal activation to reflect the engagement of systems mediating either an approach (left) or withdrawal (right) system. Davidson (1992a) argues that approach and withdrawal are two basic dimensions along which emotions differ. His theory and its relation to the lateralization of emotion is discussed next.

Asymmetries in Approach and Withdrawal

Davidson (1992a) maintains that decisions to approach or to withdraw are fundamental adaptive choices that are basic because of their phylogenetic primacy. Organisms at every level of phylogeny approach or withdraw from situations in order to survive. Davidson (1992a) suggests that in primitive organisms, rudimentary forms of approach and withdrawal emerged prior to the appearance of emotion and occur in its absence. However, in humans, over the course of evolution, approach and withdrawal actions have emerged in the context of emotion. In more complex organisms, as coordination among the perceptual, cognitive, and action systems became necessary, emotions evolved along with already established approach and withdrawal action systems. They form convergence zones in the brain, which integrate information from various neural networks to code valence of emotion, formulate action plans, and generate autonomic supports (Davidson, 1992a, 1993a). The orbital prefrontal cortical areas are the likely sites of an emotion convergence zone. These areas have the most significant input from subcortical sites in which emotional processing is known to occur. They also interconnect the more posterior dorsolateral and medial parietal cortical areas (Davidson,

1993a).

Davidson (1993a) suggests that one effective way in which competitive interactions between the approach and withdrawal response systems can be minimized is to separate them geographically in the brain. He suggests that hemispheric specialization for the approach and withdrawal response systems is the most effective separation achieved in vertebrate nervous system evolution. Davidson (1993a) argues that the empirical evidence shows that the left frontal region mediates approach-related behaviour, and that the right frontal region mediates withdrawal-related behaviour.

The infant studies mentioned above (Fox, 1989; Fox & Davidson, 1988) are compatible with such an interpretation. Infants who watched their mothers walk towards them showed greater left-frontal (approach) activation, as did those whose facial expressions appeared joyful during a game of peek-a-boo. Other less complete smiling was not associated with left lateralization of EEG data. Facial expressions of anger and sadness in the absence of crying also were associated with left frontal activation, while those that included the act of crying were associated with right frontal activation. However, in infancy, crying also can be considered an approach function, acting as an effort to obtain help or to communicate unhappiness or discomfort. Smiling expressions can represent true happiness associated with approach behaviour, or simply contentedness or politeness, not related to approach behaviours. Thus, depending on the context, expressions of anger, or sadness, or happiness can be considered expressions of either approach or withdrawal mechanisms (Fox & Davidson, 1988).

Although eliciting genuine emotions in a laboratory setting is somewhat more difficult in adults, studies using an association between facial expression and EEG data

have been carried out. In one study (Davidson, Ekman, Saron, Senulis, & Friesen, 1990), right-handed adults were presented with brief silent film clips designed to elicit either happiness (e.g., a puppy playing with flowers) or disgust (e.g., a training film designed to show nurses how to care for burn victims). These two emotions were considered most likely to be associated with approach and withdrawal, respectively. The subjects' facial expressions were unobtrusively videotaped while they watched the films. Subjects reported that the films did indeed elicit the desired emotions, and they reported very similar ratings of intensity for the different clips. As expected, disgust was associated with more activation in the right frontal area, $F(1,9) = 32.10, p < .0005$, when compared to the happy condition. All of the subjects showed more right-sided frontal activation relative to the left during disgust versus happiness.

In the above study (Davidson et al., 1990), it was only when facial expressions were used to verify and flag the presence of particular emotional states did the films show an asymmetry effect. Thus, the right-left hemispheric asymmetries occurred only when there was concurrent motor system involvement in the form of facial expressions.

The reliability of these emotion inducing EEG studies is good. Different measures of anterior asymmetry show that test-retest correlations range between 0.66 and 0.73. Coefficient alphas (based on eight separate 1-minute trials) show levels of internal reliability in the 0.85 range. Interestingly, in this study and others using a similar method, there are pronounced individual differences in the absolute magnitude of the asymmetry scores. Between-conditions differences (positive and negative film clips) are superimposed on widely differing individual differences in basal levels of asymmetry (Davidson, 1995; Davdison & Tomarken, 1989).

Based on the results of these studies, Davidson (1995) suggests that a subject's overall EEG asymmetry during a task is highly correlated with his or her resting baseline. Greater relative left-sided frontal activation at rest is associated with increased intensity of reports of positive affect in response to film clips designed to elicit happiness or amusement. Subjects with greater right frontal activation at rest report more intense negative affect to the film clips. Anterior asymmetries during baselines are stable over time, and are predictive of an individual's affective style or emotional characteristics of emotional reactivity, mood, and temperament (Davidson, 1995).

Another study using the EEG with the film clips method (Tomarken, Davidson, Wheeler, & Doss, 1992) supports the idea that there are stable individual differences in reactivity of emotional states. In this study, subjects were required to report their subjective mood using the Positive and Negative Affect Scale (PANAS; Watson et al., 1988). With this self-rating scale, subjects who showed extreme and stable left frontal EEG activation reported more positive affect and less negative affect than their right frontally activated peers.

In the above cited study (Tomarken et al., 1992), the researchers found no relation between overall level of reported affect and frontal asymmetry. Davidson (1995) suggests that this finding indicates that cortical asymmetry is specific to a particular emotional valence rather than to an overall level of arousal or affect intensity. He suggests that individuals with increased right-sided anterior activation will show an increased vulnerability or lower threshold for emotions, psychopathology, and moods associated with withdrawal. They should be more vulnerable to the emotions of fear and disgust, show more negative affect, and be more vulnerable to anxiety disorders associated with a

withdrawal component, such as phobias about social interaction. Individuals with decreased activation in the left anterior region should be more vulnerable to emotional states and traits such as depression that are associated with deficits in approach. These would include psychomotor retardation, and loss of interest and pleasure in the world around. Davidson (1993a) maintains that the most pronounced difference between normal individuals and those who are depressed is not an increase of negative affect, but a decrease in positive affect in this group.

In a more recent study Sutton and Davidson (1997) used EEG measures of prefrontal asymmetry and two self-report measures to examine individual differences in emotional reactivity. They measured EEG activation in 46 right-handers and had them complete the PANAS (Watson et al., 1988) and the BIS/BAS (Carver & White, 1994) self-report instruments. They retested the subjects about five months later on the BIS/BAS and about six and one half months later on the PANAS. The results showed quite high test-retest stability for the BIS/BAS measure. The intra-class correlation was .72 for the BAS and .68 for the BIS subscales after 5 months. It was somewhat lower for Positive Affect (ICC = .45) and Negative Affect (ICC = .57) subscales of the PANAS after 6.5 months. They found that subjects with higher left-sided EEG frontal asymmetry had higher BAS scores, $r = .40, p < .01$. Those with greater right-sided frontal asymmetry had higher BIS scores, $r = -.41, p < .01$. Although in this study the PANAS subscales were not related significantly to EEG activation, the correlation between the BAS-BIS difference score and EEG asymmetry was significant, $r = .53\ p < .001$. The results of this study are of particular import because they indicate that EEG activation is associated with longer term individual differences in emotional reactivity. These longer term differences are also

lateralized and are associated with mood and temperament.

Although other researchers are in agreement that there are different cortical mechanisms involved in emotional function, other conceptualizations of the lateralization of emotion have been proposed. For example, Tucker and his colleagues (Tucker & Frederick, 1989; Tucker, Vannatta, & Rothlind, 1990; Tucker & Williamson, 1984) and Heller (1993, 1990) suggest a different theoretical account of emotion and brain lateralization related to the function of arousal. Their conceptualization is discussed next.

Asymmetries in Activation and Arousal

Tucker and Williamson (1984) emphasize the asymmetric function of elementary activation and arousal processes as reflected by two neurotransmitter systems, the noradrenergic and dopaminergic pathways. The dopaminergic path is integral to activation or motor readiness. However, in animals, each increase in dopamine level restricts the animal's range of behaviour, until motor actions become stereotyped caricatures of their normal appearance. Tucker and Williamson (1984) proposed that this tonic activation system applies a redundancy bias to neural operations. This bias has the effect of restricting or focusing attention, which facilitates the ability of the left hemisphere in perceptual orientation and aids its expertise in the sequential control of cognitive and motor operations. The resulting internal orientation is consistent with the introvert's sensitivity to overstimulation. The focal attentional mode is produced by a preponderance of what Tucker et al. (1990) call tonic activation. The affective bias associated with the redundancy bias of the tonic activation system is described as a dimension of calmness-anxiety (or serenity-hostility).

The noradrenergic pathways form the neurophysiologic substrate of the arousal

system to apply a habituation bias to information processing. This habituation bias leads the brain to respond only to novel events. The fact that noradrenergic pathways are right lateralized means that habituation serves as the underlying expansive attentional mechanism for the right hemisphere emotional self-regulation system. Thus, the extravert's external orientation is thought to reflect a primary process mode of orienting to the social environment. The expansive scope of attentional control is produced by a preponderance of phasic arousal, which is a right parietal hemispheric function. The affective bias associated with an expansive orientation and high levels of phasic arousal is described as a dimension of valence, happy-depressed (or positive-negative) (Heller, 1990, 1993; Tucker & Frederick, 1989; Tucker et al, 1990).

Heller (1993) has extended Tucker's (Tucker & Williamson, 1984; Tucker & Frederick, 1989) theory about lateralization of emotions, postulating that different patterns of brain activity will be involved in the expression of different emotions. She suggests that there are two independent dimensions underlying emotional experience. One dimension is involved in the modulation of emotional valence and is located in the frontal lobes. Higher left than right frontal activity is associated with pleasant valence, and higher right than left frontal activity is associated with unpleasant valence. The other dimension is involved in the modulation of autonomic arousal and is located in the parietotemporal area. Higher activity in the right parietotemporal area of the brain is associated with higher levels of arousal, and lower activity in the right parietotemporal area is associated with lower levels of arousal.

Developmental tendencies and individual differences in emotion and arousal are the result of an interaction between the two emotional systems. Happiness is

characterized by pleasant valence (relatively high left frontal activation) and relatively high arousal (relatively high right parietotemporal arousal). Sadness or depression is characterized by unpleasant valence and relatively low arousal. The interactions contribute to the production of unique and stable patterns of traits and emotional characteristics (Heller, 1993).

Both the approach-withdrawal and activation-arousal accounts recognize that emotion, mood, or temperament appear to be lateralized. Heller (1993) suggests that there is a dynamic interaction that occurs between frontal and parietotemporal regions. She suggests that because frontal cortex has inhibitory influences over parietotemporal cortex (Brodal, 1981; cited in Heller, 1993), a tendency towards high right frontal activation might combine with reduced right parietotemporal activation to establish individual differences in mood or personality organization. Discrepancies can occur when researchers focus on a one dimensional right- or left- hemisphere function, rather than on a two dimensional right-left and anterior-posterior functioning.

One limitation of many of the studies that examine emotional lateralization is that they use the EEG method, which cannot handle motor movement. In EEG studies examining emotional facial expression, all motor activity must be interpreted as an artifact and all movement-related activation must be excluded from analysis. This is, ironically, in spite of the finding that only when motor responses in the form of facial expressions are used to identify appropriate emotional epochs, do the EEGs show the expected laterality (Davidson, 1995). From the perspective of understanding the meaning of motor activity, what is needed is a way to assess both emotion and motor activity at the same time.

There are other conceptual and methodological problems in studies on

lateralization of emotions. For example, some researchers fail to distinguish between the perception and the production of emotion when they interpret laterality data (Davidson, 1993a). It may make a difference if an individual is asked to report a perceived emotion rather than experience the emotion directly. Perception may be lateralized differently than experience. Likewise, as in the case of facial expressions, the relative amount of right- or left- hemisphere activation may differ if an emotional behaviour is expressed spontaneously rather than elicited in a controlled setting. Although the details are yet to be fully understood, these problems do not negate the finding that there do appear to be differences in the way positive and negative emotions, or approach-withdrawal functions, and arousal are lateralized.

Another point that I would like to emphasize is that the evidence indicates that lateral brain asymmetries and facial motor expressions are related to emotion and individual differences in temperament. It is possible that limb motor asymmetries also are related to emotion and individual differences in temperament. There are several studies in which the production of asymmetrical motor expressions are related to emotion.

Motor Asymmetries and Emotion

One ecological study was carried out by observing people in restaurants or during conversations in the laboratory (Moscovitch & Olds, 1982). In this situation, the researchers found that most facial actions were bilateral. However, about 20% of the time, the left side moved more vivaciously than the right. In another study, electromyelogram (EMG) responses were recorded from different facial muscles during positive and negative emotional expressions. The left hemiface (right hemisphere) was more mobile in expressing negative emotions and the right hemiface (left hemisphere) was more mobile

for movements related to smiles (Schwartz, Ahern, & Brown, 1979).

In another study (Brockmeier & Ulrich, 1993), 24 male subjects were videotaped for facial asymmetries while being interviewed. The interviewer induced positive, neutral, and negative moods in each the subjects. To induce a positive mood, the subjects were asked to define the word *happiness*, and recall the most recent episode of happiness and to describe three more similar life events. The negative mood induction was similar, but the subjects were asked to remember and visualize horrifying or frightening events. For each of five minutes of conversation, the videotape was examined frame by frame for evidence of mood. The point at which the facial expression peaked was printed on paper, and asymmetries of the corners of the mouth were measured. The researchers found that during positive mood, 20 out of 24 subjects showed a right-lateralized lifting of the corners of the mouth when compared to the neutral condition. During negative mood, 21 out of 24 subjects showed a left-lateralized lowering of the corners of the mouth. Both of these studies are compatible with the EEG-facial expression perception studies, in that right lateralized behaviour was associated with positive mood and left lateral behaviour was associated with negative mood.

A third study (Schiff & Lamon, 1989) is interesting in that the researchers asked subjects to maintain voluntary contractions of their facial muscles for about a minute. After each contraction, they asked the subjects to indicate how they were feeling. Ten of the twelve subjects reported having emotional experiences. Following right face contractions, the subjects reported feelings such as, *sarcastic*, *cocky*, *up*, *good*, and *smug*. Following left face contractions, subjects reported feeling *sad* or *depressed*. Although other attempts to induce emotion by motor response have failed (e.g., Kop, Merckelbach,

& Muris, 1993), the study does attempt to acknowledge the potential role that motor systems play in the experience of emotion.

Summary

To summarize the literature, there is evidence to suggest that an individual's general level of motor activity relates to temperamental aspects of arousal and reactivity. As well, some theoretical and empirical evidence points to a connection between asymmetric movement and specific emotional valence (positive or negative), irrespective of overall arousal or reactivity.

To assess these general predictions, I present the results of two correlational studies. The first study was designed to deal with some of the measurement issues in assessing motor activity and provide an indication of the direction that the second study should take. The second study assessed the relationship among overall motor activity, lateralized motor activity, temperament, emotion, and mood in a larger sample.

STUDY 1

Study 1 focused on the assessment of two types of motion-sensitive instruments used to measure motor activity. It served as a reliability and validity study, testing the consistency of different mechanical devices, and how they correspond to behavioural and self-report measures of activity. Although conceptually both instruments measure motor activity, there are no empirical studies directly comparing actometers and accelerometers. It was therefore important to validate the instruments to determine how accurately the instruments reflect different types of motor behaviour, and to determine the relationship between the instruments. The first purpose for Study 1 then, was to compare the accelerometers to the actometers and to an external source of validity (an Activity Diary).

A second purpose for Study 1 was to compare the lateral differences in each of the instruments by examining differences in activity between the right and left arms. In previous studies using actometers, we have found a consistent left bias in arm movement frequency, whether the sample under study was infants, children, or adults (e.g., Eaton & McKeen, 1992; Eaton et al., 1998; McKeen, 1995, 1997). The question is, does this lateral bias exist using the accelerometers? That is, does the lateralization effect generalize beyond the one type of instrument.

A third purpose of Study 1 was to examine various anthropometric and demographic variables that would determine the generalizability of the motor activity measures. Therefore, I evaluated potential correlates of the instrument-measured motor activity, such as gender, height, weight, age, arm length. I also asked participants a question on the habitual arm they use for carrying a knapsack. This question was asked in order to assess the possibility that the typical carrying habits of the students might be a

correlate of arm movement. I believed that these variables were useful in helping me determine the sample size necessary for Study 2 to detect an effect, should one exist.

The fourth purpose of Study 1 was to begin an exploration into the temperamental and emotional correlates of both overall movement and the lateral bias in movement. Larsen and Diener (1987) suggest that affect intensity allows individuals to self-regulate their levels of arousal, consistent with Strelau's theory of temperament (1983, 1996) in which reactivity and activity play a role in regulating the stimulative value of an individual's surroundings. If affect intensity is related to an individual's reactivity, and reactivity is related to physical activity level, then it can be argued that affect intensity also should be related to physical activity. Study 1, therefore, includes a self-report measure of affect intensity (AIM; Larsen & Diener, 1987). The AIM also assesses the specific positive or negative emotional valence of affect intensity (Weinfurt, Bryant, & Yarnold, 1994). Thus, an assessment of the connection between asymmetric movement and emotional valence can be made.

Overall Activity

Assessing the movements of participants as they go about their daily activities has two clear benefits. The data are more ecologically valid than studies based on laboratory assessments of movement. As well, the data represent a relatively large sampling of the individuals' motor activities. This last attribute is important because it allows for the aggregation of behaviour drawn from many situations. Aggregation (Epstein, 1980; 1984) cancels out uncontrollable and incidental factors, and contributes to the reliability, replicability, and generality of the resultant measurement. Thus, in Study 1, participants wore instruments measuring their motor activity over a 24-hour period while they went

about their daily routines.

The Actometer

The Kaulins and Willis Model 101 Motion Recorder, or actometer, was used in both Study 1 and Study 2. This actometer is a modified woman's mechanical analog wristwatch with a watchcase diameter of 25 mm, and weight of 10 g, excluding band. In these instruments the movement recorded is proportional to the number of times the watch is tilted or oscillated. Movement is not indicated in real time and only a summation of movement over the data-collection period is recorded (see Eaton, McKeen, & Saudino, 1996 for details on the mechanism; see also Tryon, 1991). The actometer is not responsive to intensity of movement but does provide a frequency measure of limb movement.

Given their small size and appearance, actometers can be worn for several days in naturalistic settings with minimal monitoring by the investigator and without disturbing the routines of the participant's daily life. Thus, it is possible to obtain samples of behaviour over prolonged time periods from individuals in their typical environments. Over the past decade many studies have been carried out successfully using actometers on infants as young as five weeks, on preschoolers, school-aged children, adolescents, and on adults (see Eaton et al., 1996). The basic measurement paradigm was adapted for the research population in this study.

Actometer standardization. One actometer unit (AU) is defined as the kinetic energy required to advance the 'second hand' by a one-second interval marking on the face of the dial (Eaton et al, 1996). Because of variability in the total length of time each participant wears the instruments, the readings are converted to a rate measure of ***movements per hour***.

Validity of the Actometers in the Laboratory

The validity and reliability of the actometers can be assessed using a chemical shaker bath (Eaton, McKeen, & Lam, 1988). In this procedure, the actometers are strapped to the racks of the shaker bath and oscillated at a uniform rate. It is possible to vary both the length of time of the movement session as well as the rate of rack oscillation. Using this shaker bath technique Eaton et al. (1988) oscillated 27 actometers a distance of 2.5 cm at a rate of approximately 245 cycles per minute for three independent trials of 5, 10, and 15 min. in length. Analysis of variance {Trials(3) x Actometer(27)} showed that the Trials effect was very strong, F (2,52) = 28,544.9, $p < .0001$, with means on the three trials of 481, 949, and 1567 AUs, respectively. The longer the actometers were oscillated, the higher the mean AU recorded.

In another similar study (Eaton et al., 1996), 19 actometers were exposed to trials in which time (4- or 8- min) and/or rate of oscillation (170 or 200 cycles per min) were varied. In a 3-way analysis of variance {Actometers (19) x Time (2) x Rate (2)}, significant effects emerged for both time and rate, but not for actometers, and there were no interaction effects. Longer oscillation sessions produced higher recorded movement scores. The 8-min session presented twice as many recorded movements as did the 4-min session. In addition this study also showed that the 115% higher oscillation rate (200/170) presented 118% more movements than did the lower rate. This result again confirmed that the actometers are valid and sensitive to movement.

Reliability of the Actometers in the Laboratory

To measure the reliability of the actometers, an intraclass correlation coefficient (ICC) was used to estimate the degree of concordance among the readings of the

actometers (Shrout & Fleiss, 1979). In the two shaker-bath studies described above, the Actometer effect was non-significant, and the ICCs were .99 (Eaton et al., 1998) and .98 (Eaton et al., 1996), respectively. These results and other similar studies (e.g., Tryon, 1984a) provide strong evidence for the reliability of the actometers, and one can infer that the actometers are interchangeable.

Reliability of the Actometers in the Field

Reliability can not be divorced from the measurement context, and the reliabilities of actometer studies in the field are better estimates of the functional reliability of actometers in measuring human limb movements than is the reliability of data based on shaker baths (Eaton et al., 1996) or measuring sticks (Tryon, 1984a). The measurement situation is less certain outside of the laboratory setting. Humans move somewhat differently from day to day, and behaviour is subject to the vagaries of the everyday context. Several studies have assessed the reliability of the actometers in the field setting (Eaton, 1983; Eaton & Dureski, 1986; Eaton et al., 1988; Eaton et al., 1996).

For adults, Eaton et al. (1996) estimated that a single actometer worn on one wrist for a 24-hour period had a generalizability coefficient of .37. This estimate of reliability rose to .43 if the actometers were worn on both arms for a 24-hour period. Lower reliabilities result when the actometers are worn for a shorter period of time and are based on fewer limbs (Eaton et al., 1996), consistent with behavioural sampling reliability estimates more generally (Epstein, 1980). The large repertoire of adult activities and varied everyday contexts they experience increase the chance of recording unrepresentative momentary activities. Such occurrences likely reduce day-to-day reliability estimates of movement. In comparing the level of agreement among actometers for measuring shaker-

bath movements to studies on humans, the reliability estimates are somewhat lower, but are still substantial.

Validity of the Actometers in the Field

Validity has also been examined in empirical field studies with children. Buss, Block, and Block (1980) used actometers on 129 children (65 boys and 64 girls) ages three to six years, for a longitudinal study of ego and cognitive development. They found significant correlations between actometers and teacher judges at ages three, four, and seven for girls, $r = .42, p < .01$ and at ages three and four for boys, $r = .57, p < .001$. Stevens et al. (1978) compared actometer measures of activity to clinical observers and mothers' ratings of a group of 13 boys, nine to thirteen years of age, who were attending a day hospital program for various behaviour disorders and learning disabilities. All six clinical staff raters made assessments of classroom activity that were significantly correlated with actometer scores, $r = .49, p < .05$ to $r = .73, p < .01$, but not with a measure of overall activity measured in a variety of settings. The mothers' ratings correlated significantly with their sons' overall activity, $r = .65, p < .05$, although not with classroom activity. Ullman, Barkley, and Brown (1978) used actometers and an observation of motor activity in children aged 5 to 12. In their control group of normal boys, actometer-measured wrist activity correlated with the number of quadrant changes made by the boys in the room, $r = .83, p < .0001$. Thus, in some studies subjective ratings correspond to objective measures. However, inconsistencies in the findings indicate that other factors must be involved when ratings are used. These may include the social appropriateness of the behaviour of the children.

Stability of Actometer-Measured Arm Movements

One recent study (Eaton et al., 1998) shows the stability of the actometer activity measure. The study was carried out using actometers on right- and left-handers engaged in their customary activities over a two-day period. Seventy young adults participated (21 left-handed females, 13 left-handed males, 17 right-handed females, and 19 right-handed males). Because arm movement data were obtained for each of the two days of data collection, individual differences in movement could be examined for continuity or stability over time. First day variation among participants in amount of arm activity (total movements per hour) predicted their second day activity, $r = .26, p < .05$. As well, the degree of movement asymmetry (% of right arm movements) on the first day was strongly predictive of second day asymmetry, $r = .50, p < .0001$. Handedness was not significant in this study, $F(1,66) < 1.00, p > .05$, nor was gender.

Further evidence for the stability of measured activity comes from a study of 33 college students (Tryon, 1984b). The students wore actometers on both wrists and ankles 24 hours a day for 14 days. The correlational analysis showed that the mean waking activity for all of the subjects for Week 1 was nearly equivalent to that of Week 2 (25.9 AU/min for Week 1 and 25.8 for Week 2). The correlations between Week 1 and Week 2 for the left wrist, $r = .49$, $p < .01$, for the right wrist, $r = .73, p < .0001$. Thus, this extensive sampling of student behaviour shows that movement frequency is stable from one week to the next.

The Accelerometer

The accelerometer is a new instrument developed to measure motor activity in field settings (Model 7164, available from Computer Science and Applications (CSA), 2

Clifford Drive, Shalimar, FL 32579, U.S.A.; email: csainc@fwb.gulf.net). It is designed to detect acceleration and deceleration or intensity of human movement (Janz, 1994; Tryon & Williams, 1996). The instrument measures 5.1 X 4.1 X 1.5 cm, weighs 70 g, and is powered by a 0.5 volt AA lithium coin battery. It is housed in a plastic case that can be strapped to a limb much like a normal wristwatch can be. The instruments use integrated circuitry and a memory store to provide a continuous recording of minute-by-minute movement counts in real time. Their memory store of data can be downloaded directly onto a computer disk or hard drive (Janz, 1994; Janz, Witt, & Mahoney, 1995; Melanson & Freedson, 1995).

Researchers can select the time epoch over which acceleration is averaged. The length of time the instrument can record movement depends upon the duration of the epoch chosen. For example, if a one-minute epoch is chosen at initialization, the CSA monitor will have a run time of 22.75 days. In Study 1, I used a 10-second epoch, so the instrument was capable of recording data for three days.

Accelerometer standardization of measurement. The standard unit of measure of acceleration is the rate at which bodies freely fall due to gravity. This standard is based on the G force at sea level at 45 degrees latitude. One $G = 9.80616$ m per sec^2 at sea level (Tryon, 1991). This natural metric was used to measure acceleration of movement in a limb or other area of the body. To measure human activity, the accelerometer has a threshold of 0.033 gravitational force (*G* force) of acceleration and is calibrated to respond to an acceleration magnitude from 0.05 *G* to 2.13 *G* within a specified frequency range. Only acceleration within the frequency range of 0.10 and 3.60 Hz are detectable, with maximal sensitivity to accelerations at 0.75 Hz. The 0.10- to 3.60-Hz filter is used to

discriminate human movement from vibration and other artifacts. The signal is sampled at 10 times per second (10 Hz), and the resulting values can be summed each minute, providing a frequency count of acceleration and a final measurement unit of *G*/counts. Thus, the rate of acceleration is a function of amplitude of movement, modulated by the Hertz value or speed of the movement.

Accelerometer Validity

Janz (1994) carried out a study with thirty-one 7- to 15-year-olds in their homes. She measured physical activity with the CSA accelerometer and a heart rate monitor concurrently for three 12-hour-day trials. The children completed a daily activity diary. Using the accelerometer, physical activity was defined as the mean number of movement counts per day and vigorous activity as the number of minutes spent at movement counts greater than or equal to 256 per minute per day. The 256 counts per minute value was the 80th percentile of movement counts for the entire group. The Pearson product-moment correlations between the average movement count from the CSA accelerometer and the average heart rate over the 3 days averaged $r = .57, p < .05$. For vigorous activity (above or equal to 256 accelerometer counts per min), the correlations with an estimate of vigorous heart activity (the number of minutes equal to or greater than 60% of the heart rate reserve (HRR)) also were examined. The correlation between vigorous activity and the HRR over the 3 days was $r = .57, p < .05$.

In a study of 28 young adults (mean age of 21 years) designed to validate two types of accelerometers, Melanson and Freedson (1995) had adults perform an exercise protocol on the treadmill, using different speeds (walking, fast walking and jogging) and different grades (0%, 3% and 6%). They found that the correlation between the CSA

accelerometer wrist counts and the heart rate was significant, $r = .73, p < .01$, and that the correlation between the accelerometer and the speed of walking or jogging was significant, $r = .87, p < .01$. They also found that Caltrac accelerometers, another commercially available motion recorder, and CSA accelerometers were significantly correlated, $r = .82$, but that there was no relationship between the accelerometers and the treadmill grade, $r = .02, p > .05$. The correlation between CSA wrist-activity counts and energy expenditure (measured in kcal per min) was significant, $r = .81, p < .01$.

There are several issues to note about the two above studies. First, they show that several of the criteria that one would *expect* to relate to motor activity (heart rate, vigour of exercise, and speed of walking) do relate to motor activity, as measured by various types of accelerometers. Secondly, the study was done in a laboratory setting, where vigour, speed, and grade all can be controlled. Even so, the lack of a correlation between the acceleration and grade of the treadmill (0% to 6%) may be because the speed of the movements may not have increased as the grade became steeper. Thus, the type of movements that individuals carry out will be important in examining the relationships involved. Finally, although not examined in this study, the accelerometers are quite sensitive to small movements. Janz, Witt, and Mahoney (1995) considered CSA accelerometer activity below 25 movement counts per minute as sedentary activity and excluded it from their study to minimize the impact of body fidgeting on the activity measure. They also defined movement counts per min above 250 as moderate activity, and above 500 as vigorous activity.

I did not group accelerometer data into categories because I did not want to artificially restrict the initial comparisons between the actometers and accelerometers. It

could be that the actometers are less sensitive to small movements than the accelerometers, and some differences in the activity estimates of the two instruments could result.

Accelerometer Reliability

Reliability refers to the consistency of measurement of a single measure or alternative forms of a measure (Brown, 1983). In this case, the more reliable the accelerometers are, the more they will measure the same activity in the same way from one trial to the next. Tryon and Williams (1996) give a detailed description of the CSA accelerometer reliability characteristics. Using a pendulum and a spinning device, they examined the consistency of the CSAs both over repeated trials and across instruments. For the pendulum-swing trials, the maximum difference was 30 counts out of 1,208 counts, or 2.5 per cent. Some of the differences were due to differences in the rate of the pendulum swing decay across the three trials. Consistency estimates with the spinning device produced similarly high reliability data, with a *SD* of 0.007 around a mean of 1.025 over 5 trials. Thus, the reliability of the within-instrument test was high. In another test of reliability, Tryon and Williams (1996) used 40 different CSA Model 7164 instruments and submitted each to the spinner test. Between-unit variability produced similarly low levels of measurement variability.

Accelerometer Stability in the Laboratory

Stability estimates are correlations between two administrations of the same test, separated in time (Brown, 1983). There are two types of stability. The first type relates to how similarly an instrument records the same measure on two different occasions. Using a test-retest design, Melanson and Freedson (1994) required adults to repeat the same

activity protocol (treadmill walking and running) on two different occasions. They reported a high reliability for the CSA accelerometer, $r = .93$ to .99. In another study, using a similar accelerometer, Patterson et al. (1993; cited in Tryon & Williams, 1996), obtained wrist-activity measurements from instruments worn by 15 healthy adults replicating various physical activities on two separate occasions. The activity measure for the two occasions correlated highly, $r = .98$, $p < .0001$.Thus, the accelerometers provide a very stable measurement of movement, at least in the laboratory setting.

Accelerometer Stability in the Field

It is more difficult to measure stability outside the laboratory, because variability of the instrument is to some extent due to differences or inconsistencies, not in the instrument, but in the individual wearing it. The behaviour of the individual is not completely consistent from one day to the next, for example. Behavioural consistency, or how similarly an individual scores on the same test or instrument on different occasions describes a second type of stability. In one study (Janz et al., 1995), thirty 7- to 15-year-old children ($M = 11.2$ years, 15 males) wore the CSA accelerometer at their waists for 12.2 hours per day over two 3-day periods (Monday through Saturday). Stability for the accelerometer-measured activity was moderate, $r = .42$ to .47, using one day of monitoring of typical activity. Using the full 6 monitored days, the stability was greater, $r = .81$ to .84. The data indicated that 4 days of monitoring were needed to reflect the children's typical levels of activity. Using movement counts during time spent at or above moderate activity, the CSA accelerometer showed a between-day stability range from $r = .23$ to .43 (Janz, 1994).

The difference in the magnitude of the correlations between the laboratory and

field studies can be explained by several factors. First, the instruments may be measuring a true lack of consistency in individuals' daily activity patterns (Janz et al., 1995). Secondly, the types of movement that occur in everyday life may not be well-measured. Janz et al. (1995), for example, suggest that with the accelerometers worn at the waist, they can not detect torso movement and movements in the non-vertical plane. In contrast, the movements measured in controlled settings are often activities such as walking and running, which may be more accurately measured by the accelerometers.

Day-to-day stability of the instruments was not tested in Study 1. The participants wore the instruments for one day only. However, the 24-hour period does provide a reasonable sampling of the participant's typical behaviour. With 5 instruments available, and each participant wearing two, I decided to sacrifice the length of time of data collection for a larger sample size.

The Activity Diary

A key part of the rationale for Study 1 was to assess the validity of the actometers and the accelerometers. I wanted some external empirical evidence that the instruments reflected some measure of the individual's activity. It is possible, for example, that over the course of the day an individual could make many more small tilts or twists of the wrists, which would be recorded by the actometers, but not by the accelerometers. Thus, particularly if the instruments were only weakly correlated, it would be important to know which instrument reflects the individual's 'true' level of activity.

To assess the external validity of the instruments, the participants of Study 1 were asked to complete an Activity Diary covering the same 24-hour period during which the activity instruments were being worn. The content of the Activity Diary was based on that

developed by Sallis et al. (1985) and Paffenbarger, Blair, Lee and Hyde (1993). Sallis et al. (1985) listed examples of activities in three categories: Moderate, Hard, and Very Hard activities. Within each category, he offered examples in three domains: Sports Activities, Household Tasks, and Occupational Tasks. Examples of moderate activities in each of the three domains are brisk walking, mowing the lawn with a power mower, making deliveries, and lifting and carrying light objects (for sports, household and occupational categories, respectively). Hard activities include, doubles tennis, scrubbing floors, and construction work. Very hard activities include, jogging, swimming, digging a garden, and carrying heavy loads.

I made one change to the content of the Activity Diary for Study 1. Sallis et al. (1985) obtained a measure of light activity by subtracting total diary time from time spent in more vigorous activities, rather than having participants estimate time spent in light activity directly. Because I knew that the participants would be spending some part of their day in light or very light activities, such as sitting in class and studying, I thought it would be less confusing if they marked down all of their activities. I therefore extended the diary by adding a 'Sleep' category, a 'Light,' and a 'Very Light' activities categories. I supplied examples for light activities as suggested by Paffenbarger et al. (1993), and provided examples of activities for each level that included the three categories: leisure or sports, household tasks, and occupational tasks.

The students' Activity Diaries were based on a combination of the format used successfully by others (Barr, Kramer, Boisjoly, McVey-White, & Pless, 1988; McKeen, 1988). The diary was laid out something like a musical scale. Time was indicated across the bottom from left to right, with each hour divided into four sections representing

quarter hours. The lowest level on the scale indicated the lowest level of activity, sleep. Each higher level on the scale represented a higher level of activity. The range was from 1 (sleep) to 6 (very hard activity) (see Activity Diary in Appendix A).

Hypotheses About Overall Activity

I have described three activity measurement approaches, actometers, accelerometers, and an activity diary. While both instruments measure ***motor activity***, the relationship between actometers and accelerometers is not known. It is possible for example, that individuals might carry out some activity in which they repeatedly twist their wrists (movements that would register on the actometer), but so slowly that acceleration was minimal (movements that might not register on the accelerometer). However, when data are aggregated over the 24-hour period, I am predicting that the two activity measures will show a positive correlation.

The Activity Diary was included in Study 1 to provide a measure of external validity for the activity-measuring instruments. The instrument measures of activity level should show a relation to the participants' diary reports of activity. Therefore the prediction is that the mean diary activity levels will correlate positively with the mean overall activity measures from both the actometers and the accelerometers.

Lateral Activity

Rather than aggregating movement across limbs, motor activity can also be examined for between-limb differences. For example, in one recent study described earlier, Eaton et al. (1998) found a left lateral bias in arm movement in 70 young adults. The lateral difference measure of per cent of right-arm movement over total arm movement had a mean of 46% (SD = 11%). Individuals moved their left arms about 80

times per hour more often than their right arms (Eaton et al., 1998). When this lateral difference was examined categorically, 66 per cent (72% of right-handers and 59% of left-handers) of the participants showed more movement in their left arms than their right arms. In fact, a consistent left bias in motor activity has been found, whether the sample under study was infants, children, or adults (Eaton & McKeen, 1992; Eaton et al., 1998; McKeen, 1995, 1997).

As in the studies above, lateral asymmetries in arm movement will be described in two ways. A continuous measure of dextrality will be calculated and defined as *Per cent of Right-Arm Movement/Total Arm Movement*. As well, a categorical measure of laterality will classify individuals as either right- or left- biased in the frequency and acceleration of their movements.

Potential correlates of asymmetric movement are other lateral preferences. Therefore, in addition to describing and comparing the lateral movement asymmetries as measured by the actometers and accelerometers, several other lateral preferences will be examined as potential correlates.

Lateral Preference Inventory

Past research with the actometers indicates that spontaneous motor activity is not related to handedness (Eaton et al., 1998). However, I had neither empirical data nor reports in the laterality literature indicating whether or not a relation exists among the other lateral preferences and either the actometers or the accelerometers. On the one hand, it seems intuitively reasonable to hypothesize that more right-sided movement will reflect a right-sided preference for doing things. However, to the extent that lateral preference inventories usually assess only skilled motor activities, while the actometers and

accelerometers measure all types of skilled and unskilled activities, a strong relationship is not anticipated.

Coren's (1993a) Lateral Preference Inventory (LPI) was administered to the participants at the end of data collection. Coren's self-report questionnaire is brief and covers four different common lateral preferences. It is a 16-item questionnaire containing four items each on eyedness, footedness, earedness, as well as handedness. The eyedness questions inquire about the eye used to look through a telescope and a rifle sight, look into a dark bottle and through a keyhole. The footedness questions refer to preferences for kicking a ball, picking up pebbles with the toes, stepping on a bug, and stepping up onto a chair. The earedness questions inquire about which ear is used to listen at a closed door, to an earphone, to someone's heartbeat, and to a faint clock. The handedness questions ask about with which hand an individual draws, throws a ball, uses an eraser, and deals a card. Each item requires a response of *left*, *right*, or *either*.

Reliability and validity of the LPI. The LPI was normed on a sample of 3307 volunteers, ranging in age from 17 to 35 years of age, recruited from the campus of the University of British Columbia. Coren (1993a) found differences between males and females. In his sample, 91% of females and 88% of males were right-handed, $p < .05$, 89% of females and 84% of males were right-footed, $p < .001$, 67% of females and 61% of males were right-eared, $p < .001$. There were no sex differences in eye preference (70% for females and 71% for males). Experiments between self-reports on the LPI and direct observation of lateral performance have demonstrated a 92% concordance (Porac, Coren, & Duncan, 1980). The handedness subscale shows the highest concordance rate at 97%. Test-retest reliability over a one-year period averages 98% (Coren & Porac, 1978).

Hypotheses About Lateral Activity

As with earlier studies, I expect to find a left bias in actometer-measured arm activity. Because the reason for the greater left-arm actometer-measured activity is unknown, however, it is unclear whether or not the accelerometers will show the same pattern as the actometers. The accelerometers may be more sensitive and record smaller, finer movements than the actometers. If that is the case, and the dominant (usually right) side makes more small movements than the non-dominant side, then the left-greater movement (that has been found with the actometers) may not occur with the accelerometers. The prediction though, is that the accelerometers will follow the same lateral pattern as the actometers and show greater left-side activity.

Anthropometrics and Demographics

If sex differences in activity are found to exist in studies, usually males are found to be the more active. In children, males are generally more active than females by about one-half standard deviation (Eaton & Enns, 1986). There are very few adult field studies of objectively measured activity which contain gender data. In an actometer study with young adults, no sex differences in activity were found (Eaton et al., 1998). In another study of 78 men and women activity was measured using Caltrac accelerometers and various self-report scales (Jacobs, Ainsworth, Hartman, & Leon, 1993). In this study mean levels of motion were recorded for an average of 14 two-day sessions spaced over a one-year period. Females were slightly more active than males by 30 activity units per day, resulting in a small *ES* ($d = 0.20$).

However, in this study and another (Matthews & Freedson, 1995) the objective activity data (based on Caltrac and Tritrac accelerometers) were converted into Metabolic

Equivalence units (METs). These units were designed to measure energy expenditure and took into account sex, height, weight, and age in their calculation. Using MET estimates of energy expenditure, males were estimated to be more active than females by fairly substantial amounts, *ES* = 1.6 (Jacobs et al., 1993), and *ES* = 2.6 *SD* (Matthews & Freedson, 1995). The METs however, do not allow a direct and objective comparison of activity between men and women. Thus, there is no clear consensus in the literature on whether or not adults show sex differences in motor activity. Sex differences in activity will be examined in both dissertation studies, but none are expected.

Physical Measures

Because the instruments measuring activity may be influenced by an individual's size, each participant had his or her height, weight, arm length, hand length, and wrist breadth measured, while wearing summer clothing. For reliability purposes, two separate measures of each were taken, and the mean values used as the true values. Because I examined differences in lateral activity, and it is possible that values obtained from the dominant side will differ from those of the non-dominant side (Martorell et al.,1988), limb lengths were measured on both the right and left sides.

Height and Weight Measures

In infants and children, activity level measured by means of actometers increases with age and size (Eaton et al., 1996). However, in an actometer study of young adults (Eaton, et al., 1998) activity was not related to size. Thus, although it is possible that age or size may contribute to motor activity level, I am not predicting that age or size are significant correlates of activity in adulthood.

Height and weight reliability. Height and weight are easily taken measurements

and so common that reliability figures are often not reported. In one study, two consecutive height and weight measures of children showed the same high Spearman-Brown reliability coefficient of .99 (Campbell, 1995). Height and weight differences between measurers in the Fels Longitudinal Study were minimal with the largest mean measurement discrepancy of 2.4 mm (SD = 2.1 mm) for height and 1.7 g (SD = 3.8 g) for weight (Chumlea & Roche, 1979). These small discrepancies in inter-measurer consistency for both weight and height indicate that the reliability of these measures taken at any one time is very good.

Limb Length Measures

Previous studies have not found evidence of a relationship between limb length and actometer-measured activity (Eaton et al., 1998). However, as Study 1 is an exploratory one, designed to examine the characteristics and correlates of the CSA accelerometers, I took arm, wrist, and hand measures of the participants. Although I am not predicting that limb length will influence the activity measures, it is conceivable that long arms (like a long pendulum swinging) could influence the activity or acceleration recorded by the instruments.

Affect Intensity Measure

The Affect Intensity Measure (AIM; Larsen & Diener, 1987) is a 40-item questionnaire that assesses the magnitude or intensity with which an individual typically experiences his or her emotions. It is rated on a 6-point Likert-type scale, in which participants indicate to what degree their intensity varies in reaction to the emotional events of daily life (see Appendix A). The original intention of the questionnaire was to assess emotional intensity without regard for the particular emotion that the individual

experienced. Affect intensity is a psychological construct that emphasizes that regardless of the specific emotional content or hedonic tone, individuals who characteristically experience their positive emotions quite strongly, will also tend to experience their negative emotions more strongly. Affect intensity will be manifest in a variety of ways, including bodily responses or cognitive changes (e.g., a pounding heart, or feelings of energy or arousal, and behavioural consequences like difficulty concentrating or inability to inhibit motor actions) to specific common every-day situations.

Larsen and Diener (1987) suggest that affect intensity is a dimension of temperament. They make a distinction between personality and temperament, maintaining that personality refers to the 'what' or the content of behaviour. Temperament, including affect intensity, refers to the 'how' or the style of behaviour. Thus, to satisfy a gregarious, social nature, the content of an individual's behaviours may consist of many social interactions. However, the content of behaviours can be differentiated from the style of behaviour. In the style of behaviour, it is not so much what one does, but how one does it. For example, some individuals will achieve their goals by working methodically, slowly, and persistently. Others will work more energetically, frantically, and sporadically to achieve the same goals.

Affect intensity as a dimension of temperament has several characteristics (Larsen & Diener, 1987). First, it cuts across specific responses and refers to a generalized style of emotional experience and response. Secondly, it appears early in life (i.e., has an unlearned component to it), and thirdly, it is stable over a long period of time. These characteristics are three central components of temperament (Goldsmith & Rieser-Danner, 1986; Rothbart, 1986b; Strelau, 1996). They refer to a style of emotional

experience and an individual's response tendency.

Larsen and Diener (1987) found that affect intensity was significantly related to four major dimensions of temperament. It correlated significantly with each of the dimensions on the Buss and Plomin (1984) temperament questionnaire: Emotionality (r = .57), Activity (r = .41), Sociability (r = .36), and Arousability or Reactivity (r = .39). Thus, empirically, it is not an orthogonal or independent temperament dimension, but rather a component of various dimensions. It also loaded on two factors in a factor analysis of personality and temperament traits. The first was a positive loading on a Social Affiliation factor which included measures of empathy, nurturance, social recognition, dependency, and (negatively) strength of excitation. The second factor, perhaps best characterized as Adaptability, was associated negatively with affect intensity. It included traits of non-neuroticism, non-impulsiveness, and non-aggression, along with strength of inhibition, and mobility of the nervous processes (Strelau & Zawadzki, 1995).

Although they do not specify the exact mechanism, Larsen and Diener (1987) suggest that emotional response intensity functions to regulate internal stimulation level or CNS arousal level. Individuals have different levels of optimum arousal and will seek to alter their level of arousal in order to maintain or modulate it. They will regulate their arousal level by regulating their behaviours, typically either responding to sensory stimulation or dampening its effects. When individuals are presented with the same emotion-provoking stimuli, those who score high on affect intensity respond more intensely than do individuals who score low on affect intensity. It is not that the high scorers objectively lead more stimulating lives. They simply respond to every-day events with more intensity or arousal (Larsen & Diener, 1987).

Age effects in the AIM. Age and gender effects were examined in a study of 242 individuals ranging in age from 16 to 68 years (Diener, Sandvik, & Larsen, 1985). There were decreases in affect intensity as age increased, $r = -.26, p < .01$. When they divided the participants up into 4 age-groups, the researchers found that the most pronounced drop occurred between the young adult and middle-aged groups. Diener et al. (1985) suggest that the change may reflect either biological changes or environmental effects that could occur with age. The younger individuals may lead more stimulating (and stressful) lives, while the older individuals may have adapted to their emotional activities.

Gender effects in the AIM. Women score higher than men at each age category on the AIM (Diener et al., 1985). This gender issue is not simple, however. Bryant, Yarnold, and Grimm (1996) did not find significant gender differences in one study of 218 university students (150 females), but did find them in another of 1304 students (803 females). The mean differences are small but consistent, with females reporting higher scores than males. The discrepancy between the studies may be due to differences in statistical power. Bryant et al. (1996) discuss the matter of gender differences in affect expression, and they suggest that a distinction should be drawn between inner emotional experience and outward expression of emotion. They interpret their pattern of results to indicate that women may be more aware of negative emotional stimuli and be more willing or able to express them, relative to men (Bryant et al., 1996).

The validity of the AIM. The AIM has been used in studies of daily reports of affect intensity. Larsen and Diener (1987) report the results of three separate studies in which individuals report their daily moods and life events. The AIM correlated significantly with average daily emotional events in all three studies, with *r*'s ranging from

.49 to .61. The AIM relates significantly and positively to mood scales that measured feelings of physical activity, arousal, tenseness, productivity, energy, and sociability (Larsen & Diener, 1987). These moods relate to the arousal or energy level that an individual feels, but are non-valenced in that they could accompany either positive or negative emotional states. They provide a picture of the daily state of the high affect intensity person who is usually *on the go*, *keyed up*, and *vigorous*. Larsen and Diener (1987) again report that in one study of 74 college students, the AIM correlated with both positive affect, $r = .41, p < .01$, and negative affect, $r = .39, p < .01$.

The reliability of the AIM. The AIM obtained a coefficient α (Cronbach, 1951) in the range of .90 to .94 across four separate samples. The test-retest reliabilities for the AIM at 1-, 2-, and 3-month intervals were .80, .81, and .81 respectively. For one group of 41 individuals (out of a total 76) who had been given the AIM two years previously, the correlation for test stability was significant, $r = .75, p < .01$ (Larsen & Diener, 1987). In another study, 48 undergraduates (25 females) participated in a self-report reliability study in which the AIM was given (Hjelle & Bernard, 1994). Test-retest reliability across a 10-week time period was good, $r = .71, p < .01$. The evidence consistently shows that the AIM has good psychometric properties, with good internal consistency and stability.

The Development of AIM Factors

The AIM scale was developed originally as a putative unidimensional construct measuring affect intensity irrespective of emotional valence. Several researchers have investigated the validity of the unidimensional interpretation (e.g., Bryant, Yarnold, & Grimm, 1996; Weinfurt, Bryant, & Yarnold, 1994). Using factor analysis, Weinfurt et al. (1994) evaluated the fit of several models, including Larsen and Diener's (1987) single

factor model. As a result, they recommended a four-factor model which contains two positive affect dimensions and two negative affect dimensions. The model was derived using principal components analysis (PCA), and fit both male and female samples reasonably well. These factors were used in Study 1 to examine the relation of both positive and negative affect to measures of motor activity, both overall activity and lateralized.

The first factor (Positive Affect) consists of 17 items that reflect feelings of happiness, elation, exuberance, euphoria, enthusiasm, excitement, and joy. Eight of the items tap positive reactivity or the degree to which the individuals typically react to pleasurable events with positive emotion. For example, *When I accomplish something difficult I feel delighted or elated* is an item included on the Positive Affect factor. The second factor (Negative Intensity) contains 10 items that tap a wide range of negative affective responses, including anxiety, tension, negative visceral reactions and general negative emotional intensity. *My emotions tend to be more intense than those of most people*, is an item included in this factor. The third factor (Serenity) consists of seven items describing positive affect as calm, content, relaxed, quiet, peaceful and untroubled. An example item is, *I would characterize my happy moods as closer to contentment than to joy*. The Serenity factor is negatively related to both Positive Affect and Negative Intensity and unrelated to the fourth factor, Negative Reactivity. Weinfurt et al. (1994) suggest that these relations may indicate in part that the experience of positive affect as tranquil contentment reflects for some individuals their rejection of intense affective experience. The fourth factor (Negative Reactivity) is composed of six items assessing negative affective reactions to environmental stimuli or events. An example item is, *The*

sight of someone who is hurt badly affects me strongly. Negative Reactivity is conceptually and empirically distinct from Negative Intensity. For example, one may be very disturbed by an undesirable event (Negative Reactivity), but then dampen the negative reaction with coping measures that produce a low Negative Intensity. This reactivity-intensity distinction did not emerge for Positive Affect. It may be that people do not typically control their positive emotional reactions to events to the same extent that they control their negative reactions (Weinfurt et al., 1994).

Hypotheses about the AIM

In terms of overall motor activity, several hypotheses can be drawn about the relationship with the AIM factors. Overall movement (as measured by both the actometers and the accelerometers) should relate positively to high levels of arousal as reflected in Negative Reactivity, Negative Intensity, and the Positive Affect factors. The Serenity factor, if it represents low arousal, should relate negatively to overall activity level.

So too, can hypotheses be made about the lateralized activity measures of activity (dextrality), as described earlier in the general introduction. In an infant study, negative affectivity (crying) was associated with right leg movement, as measured by the actometers (McKeen, 1995). Contentedness and happiness were associated with left arm movement. Assuming that the above-mentioned relationship between lateralized motor activity and affect holds for older people, dextrality (relatively greater right-sided activity) should be related positively to Negative Reactivity and/or Negative Intensity but related negatively to Positive Affect. If the Serenity factor reflects positive affect, then it should be related negatively to dextrality.

Age has been found in the past to correlate negatively with affect intensity, and females have been found to report more intense negative reactivity (Weinfurt et al., 1994). Since both age and gender differences have been found with the AIM, I am assessing these in Study 1.

METHOD STUDY 1

Participants

The participants were recruited from a Spring session Introductory Psychology class at the University of Manitoba. For their participation, students received three credits towards their final grade. There were no restrictions for sign-up. One female student failed to arrive for her scheduled appointment. One additional female student was recruited from among the Psychology Graduate Students. The final number of student participants was 23 (12 males and 11 females).

Summary of Procedure

Before the data were collected for this study, 48 actometers were checked for sensitivity using the chemical shaker-bath method, identical to the method described earlier (Eaton et al., 1996). Four of those actometers with valid readings, showing a very high level of agreement, were used in Study 1. I counterbalanced both instruments by systematically reversing the hand on which each instrument was to be worn.

When students arrived at the research room for their scheduled appointment, I gave them a brief description of the study, including a general description of what would be required of them during the 24-hour data collection period. They then signed a consent form informing them that they were under no obligation to participate and were free to withdraw from the study at any time. I agreed to keep confidential any information they

provided me.

I took several physical measurements, including height, weight, arm length, wrist breadth, and hand length. I then described, demonstrated, and attached two activity-measuring instruments to each of their wrists. Specifically, one actometer and one accelerometer, were attached to each student's right- and left- wrists with sports-type wristbands.

I provided each student with a folder which contained information and instructions for recording data over the next 24-hour period, and which the students took home. Each folder held five data-collection forms (see Appendix A), and each of the forms was shown and explained to the students. The first form provided instructions on the wear and care of the instruments and instructions on how to record any period of time over the data-collection day that the instruments were removed. On the second form, the students recorded their bedtime and morning wake time, along with the current readings on one of the instruments, the actometer. The third and fourth forms were, respectively, an Activity Diary and a sample example of how to record their daily activities on the diary. The last form was a list of examples of various physical activities to help the students classify the physical elements of their occupational, household, and leisure tasks carried out over the data-collection day. Finally, students were asked to complete an affect intensity questionnaire (the AIM) before they left.

About 24 hours later, the students returned for a second and final appointment. The instruments were removed, the final readings recorded (for the actometer) or data downloaded (for the accelerometer), and the Activity Diary was reviewed briefly to check for completeness. During these activities, the students completed the LPI (Coren, 1993).

I then provided each student with verbal and written feedback (Appendix A), describing the external validity aspects of the study (comparing relations among the actometer and accelerometer and the Activity Diary), the reliability aspects (wearing instruments on both wrists to compare within individual instruments), and briefly describing findings from previous activity studies with infants and children. Finally, I thanked the students for participating in the study and told them where and when I would display the final results of the study.

To restate briefly, the first purpose of Study 1 was an exploratory one to compare the actometers to the accelerometers, and relate both types of instruments to an external source of validity (an Activity Diary). A second purpose was to evaluate the lateral differences on both instruments by examining differences between the right and left wrists. The third purpose for the study was to examine various anthropometric and demographic variables that might affect either of the activity-measuring instruments. The fourth purpose was to examine individual differences in affective experience as a correlate of overall and lateral differences in motor activity. Beginning with a description of the mechanical device measures, I will describe each measure used in Study 1.

Overall Activity Level Variables

Movements per hour. Eaton et al. (1996) estimated that an actometer registers 1 AU for every five changes in direction. One AU appears as 1 s on the actometer face. Using this information, the number of arm movements equals the number of elapsed actometer seconds multiplied by 5. This number is then converted into a measure of total *movements per hour* by dividing by the number of hours the actometer had been worn (less those times the actometer had been removed for bathing, etc.). For example, a

participant whose actometer showed an elapsed time of 64 min (3840 sec) over 24.0 recording hours would generate a total *movements per hour* estimate of 800 (800 = 5 x 3840 / 24). I used this *movements per hour* measure rather than raw AUs as a summary dependent variable because it is more easily envisaged and comprehended.

Accelerometer quarter-hour variables. I initialized the accelerometers to record the average acceleration on each limb for every ten-second epoch. This setting resulted in approximately 8640 data points recorded by each accelerometer (24 hr x 60 min x 60 sec /10 sec= 8640) over the twenty-fours hours. Because the participants kept an Activity Diary based on activity notations for every 15-minute period throughout the data-collection period, the acceleration data were summarized and expressed as three variables based on the mean acceleration for each limb over each quarter hour (*Mean right* and *Mean left*).

Accelerometer 24-hour variables. Similarly, for each individual, I summarized the data over a 24-hour period and expressed it as a mean acceleration value for each arm. The mean value for both arms represents the overall measure of the individual's *mean G/count* over the 24 hours.

Accelerometer count estimates. Because the study is in part designed to compare the two types of activity-measuring instruments, I created from the accelerometer data, estimates of frequency of movement that might mimic the way the actometers measure movement. Because the actometers are not sensitive to small movements, I decided to exclude any acceleration below 50 G/counts from the data. These G/counts of accelerometer data were calculated in the same manner as the acceleration variables (*Mean count left arm, Mean count right arm, and Overall mean count* for each quarter

hour and each individual over 24 hours).

The Activity Diary

The Activity Diary consisted of a one-page 24-hour log with the start and finish times and each hour indicated. Participants estimated and recorded their average level of activity for every quarter hour of the day on which they were wearing the motion-recording instruments. They did this by drawing a line through the diary at the appropriate level for the appropriate quarter hour. A sample diary demonstrated the reporting method for a hypothetical individual's day and contained a page listing examples of activity level intensity for various common daily activities in which they might be engaged. They were not required to fill in the diary at 15-minute intervals. They were simply asked to keep track of their activity levels throughout the day as accurately as they were able and to record the activity level in the diary when it was convenient for them to do so. An effort was made at the end of the data collection to check the diaries for missing times and to inquire if there were any activity in which the participants had engaged, but were unsure of how to categorize it. Copies of the diary, sample, and examples are included in Appendix A.

Activity Diary variables used in Study 1. Because the participants kept their diaries for 24 hours, there were approximately 96 data points recorded for each individual (24 hr x 4 quarters per hr = 96). These quarter-hour epochs were matched by time and correlated with the quarter-hour epochs for the accelerometers. In addition, I used each individual's ***mean 24-hour activity level***, as reported by the Activity Diary, as the dependent variable to correlate with the mean actometer-measured activity.

Lateral Activity Variables

Actometer dextrality measure. Using the total movements per hour from the left and right arms, Eaton et al. (1996) calculated for each individual a percent right arm movements (*% RA moves*) score. This score was the percentage of all movements, right or left, that were right-arm movements (100 x right arm movements / total arm movements). This same dextral index in this study is the continuous laterality measure. Thus, a participant whose arm movement frequencies were perfectly symmetrical would generate a *% RA moves* score of 50. A right-biased participant would generate a score over 50, and a left-biased person, a score under 50. A categorical laterality variable also was created with participants classified as either left biased, % RA less than 50, or as right biased, % RA equal to or greater than 50.

Accelerometer dextrality measure. To examine lateral differences in acceleration counts between the right- and left- arms, I created a separate dextrality index variable (*100xTotal Right Arm Acceleration) / (Total Right Arm Acceleration + Total Left Arm Acceleration*). With the denominator based on the total acceleration for each individual, I calculated differences in individual's lateral acceleration while taking into consideration their overall acceleration. The lateral measure is expressed in terms of right-sided acceleration. For greater accuracy I calculated the lateral summary variables (dextrality based on quarter-hours and 24 hours) from the original 10-second-epoch data. This method of calculation means that a right-greater or left-greater between-limb determination was based on the relative differences between right- and left- limbs for every 10 s, rather than over the quarter-hour or 24-hour periods.

Lateral Preference Inventory

Participants completed the LPI so that the possibility could be evaluated that a lateral preferences is related to the measures of asymmetric activity. Because lateralized actometer-measured activity was uncorrelated to handedness in a previous study (Eaton et al., 1998), I did not anticipate that the measures would be related in Study 1. I decided to use a quick 12-question laterality self-report, which would assess four commonly measured lateral preferences (Coren, 1993, in Appendix A).

LPI measures used in Study 1. Data are scored for each four-item subscale as the sum of the 4 items. *Left* responses were given a score of -1. *Either* responses were given a score of 0. *Right* responses were given a score of +1. Each of the four subscales can range in value from -4 to +4. Four indicated consistent left preference, and +4 indicated consistent right preference. A score of 0 indicated ambidextrality. Combined, the four scale values can range from -16 to +16, with mean LPI scores ranging from -4 to +4.

Anthropometric Measures

Height. Height is an indicator of stature and was measured in centimeters with an anthropometer, according to the method set out by Gordon, Chumlea, and Roche (1988). The anthropometer consists of a graduated vertical rod on a stand, with a moveable rod fixed to the vertical rod at right angles. The moveable rod is positioned so that it touches the vertex of the subject's head. To have their height measured, participants stood in stocking feet on a flat floor. Their body weight was distributed evenly on both feet, and they were asked to face forward so that their eyes were looking at a spot on the opposite wall at eye level. Arms hung down freely at the sides of the trunk, with the palms facing the thighs. Heels were placed together with the backs of the heels touching the base of the

anthropometer. The angle between the medial part of the two feet was about 60 degrees, comfortable for maintaining balance. The participants were asked to inhale deeply and maintain a fully erect position during the measurement procedure. Height was measured twice and recorded to the nearest 0.1 cm. The mean value was used as the final measure.

Weight. Weight was measured twice using a portable scale placed on the linoleum-covered floor. The participants distributed their body weight evenly with both feet over the centre of the scale. They wore light-weight indoor clothing, without shoes and sweaters. I recorded their weight to the nearest half pound.

Limb length measures. Because the G/count measure of the accelerometer is a function of both amplitude and speed, it is possible that limb length influences the measure. As there are no reports in the literature, I decided to measure limb length in Study 1. I measured arm length in segments (Lohman, Roche, & Martorell, 1988). Each arm segment was measured twice per side, and I used the mean of the two measures as the final value.

Shoulder to elbow length. This measurement allows for the measure of the shoulder to elbow length with minimal effect of adipose and muscular tissue (Martin, Carter, Hendy, & Malina, 1988). It is made using an anthropometer configured as a sliding-beam caliper, which has a metric rule rod with a fixed blade at 90 degrees to the rod at one end and a sliding blade parallel at the other. The participants wore light indoor clothing for ease of measuring and stood erect on the linoleum floor with their weight distributed evenly on both feet. The beam of the anthropometer was positioned lengthwise behind the arm. The fixed blade of the anthropometer was in contact with the acromion process (the highest point of the lateral edge of the acromial spine or outer point

of the shoulder), as determined by palpation. I moved the sliding blade of the anthropometer to the posterior surface of the olecranon process of the ulna (at the elbow). That distance, measuring the longitudinal axis of the upper arm, was recorded to the nearest 0.1 cm. Two measures of the shoulder to elbow length were taken on each arm. The mean was used as the final measure.

Shoulder-elbow reliability. A 1985 survey of 530 Canadian Forces aircrew produced an intra-measurer variance of 2.7 mm and an inter-measurer variance of 8.4 mm (Stewart, 1985).

Elbow-wrist length. Elbow to wrist length was also measured with the actometer configured as a sliding caliper. The participant stood erect on the floor with feet together, weight equally distributed between both feet, shoulders drawn back, and the head positioned with eyes gazing straight ahead. The subjects let their arms hang by their sides, then flexed their elbows at 90 degrees, with their palms facing medially and the fingers extended. I positioned the fixed arm of the caliper with the most posterior point overlying the olecranon (at the elbow). I aligned the sliding arm of the caliper with the most distal palpable point of the styloid process of the radius (at the wrist). During the measurement, the arms of the caliper were held perpendicular to the long axis of the forearm. This measure was recorded to the nearest 0.1 cm (Martin et al., 1988). Two measures of each elbow to wrist length were taken on each arm. The mean was used as the final measure.

Elbow to wrist reliability. Test-retest data from an anthropometric survey of 530 Canadian Forces aircrew produced an inter-measurer variance of 2.9 mm and an inter-measurer variance of 9.8 mm (Stewart, 1985).

Hand length. This measurement was made with the anthropometer configured as

a caliper. Participants stood with their arms hanging relaxed and their forearms extended horizontally. Their hand and fingers were extended (but not hyperextended), palm up. I held the central bar of the sliding caliper parallel to the longitudinal axis of the hand. I aligned the fixed cross-arm of the caliper with the most distal palpable point of the styloid process of the radius (at the wrist). I placed the sliding cross-arm of the caliper at the tip of the third (middle) finger. That measurement was recorded to the nearest 0.1 cm (Martin, et al., 1988). Two measures of each hand were taken. The mean length was used as the final measure.

Hand-length reliability. Data are not available in the literature (Martin, Carter, Hendy, & Malina, 1988).

Wrist breadth. Wrist breadth is used as an index of skeletal mass and frame size. In the Brussels Cadaver Study, wrist breadth was the skeletal measure most highly correlated with skeletal mass, $r = .88$ (Clarys, Martin, & Drinkwater, 1984). I used a sliding caliper to measure the distance between two bony prominences on the wrist, the ulnar and radial styloids. The participants stood facing me, flexing their forearms to 90 degrees at the elbow and close to the chest. They presented the dorsum of each hand to be measured. I palpated the most medial aspect of the ulnar styloid with the middle finger of my right hand, and slid the tip of the caliper onto this landmark. I located the most lateral aspect of the radial styloid with the middle finger of my left hand, and moved the other end of the caliper to this position. I applied firm pressure and recorded the breadth to the nearest 0.1 cm (Wilmore et al., 1988). This measure was taken twice, and the mean was used as the final breadth.

Wrist-breadth reliability. According to Wilmore et al. (1988) the wrist breadth is a

highly reliable measure, showing an intra-measurer reliability of $r = .99$. One study showed a test-retest correlation of .96 between measurements taken on the same day on college-aged males (Wilmore & Behnke, 1969).

The Affect Intensity Measure

I administered the Affect Intensity Measure (AIM) to the participants for two reasons. First, it seemed relevant to the measurement of motor activity and to theoretical notions such as arousal, reactivity, and self-regulation. Secondly, I was interested in finding correlates of lateralized activity that are related to measures of positive and negative affect.

AIM variables used in Study 1. I used the four positive and negative AIM factors (Weinfurt et al., 1994; listed in Bryant, et al., 1996) in the analysis of Study 1 because they provide an opportunity to examine the relationship between both affective valence and arousal for both overall and lateralized measures of motor activity.

RESULTS STUDY 1

Preliminary Data Assessment

I conducted all of the statistical analyses with SAS-pc software for Windows95, version 6.12 (SAS Institute, 1996; SAS Campus Drive, Cary, North Carolina, USA 27513). All major variables were examined for possible outliers and skewed values using the SAS Univariate and Frequency procedures.

The original sample consisted of 23 individuals, 11 females and 12 males. However, I decided to drop two right-handed male participants after examining their activity data. For one of the males, an accelerometer appeared to malfunction. The accelerometer on this individual's left wrist output approximately double the data points

that it was set to output (17,000 data points instead of 8,500), rendering this left-arm data unreliable. Because the comparison between the right and left arms was an important part of Study 1, I decided to drop this individual from the sample. The second male was identified as both a univariate and a bivariate outlier. When his mean right-arm accelerometer value was plotted against his mean right-arm actometer value, it was evident that his data were unusual. His mean right-arm accelerometer value was the lowest of all of the values for the sample (at 75 counts, about 3 *SD* below the mean of 183.6). At the same time, his mean right-arm actometer value was 2.4 *SD*'s above the mean (at 1180 movements /hour, $M = 601$ movements/hr, $SD = 245$). His mean left accelerometer value was also the lowest of the sample (at 83.9 counts, $M = 182.7$ counts, $SD = 62.9$), while his mean left actometer value was at 1594 ($M = 864$ movements/hr, $SD = 451$).

To test the influence of the second participant's data on the regression coefficients, I ran the SAS Regression procedure, using the right- and left- acceleration values as dependent variables and the actometer values as the regressors. I included the Influence Diagnostics option (Cook's Distance). Cook's D statistic is a measure of the influence of an observation and determines how much the regression coefficients are changed by deleting any particular observation. A Cook's D result greater than one deserves closer scrutiny as an outlier (Kleinbaum, Kupper & Muller, 1988). My questionable data had Cook's D values of 6.2 (right accelerometer), 5.4 (left accelerometer), and 1.2 (right actometer). Taking into account that 21 tests were done (a D statistic for each participant), the critical value for the upper 2.5% of the distribution is $F(1, 18) = 5.98$. One of this individual's three questionable data points lay outside this

value. This participant was a left-handed individual who, I had noted, wrote with his hand in a hooked position. His Activity Diary did not indicate any information that might help explain the unusual pattern. I decided to drop this individual from the sample. No other participant's Cook's D was statistically significant.

One other male reported that he stayed up studying for an exam and did not sleep the night of data collection. I was therefore unable to examine his wake-sleep data. Because the examination of the wake-sleep data was only a small part of Study 1, I kept this individual in the sample, except for analyses involving sleep or wake times. Thus, the final sample consisted of 21 individuals, 10 males and 11 females.

Data Standardization and Aggregation

Actometers. The correlation between the right- and left- arm actometer scores was significant, $r = .86$, $p < .0001$. Therefore, I used the mean from the two limbs as the overall activity variable.

Actometer intraclass correlation. I used four actometers in Study 1 and divided them into 2 sets of 2 actometers each. I counterbalanced the order of their use so that each participant wore the instruments on the limbs opposite to the person before. Thus, about half of the participants used each set of instruments, and within each set, each actometer was used on the right or left arm for about half the time. I estimated the reliability of the instruments by using an intraclass correlation coefficient (ICC). The ICC is an estimate of the degree of concordance between the readings of each actometer in a set. It was calculated from a 2-way analysis of variance (ANOVA) in which k judges (actometers) assess n targets (individuals) (Shrout & Fleiss, 1979). I used the mean squares output for targets, judges, and residual error to obtain the ICC. The ICC was .62 and .41, for the first

and second set of actometers, respectively. This result is similar to the reliability coefficient of .43, obtained when adults wore the instruments on both arms for 24-hours (Eaton et al., 1996). The ANOVA main-order effect for individuals was significant, indicating that there were significant individual differences in activity level, but the actometer effect was non-significant. This finding indicates that the there is a high degree of agreement between instruments, and that the instruments are therefore reliably interchangeable.

Accelerometers: quarter-hour data. The accelerometer data were based on the average acceleration of the limb calculated every 10 s throughout the wearing time. This epoch length for the 21 participants over the 24-hour period resulted in a data set containing approximately 200,000 observations. Data reduction involved combining these 10-s epochs into acceleration values based on longer epochs of time. For Study 1, it was most useful to combine the data into quarter-hour epochs, as this epoch was the unit of time on which the Activity Diaries were based. I reduced the 10-s data to quarter-hour data by using the Summary procedure in SAS. In the analysis of the accelerometer data, the initial starting times and final ending times of the data collection were linked to the starting and ending times of the Activity Diaries. The participants had started and ended their diaries on the quarter hour (e.g., 10:00, 10:15, 10:30). Thus, some of the accelerometer data at the very beginning and end of the data collection were eliminated, if it was obtained either before the Diary started or after the Diary finished. In order to ensure that each quarter hour contained a good sampling of accelerometer data, I kept only quarter-hour periods which contained at least 80% of the data (at least 72/90 data points). This procedure caused a drop of four percent in the number of observations

(from 2098 to 2012). Thus, the final aggregation of the 10-s data into quarter-hour epochs resulted in a dataset that contained about 2000 observations (about 90 observations for each of the 21 participants).

Accelerometers: per individual data. The accelerometer data were further reduced to produce a mean acceleration count per individual. The SAS Summary procedure was used to create a mean variable for each person, resulting in a data set containing 21 observations. The correlation between the right- and left- accelerometer scores was significant, $r = .96, p < .0001$. I used the mean of the right- and left- arm accelerometer data to calculate an overall accelerometer count for each participant.

Accelerometer intraclass correlation. Two sets of 2 accelerometers were created for Study 1. The same counterbalancing procedure as for the actometers was carried out, so that each set of instruments was worn by approximately half of the participants, half on one arm and half on the other. The ICC for the accelerometers was calculated in the same way as for the actometer sets and was 0.92 and 0.98. The ICC value is a minimum value estimate, because it includes the extraneous effects of having one instrument worn on the right and one worn on the left.

Physical measurements. Each of the physical measurements were taken twice and means were calculated for weight, height, arm length, hand length, and wrist breadth. The correlations between the first and second measurements ranged from $r = .98$ to $r = .99$. I used the mean values of each measure as the best estimate of the true values. Correlations between the right- and left- limbs ranged from $r = .94$ (for right- and left- wrists) to $r = .98$ (for right- and left- arm and hand lengths). Taking the means of the 4 limb measurements (first and second measures, left and right limbs) produced the final limb length values.

Descriptive Statistics for Overall Activity

A summary of the descriptive statistics for the Study 1 sample follows in Table 1.

Demographics. As expected, the females were on average smaller than the males in height, weight, and limb lengths. Males were on average about one year younger (about 21 years of age) than the females (about 22 years), with more variability in the ages of the females.

Table 1. *Descriptive Statistics of Study 1 Sample.*

	Males		Females	
	Mean	*SD*	Mean	*SD*
Demographics				
Age (yrs)	20.8	1.9	21.9	4.1
Height (cm)	178.9	8.7	165.8	6.2
Weight (lb)	176.0	38.9	153.4	40.9
Limb Lengths				
Arms cm (R)	67.1	3.6	61.9	3.0
cm (L)	66.9	3.5	61.6	3.4
Wrists cm (R)	5.9	0.2	5.0	0.3
cm (L)	5.7	0.3	4.9	0.3
Hand Length cm (R)	19.8	1.0	18.1	0.9
cm (L)	19.8	0.9	17.9	1.0
Activity Monitors				
Actometer Mv/Hr (R)	612.3	277.6	591.2	223.8
Mv/Hr (L)	919.2	519.2	813.5	397.3
Accelerometer g (R)	185.0	72.8	182.4	40.8
g (L)	190.8	74.6	175.3	52.6
Activity Diary				
Mean (*M*/6)	2.2	0.3	1.9	0.1
AIM				
Mean (*M*/6)	3.7	0.5	4.0	0.4
Positive Affect	4.3	0.7	4.1	0.6
Negative Intensity	3.2	0.7	3.8	0.7
Serenity	3.8	0.7	3.4	0.7
Negative Reactivity	3.8	1.3	4.5	0.7

N: Males = 10 Females = 11

Activity measures. There was no statistically significant difference between the males and females in overall actometer-measured activity (765 movements per hr for males, $SD = 384$, versus 702 for females, $SD = 301$), $F(9,10) = 1.63, p < .46$. Nor were there sex differences in accelerometer-measured activity (males 188 g/counts, $SD = 73.4$, versus females 179 g/counts, $SD = 59.2$, $F(9,10) = 2.52, p < .17$. When the data from the males and females were combined, the mean acceleration force was about 184 g/counts. on the right and 183 g/counts on the left. For the actometers with males and females combined, the mean right value was 601 movements per hour, and the mean left value was 866 movements per hour.

Activity Diary. The reports of activity by the participants in their Activity Diaries (Table 1) indicated that the males were significantly more active than the females, $F(9,10) = 3.87, p < .05$. This finding is somewhat surprising, because all participants were given the same instructions for keeping the diary, and both objective measures of activity indicate that there were no statistically significant differences in activity between the sexes. The correlations of mean diary activity with activity measures were higher for the males, $r = .58, p < .08$, and $r = .74, p < .02$, than for females, $r = .40, p < .22$, and $r = .38$, $p < .25$, for actometers and accelerometers, respectively. The test of significance between two non-independent correlations (Appelbaum & McCall, 1983, p. 444), showed that the difference between the male-female correlations was statistically significant for both actometers, $z = 2.64, p < .004$, and accelerometers, $z = 8.80, p < .0001$.

Dextrality Variables

With one actometer and one accelerometer attached to each individual's right- and left- wrists, measures of activity were available for both the right- and left- arms. I

calculated a dextrality index for each limb for each of the instruments.

Actometer-based dextrality. The actometer dextrality variable was an index based on a percent of mean right-sided movements per hr relative to the total movements per day (*100* Right) / (Right + Left*). The actometer dextrality variable had a normal distribution. The minimum value was 30.4 and the maximum value was 53.9. The median was 42.0, and the mean was 42.1. A value less than 50 indicated more left-sided movement relative to right-sided movement over the day.

Accelerometer-based dextrality. The accelerometer dextrality variable was an index based on a percent of mean right-sided counts relative to total counts for the individual (*100* Right / Right + Left*). It was calculated based on the right- and left- limb data for each 10-second epoch of the day. The accelerometer dextrality variable also had a normal distribution. The minimum value was 48.4 and the maximum value was 54.8. The median value was 51.8, and the mean was 51.5. A value above 50 indicated more right- than left- sided acceleration relative to the total.

Descriptive Statistics for the Dextrality and Laterality Data

Table 2 shows the descriptive statistics for the variables related to the dextrality and laterality measures. The activity measures in Table 2 refer to the dextrality variables created for both the actometers and accelerometers as a measure of right-sidedness, relative to total activity. Any score below 50 represents greater left-sided activity. Any score above 50 represents greater right-sided activity. Table 2 shows that when the data are grouped into two categories, above and below 50, the actometer data show greater left-sided activity, and the accelerometer data show greater right-sided activity.

Table 2. *Descriptive Summary of Variables Related to Laterality.*

	Males		Females	
	Mean %	*SD*	Mean%	*SD*
Activity (100*R/R+L)				
Actometer	40.8	5.1	43.2	5.9
Accelerometer	51.0	1.7	51.9	1.4
LPI (% of right-biased participants)				
Hand	95.0	15.8	97.7	5.3
Foot	86.7	20.1	91.7	11.8
Eye	90.0	20.7	73.5	29.5
Ear	74.2	20.5	78.0	23

Note. Activity monitor values < 50 = greater mean left-sided activity.

Dextral activity. The actometer data results shown in Table 2 replicate the Eaton et al. (1998) results. A repeated measures ANOVA (with arm as the within- and gender as the between- factor) found a significant arm effect, $F(1,19) = 19.3, p < .0003$. The actometers again recorded greater left-sided activity than right-sided activity. Only two participants had mean right actometer data greater than 50%. Males made an average of 307 more movements per hr on the left, and females made an average of 222 more movements per hr on the left. In contrast, the accelerometer data showed no lateral bias, $F(1,19) = 0.03, p < .86$. Neither the actometer nor accelerometer dextrality measures showed statistically significant differences between males and females, Actometer: $t(19) = -.97, p > .33$; Accelerometer: $t(19) = -1.2, p > .23$. When the data were combined for the males and the females, the mean dextrality value for the actometers was 42.07%,

SD = 5.56, and for the accelerometers was 51.49%, *SD* = 1.58.

Lateral preference. Each LPI raw score ranged from -4 (extremely left-handed) to +4 (extremely right-handed). The scores were converted to a mean percent value for the sample. With extreme right-handedness at 100%, the mean handedness value for both males and females combined was 96.44%. None of the lateral preference measures (eye, ear, foot, or hand) showed statistically significant differences between the males and females, except for handedness. The gender difference in handedness is probably explained by the fact that one male in Study 1 was left-handed. All the other participants reported that they were right-handed.

Gender differences on the AIM. There was some discussion in the literature (Larsen & Diener, 1987; Weinfurt et al., 1994) about the differences between males and females in the intensity of their reported affect intensity, and whether the differences are due to the females awareness of negative emotional reactions and their willingness to express them, relative to males. Therefore, the data were examined separately by gender for the AIM. Larsen and Diener (1987) found that females scored higher than males on the overall mean AIM for ages ranging from 16 to 68 years. Bryant et al. (1996) found that females scored higher than males on the Negative Reactivity scale in one study, but found no differences in the pattern for males and females in another. One of the advantages in using Weinfurt et al.'s (1994) factors in Study 1 is that the model was developed to fit both male and female data. In this study, there were no statistically significant differences between males and females on any of the AIM factors (Positive Affect, $F(9,10)= 1.26$, $p < .73$, Negative Intensity, $F(9,10) = 1.02, p < .98$, Serenity, $F(9,10) = 1.13, p < .87$, and Negative Reactivity, $F(9,10) = 3.23, p < .09$). Table 3 is a summary of the predicted

relationships between the activity measures and the other variables collected in the study.

Results of Predictions with Overall Activity

Demographics. As expected there were no significant differences between males and females in activity level. However, contrary to the hypothesis, there were age effects in the data. The mean age of the sample was 21.4 years of age (SD = 3.2 years). The negative correlation between age and the overall actometer score (Table 3) indicates, at a trend level of significance, that older individuals move less frequently than younger individuals. The relationship with weight follows a similar pattern, although not significant in this sample. Height is not significantly related to movement activity.

Limb lengths. Limb lengths (Table 3) did not show significant correlations with either the actometer or accelerometer measures of activity. The correlation between arm length and height was statistically significant, $r = .90, p < .0001$. In Study 2, height will be used as a proxy for limb length and limb length will not be measured.

The AIM. The AIM questionnaire factors show some interesting relations with the activity measures (Table 3). The prediction that overall activity would be positively related to Positive Affect, Negative Intensity, and Negative Reactivity was not confirmed. In fact, overall actometer-measured activity was unrelated to both Positive Affect and Negative Intensity, and significantly ***negatively*** correlated with Negative Reactivity, $r = -.54$. The correlation of activity with Serenity was significant (negative), as predicted. None of the predicted correlations between the AIM factors and overall accelerometer-measured activity were found. However, given the small sample size, the correlation between acceleration and Negative Reactivity looked promising.

Table 3. *Summary of Hypothesized Relationships in Study 1.*

Other Variables	Activity Measures			
	Overall Activity (AL)		Dextrality	
	Actometer	Accelerometer	Actometer	Accelerometer
Demographics				
Sex (♂=1;♀=2)	(ns) -.10	(ns) -.08	(?) .22	(?) .27
Age	(ns) *-.40**	(ns) -.24	(?) .34	(?) .36
Height	(ns) -.10	(ns) -.20	(ns) -.14	(ns) .02
Weight	(ns) -.28	(ns) -.26	(ns) .31	(ns) .22
Limb Lengths				
Arm Length	(ns) -.08	(ns) -.26	(ns) -.06	(ns) .02
Hand Length	(ns) -.05	(ns) -.10	(ns) -.20	(ns) .01
Wrist Breadth	(ns) .04	(ns) -.05	(ns) -.26	(ns) -.14
Lateral Preferences				
Handedness	(ns) .13	(ns) .16	(?) -.12	(?) .18
Footedness	(ns) .00	(ns) .06	(?) -.00	(?) .20
Eyedness	(ns) -.04	(ns) .12	(?) .10	(?) .06
Earedness	(ns) .02	(ns) .12	(?) -.18	(?) .05
AIM				
Positive Affect	(pos) -.04	(pos) -.05	(neg) .00	(neg) **-.22**
Neg Intensity	(pos) *-.23*	(pos) .03	(pos) -.02	(pos) -.06
Serenity	(neg) **-.62*****	(neg) .22	(neg) **-.36**	(neg) .36
Neg Reactivity	(pos) *-.54***	(pos) **.26**	(pos) -.27	(pos) **.40***
Activity Diary				
Mean	(pos) **.48****	(pos) **.58*****	(ns) -.14	(ns) -.35

Note. n=21. Predicted directions of correlations are in brackets. Bolded items confirm hypotheses. Italicized items are opposite to hypotheses. Gender Coding: Males=1. Females=2. Predictions: ns = non-significant; pos = positive; neg = negative; ? = unknown.

$^{*}p < 10$. $^{**}p < .05$. $^{***}p < .001$.

Convergence among activity measures. The correlation between the overall actometer and the overall accelerometer scores was significant, showing evidence of convergent validity (see Table 4). Thus, although the actometers and accelerometers measure different aspects of activity, they appear to be measuring some aspect that is common to both instruments. The significant correlations between the mean Activity Diary score and overall activity, as measured by both the actometers and the accelerometers provides further convergent validity among the instruments. The Activity Diary also provided evidence for external validity for both the actometers and the accelerometers (see Table 3).

Results of Predictions with Dextrality Variables

The analysis presented some interesting, if unexpected, findings. Actometers showed the predicted left-sided bias in movement. Accelerometers, however, did not show such a sinistral bias. A similar inconsistency was evident when participants were classified into either a greater right- or greater left- arm movement category. According to the actometer-recording, 20/21 people in the study were more active on the left, while according to the accelerometers, 18/21 were more active on the right. Nonetheless, the dextral measures between these two instruments were correlated significantly with each other (Table 4).

Demographics and physical measures. None of the demographic variables reached statistical significance in the correlations with the dextrality measures (Table 3). As expected, limb lengths were not correlated with either measure of dextrality (Table 3). It is not expected that these measures would be significant correlates of dextral activity, and they will not be measured in Study 2.

Laterality preferences. There was no relation between handedness and dextrality for either actometer- or accelerometer-measured activity (Table 3). However, with only one left-hander in the Study 1 sample, no conclusions can be drawn about the relationship between lateralized activity and lateral hand preference.

Overall and Dextral Activity Intercorrelations

Because two different dependent variables were created from the same instrument measures, it is useful to show the correlations among them. Table 4 shows the correlations among the overall activity measures (*M* of both arms) and the dextrality measures for both actometers and accelerometers.

Table 4. *Overall and Dextral Activity Intercorrelations.*

	Pearson Correlations		
	Overall Actometer	Overall Accelerometer	Dextrality Actometer
Overall Actometer			
Overall Accelerometer	.52***		
Dextrality Actometer	-.42*	-.15	
Dextrality Accelerometer	-.69****	-.36	.51**

$n = 21$. * $p < .10$. ** $p < .05$. *** $p < .01$. **** $p < .001$.

The AIM

Table 5 shows the AIM factor intercorrelations. Although Negative Intensity is conceptually distinct from Negative Reactivity, a significant relation emerged between the two. As well, a significant relation emerged between Positive Affect and Negative Reactivity, but none between Positive Affect and Negative Intensity. Therefore, it does

not appear that intensity of affect occurs irrespective of emotional valence.

Table 5. *AIM Intercorrelation Matrix.*

	Pearson Correlations		
	Positive Affect	Negative Intensity	Serenity
Positive Affect			
Negative Intensity	.06		
Serenity	.06	-.19	
Negative Reactivity	.46**	.45**	.26

Note. n = 21. * $p < .10$. ** $p < .05$. *** $p < .01$.

Activity and AIM correlations. The prediction was that dextrality would relate to the affective measure (AIM) factors. Specifically, there would be a positive correlation between dextrality and Negative Reactivity and Negative Intensity, and a negative correlation between dextrality and Positive Affect and Serenity. The results show some evidence in those directions (Table 3), although not significantly so in this small sample of 21 individuals. For example, dextral acceleration is negatively correlated with Positive Affect and positively correlated with Negative Reactivity.

DISCUSSION STUDY 1

Study 1 was an exploratory one, designed to assess two types of activity monitors and initiate an examination of the correlates of overall and asymmetric motor activity. One of the main purposes of the study was to examine the relationship between the actometers and the accelerometers, and to show some evidence of external validity for the instruments. In this, the study was successful. I found a significant relationship between the actometer and the accelerometer measures. I also was able to find evidence of

convergent validity for the concept of activity level with a positive relation between the instruments and the Activity Diary. Self-ratings of activity correlated significantly with the instrumented measures.

The result of the correlation between sex and the mean Activity Diary level raises a question. Using the instruments to estimate overall activity level, sex differences were not significant. However, diary reports of physical activity did show significant sex differences. Males reported higher mean activity levels on their diaries than did the females. Are the males inflating their activity levels or are the females underestimating their activity levels? The higher correlations between the instruments and diary activity for the males suggests that it is the females who are underestimating their activity levels, rather than the males who are inflating theirs.

Why might males be more accurate than females in reporting their activity? One possibility lies with the sensitivity of the instruments. The males may be making larger movements and more high acceleration movements, which are picked up by the instruments, particularly the accelerometers. Another possibility is that the Activity Diary categories less adequately describe the physical activities of females. I provided the participants with examples of physical activities (see Appendix A). Light activity examples included shopping, strolling, and looking for books in the library. Moderate activities included brisk walking, and household tasks, such as sweeping, dusting, doing the laundry, and gardening. If females are doing more of these types of activities than males, and if these activities are really more active than expected, then the Activity Diary could be underestimating the physical activities of females. Shopping may be more of a moderate activity than a light activity, and housework may be more hard than moderate.

The data should be more carefully evaluated for placement in an activity category. Perhaps some of these physical activities could be promoted to the next higher level in the diary. At the very least, we could promote a healthier level of physical activity in females, something akin to weightlifting small weights, by encouraging them to do more shopping.

Demographic variables, such as age, height, weight, or limb length were not predicted to act as moderator variables for the activity measures. For the most part, the findings were as expected. Neither arm, or hand length, nor wrist size were significant correlates of instrument-measured activity. Because the limb length measures were not implicated as correlates of activity, either overall or asymmetric, limb length was not measured in Study 2. Chronological age was the only demographic variable significantly related to activity. Even though the participants in this study were within a very limited age-range, it appears to be the case that the older individuals were not as physically active as were the younger ones. Although age effects are not being examined as a main focus in Study 2, this surprising outcome needs further attention in future studies.

The negative relationship between overall actometer-measured activity and Negative Reactivity (Table 3) was surprising, as a positive relation was predicted. The question items making up this scale (Appendix A) ask about respondent reactions to unpleasant, sad, or guilt-inducing situations. These questions perhaps reflect more anxiety or withdrawal-inducing situations, which may be expressed by a reduction of activity. On the other hand, the relation between Negative Reactivity and accelerometer-measured activity did not show a similar relation to that of the actometer measure (Table 3). It is therefore, difficult to make a conclusive statement regarding the relation of Negative Reactivity with activity. Reports of low levels of Serenity or calmness were associated

with higher levels of overall actometer-measured activity, as predicted. In Study 2, I will further examine this intriguing data by collecting more activity data and relating it to other measures of both arousal and emotion.

In terms of the dextrality, as was found with the actometers, handedness and other measures of lateral preference were not related to asymmetric activity. This finding replicates that of Eaton et al. (1998) in an independent sample. However, it still does not clear up the mystery as to what this asymmetry is related, and to what its purpose.

In discussing the literature and developing my hypotheses, one of the working assumptions involves the putative brain-behaviour relationship. I have been making the assumption that greater neural activation or arousal is related to or even equivalent to greater physical arousal in the form of motor activity. In Study 1, overall actometer-measured motor activity was negatively related to the Serenity or calmness arousal subscale of the AIM. Thus, in this case, motor activity was related to a dimension of arousal in the assumed manner. In the valence-motor activity hypotheses, one also might assume that hemispheric arousal of valence will be related to contralateral motor activation. The left hemisphere mainly activates the right limbs, and the right hemisphere activates the left limbs. The difficulty is that the theoretical literature on hemispheric valence consistently reports a left hemisphere-positive emotion connection and a right hemisphere- negative emotion connection. This situation should result in a right-arm movement-left hemisphere-positive emotion connection and a left arm movement-right-hemisphere-negative emotion connection. However, the empirical data relating valence of affect to lateral motor activity (McKeen, 1995; McKeen, Eaton, Campbell, & Saudino, 1998; and Study 1 above) have shown that right-arm movement is related to negative

emotion. How can this counter-intuitive result occur?

Let me refer to the results of Study 1. If the Serenity subscale of the AIM represents positive emotion and low arousal and Negative Reactivity represents negative emotion and high arousal, the relation with motor activity might not be as simple as it first appears. Both subscales are negatively related to motor activity. It seems that neither valence nor arousal offers a satisfactory explanation. One possibility is that arousal and valence are independent dimensions (Heller, 1993), and there need not be the same pattern of arousal for both constructs.

Another possibility is that the assumption is wrong that greater lateralized neural activation leads to greater limb activity. Instead of activating a contralateral limb, arousal of one hemisphere may *inhibit* motor activity of the contralateral limb. Thus, one could explain the right-arm movement-negative emotion relation by suggesting that the aroused right hemisphere is inhibiting movement in the left arm. This explanation works for the positive and negative emotions and dextral motor activity found thus far.

It would be premature at this point to attempt to explain the apparent inconsistencies in the brain-behaviour relationship. Study 1 was limited in that it was based on a small sample size, and the results should be considered preliminary. In Study 2, I more systematically assessed arousal and valence of emotion and their relation to motor activity in a larger sample.

STUDY 2

In a second study with a larger sample, both overall motor activity and lateralized motor activity level were examined, as they related to temperament, mood, and affect intensity. For theoretical reasons, lateral preferences were also assessed, including an additional measure of laterality, the dichotic listening (DL) task.

Overall activity and arousal. In keeping with the results of Study 1, it was hypothesized that overall activity would relate to measures of general arousal. Individuals with relatively higher levels of arousal, either negative or positive in tone, would show higher levels of activity. As with the other lateral preferences, I did not hypothesize a relation between overall activity and the DL measure.

Lateralized activity and emotional experience. Lateralized activity (the dextrality measures) should relate more specifically to the nature of the affect experienced by the individual. Consistent with previous empirical findings (Study 1 and McKeen, 1995), it was hypothesized that individuals with relatively greater right-sided activity (more dextral) also would experience more negative affect. As well, it was hypothesized that individuals with relatively less right-sided activity (less dextral) would experience more positive affect.

Lateralized activity and emotional perception. Based on Davidson and Hugdahl's (1996) findings relating DL to EEG measures (left frontal activation-less REA, right frontal activation-greater REA) and the left-positive, right-negative association between EEG and emotion (Davidson, 1995), I am hypothesizing a positive relationship between REA for negative emotion perception (*angry* and *sad* conditions on the DL tape) and negative affect on the self-report measures and also a positive relationship between

REA for negative affect and dextral activity. Those who describe themselves as more positive in affect should show less of an REA for negative tone (*angry* or *sad* on the DL tape) and a negative association with dextral activity.

In the following section, I review the measures of temperamental arousal, emotional valence, mood, and affective perception used in Study 2. As mentioned above, a dichotic listening tape (as used by Bryden et al.,1991; Bryden & MacRae, 1989; and Bulman-Fleming & Bryden, 1994) is used to assess emotional perception. Measures of emotional experience are obtained using two self-report scales, the Positive Affect-Negative Affect Scale (PANAS; Watson et al., 1988) and the Affect Intensity Measure (AIM; Larsen & Diener, 1987). The AIM assesses arousal, as well as positive, and negative affect. The Behavioral Inhibition /Behavioral Activation Scale (BISBAS; Carver & White, 1994) and the Pavlovian Temperament Scale (PTS; Newberry et al., 1997) assess aspects of temperamental arousal. In reviewing the validity and reliability of these instruments, I highlight the empirical nature of each concept and outline the hypothesized relations between motor activity and the emotional concepts. Copies of the instruments used in Study 2 are in Appendix B.

Instruments

Pavlovian Temperament Survey

The Pavlovian Temperament Survey (PTS-American English Version) is a 66-item self-report questionnaire developed to assess Pavlov's conception of the constitutional characteristics of the nervous system (Newberry et al., 1997a). It contains three subscales, reflecting three definitional facets of the temperament dimensions. The subscales are named the Strength of Excitation (SE), Strength of Inhibition (SI), and Mobility of

Nervous Processes (MO), described earlier. Each contains 22 items answered in a 4-point Likert-type scale (*strongly agree*, *agree*, *disagree*, and *strongly disagree*).

Validity of the PTS

In validating the questionnaire, researchers have compared it to results obtained with other temperament or personality questionnaires also referring to the concept of arousal. These include inventories measuring extraversion, neuroticism, psychoticism, sensation seeking, impulsivity, and affect intensity (Ruch, Angleitner, & Strelau, 1991). For example, the results of one study of 159 participants showed that SE was correlated with the subscales of Zuckerman's (1979) sensation seeking questionnaire. These subscales included Thrill and Adventure Seeking, $r = .45, p < .001$, Experience Seeking, $r = .46, p < .001$, Boredom Susceptibility, $r = .31, p < .001$, and Disinhibition, $r = .36$, $p < .001$. Strength of Inhibition was correlated negatively with the sensation seeking subscales of Experience Seeking, $r = -.35, p < .001$, and Disinhibition, $r = -.35, p < .001$. Mobility was most highly correlated with Thrill and Adventure Seeking, $r = .36, p < .001$ and Experience Seeking, $r = .43, p < .001$.

In that same study (Ruch et al., 1991) SE was related to Impulsivity , $r = .27$, $p < .001$, Venturesomeness, $r = .54, p < .001$, and negatively with Empathy, $r = -.29$, $p < .001$ on an Impulsivity scale (Eysenck, Pearson, Easting, and Allsopp, 1985). Strength of Inhibition was related negatively to Impulsivity , $r = -.42, p < .001$, and Venturesomeness, $r = -.22, p < .01$, and to Affect Intensity on the AIM (Larsen & Diener, 1987), $r = -.48, p < .001$. Thus, the arousal subscales of the PTS are consistent with other self-report instruments designed to assess levels of arousal.

The PTS subscales are also related to various personality dimensions, as evident in

a series of validity studies described below (see Ruch et al., 1991). The participants in these studies came from three independent samples. The first consisted of 159 participants, aged 18 to 67 years ($M = 33.6$, $SD = 12.8$). The second consisted of 102 subjects, aged 19 to 70 years ($M = 32.1$, $SD = 12.0$). The third consisted of 74 subjects, aged 17 to 68. Approximately half were female. Strength of Excitation correlates with gender, $r = -.29$, $p < .01$, and SI correlates with age, $r = .27$, $p < .01$. This finding is compatible with the idea that males will show a greater desire for sensation seeking and assertiveness. It is also plausible that the ability or willingness to inhibit action should increase with age (Newberry et al., 1997a).

On Eysenck's Personality Questionnaire (EPQ-R; Eysenck, Eysenck, & Barrett, 1985a) SE was related positively to Extraversion, $r = .39$, $p < .001$ and Psychoticism, $r = .23$, $p < .01$, and negatively to Neuroticism, $r = -.42$, $p < .001$. The SI was related negatively to Extraversion, $r = -.37$, $p < .001$, Psychoticism, $r = -.36$, $p < .01$, and Neuroticism, $r = -.38$, $p < .001$. Mobility related positively to Extraversion, $r = .46$, $p < .001$, and negatively to Neuroticism, $r = -.34$, $p < .001$. Thus, it is evident that SE and SI differ most in their relationship to Extraversion. It is not clear to what extent SE and SI predict Neuroticism independently or whether the two facets are redundant to some extent. More analyses examining demographic variables and the influence of gender needs to be done (Clark & Newberry, 1995).

On the NEO Personality Inventory (NEO-PI; Costa & McCrae, 1985), SE was most highly related to Neuroticism, $r = -.57$, $p < .001$, and Extraversion, $r = .47$, $p < .001$. Strength of Inhibition was also related to Neuroticism, $r = -.26$, $p < .01$, and Agreeableness, $r = .29$, $p < .001$. Mobility was also related to Neuroticism, $r = -.53$,

$p < .001$, and Extraversion, $r = .53, p < .001$. The patterns of correlations among the PTS scales and two personality scales are similar, although there appears to be some empirical overlap with the concept of Neuroticism (or rather non-neurotic emotional stability).

In the temperament domain on the Emotionality-Activity-Sociability-Impulsiveness inventory (EASI; Buss & Plomin, 1984), SE was again correlated negatively with Emotionality (negative emotionality), $r = -.42, p < .001$, and positively with Activity, $r = .43, p < .001$. Strength of Inhibition was correlated negatively with Emotionality, $r = -.39, p < .001$, and Impulsivity, $r = -.56, p < .001$, and positively with Activity, $r = .26, p < .01$. Similarly, MO was correlated negatively with Emotionality, $r = -.46, p < .001$, and positively with Activity, $r = .42, p < .001$, and Sociability, $r = .33$, $p < .01$. It is noteworthy that the EASI Activity subscale is associated with the SE, SI, and the MO. The main differences among the scales involved their relations with Emotionality for SE, Impulsivity for SI, and Sociability for the MO subscale.

The SE, SI, and MO subscales are conceptually independent, but not empirically so. The intercorrelations among the three scales are statistically significant, the SE-SI relation, $r = .22, p < .01$, the SE-MO relation, $r = .43, p < .01$, and the SI-MO relation, $r = .16, p < .01$. The SE-MO relation is based mainly on the high correlations between questions dealing with demanding, intensive activities (on the SE) and questions dealing with the ability to change from one activity to another (on the MO). From the pattern of correlations, Clark and Newberry (1995) maintain that each contributes something that the other does not.

Reliability and Stability of the PTS

On a study sample of 554 individuals, the items making up the SE, SI, and MO

subscales of the PTS (Newberry et al., 1997a) produced Cronbach's (1951) alpha coefficients of .83, .75, and .83, respectively (Clark & Newberry, 1995). Test-retest reliabilities for the PTS were assessed on a sample of 375 individuals. The intervals between test-taking varied between one and 56 days, with a median interval of 27 days. Correlations between the first and second times were .72, .70, and .70 for the SE, SI, and MO subscales. Both reliability and stability are quite acceptable.

Hypotheses about the PTS

I am hypothesizing that the SE and MO subscales of the PTS will relate to arousal and thus, to overall motor activity. The SI should be related negatively to overall activity. In contrast to an expected relation between arousal and overall activity, I do not expect to find a significant relationship between the PTS subscales and lateralized activity. On the whole, the question items on the PTS are not related to specific positive or negative emotional valence, but reflect the intent of the scale to measure the individual's general arousal level.

The BISBAS Scales

The Behavioural Inhibition/Behavioural Activation Scale (BISBAS) is a 20-item questionnaire designed to assess Gray's theory (1972) of behavioural inhibition and activation. Gray's theory attributes approach behaviour and positive affect to a sensitivity to signals of reward (BAS activity) and inhibition of behaviour and the creation of negative affect to sensitivity to signals of punishment (BIS activity). BIS functioning is related to a proneness to anxiety and the BAS is related to impulsive or antisocial tendencies (Carver & White, 1994).

Although there well may be a significant correlation with anxiety, the BISBAS

scale is not the same as one measuring trait anxiety or impulsiveness. The reason is that although a person with a highly sensitive BIS may be vulnerable to states of anxiety or other negative affects, the individual may be quite adept at arranging his or her life to avoid threatening situations that would cause anxiety. The BISBAS is designed to measure the *sensitivity* of the system rather than the individual's *typical experiences* in day-to-day life (Carver & White, 1994).

The BIS and BAS physiological systems should be independent of each other, although empirically, the degree of independence varies across subscales. In Carver and White's (1994) study ($N = 732$), the BIS scale correlated $r = -.12$ with BAS Drive, $r = .28$ with BAS Reward Responsiveness, and $r = -.08$ with BAS Fun Seeking. In Sutton and Davidson's (1997) study, the correlation between the BIS and BAS scores was not significant, $r = -.17, p > .26$.

The answers to the BISBAS scale questions follow a Likert-type format. Responses are made on a 4-point response scale with 1 indicating *strong agreement* and 4 indicating *strong disagreement*. There is one BIS scale and three BAS-related subscales in the BISBAS. This scale was derived originally from a factor analysis study of 732 college students. Items assessing the BIS reference potentially punishing events. These include statements such as, ***I worry about making mistakes***, and ***If I think something unpleasant is going to happen I usually get pretty 'worked up.'*** Items assessing the BAS reference potentially rewarding events. These include statements such as, ***When I get something I want, I feel excited and energized***, and ***When I'm doing well at something, I love to keep at it*** (Carver & White, 1994).

Validity of the BISBAS

Carver and White (1994) administered several other scales to assess the convergent and discriminant validity of the BISBAS scale. As expected, the BAS scales were related to extraversion. On a sample of 381 people, researchers found that extraversion was correlated with BAS Drive, $r = .41, p < .001$, BAS Reward, $r = .39$, $p < .001$, and BAS Fun Seeking, $r = .59, p < .001$, but was uncorrelated with the BIS, $r = -.14, p > .05$ (Eysenck & Eysenck, 1985b). The BIS scale was related negatively to the Optimism scale on the Life Orientation Test (LOT; Scheier & Carver, 1985), $r = -.22$, $p < .001$.

The BISBAS shows good discriminant validity for the affective component of the scale. Tested on a sample of 498 adults (Carver & White, 1994), the BIS score was related to Negative Affectivity on the PANAS scale (Watson et al., 1988), $r = .42, p < .001$, but Negative Affectivity was uncorrelated with the BAS subscales, Drive, $r = -.07, p > .05$, Reward, $r = .05, p > .05$, and Fun Seeking, $r = -.05, p > .05$. Positive Affectivity was correlated with the BAS scales, Drive, $r = .31, p < .001$, Reward, $r = .28, p < .001$, and Fun Seeking, $r = .19, p < .001$, but was uncorrelated with the BIS scale, $r = -.06, p > .05$. This evidence of both convergent and discriminant validity will allow me to examine the hypothesized relations among motor activity, emotion, and arousal.

Reliability and Stability of the BISBAS

Internal reliability for each of the subscale items was assessed in a study of 732 individuals (Carver & White, 1994). The alpha coefficient (Cronbach, 1951) for the BIS scale was .74, $M = 19.99$, $SD = 3.79$. The alpha coefficient for the BAS subscales were .73, $M = 17.59$, $SD = 2.14$ for BAS Reward Responsiveness, .76 for BAS Drive, $M = 12.05$,

SD = 2.36, and .66 for BAS Fun Seeking, *M* = 12.43, *SD* = 2.26. A gender difference in mean BISBAS ratings was also found (Carver & White, 1994). BIS scores were lower among men, *M* = 18.84 than among women, *M* = 21.09. BAS Reward Responsiveness (the first BAS subscale) scores were also lower among men, *M* = 17.27, than among women, *M* = 17.90. In another study, Sutton and Davidson (1997) found average alpha coefficients of .75 for the BIS items and .85 for the BAS items.

To assess reliability across time, a sample of 113 subjects were retested about eight weeks after the initial testing. Test-retest correlations were .66 for the BIS scale, .59 for BAS Reward Responsiveness, .66 for BAS Drive, and .69 for the BAS Fun Seeking subscale (Carver & White, 1994). Sutton and Davidson (1997) administered the BISBAS scale twice, about five months apart, to a group of forty-six 18- to 22-year olds. The intraclass correlation as a measure of test-retest stability was .68 for the BIS scale, .72 for the BAS, and .81 for the difference (of *z* scores) between the BIS and BAS scores.

Hypotheses about the BISBAS

It was hypothesized that the BISBAS scale, as a measure of arousal, would correlate positively with overall activity. Those whose BAS scores were higher would be more highly aroused, and their overall activity would correlate positively with their BAS score. The BIS score represents essentially an inhibition of arousal, so it was hypothesized that the BIS score would be negatively correlated with overall activity. Additionally, if the BIS score also represents a negative emotional tone (anxiety), then dextral activity should correlate positively (greater right-arm activity) with BIS scores.

The PANAS Scales

In studies of the structure of affect in which researchers investigate facial expressions or mood, two dominant dimensions emerge. The two are usually described as a dimension of pleasantness-unpleasantness or positive-negative affect and a dimension of arousal. Although the terms positive affect and negative affect might suggest that these two mood factors are opposites and therefore highly negatively correlated, they have emerged as two distinct mood dimensions. In factor analytic studies of affect, they are meaningfully represented as orthogonal dimensions. When individuals rate their moods daily using the PANAS, within-subject analysis indicates that the Positive and Negative Affect scores share only about 12% of the variance (Watson & Clark, 1997).

Positive Affect (PA) reflects an individual's enthusiasm, activity, and alertness. High PA involves high energy, full concentration, and pleasurable engagement. Negative Affect (NA) reflects a dimension of subjective distress, aversive mood states, including anger, contempt, disgust, guilt, fear, and anxiety. Low NA involves a state of calmness and serenity. Trait dimensions of positive and negative emotionality roughly correspond to the dominant personality factors of extraversion and anxiety-neuroticism, respectively (Watson et al., 1988).

The PANAS scale (Positive and Negative Affect Schedule; Watson, Clark, & Tellegen, 1988) is a 20-item self-report scale. The scale contains 10 emotion descriptors which assess Negative Affect and 10 which assess Positive Affect. To complete the scale, individuals indicate whether they have experienced a particular mood state during a specified time frame. Individuals rate their moods on a 5-point Likert-type scale, labelled ***very slightly*** or ***not at all***, ***a little***, ***moderately***, ***quite a bit***, and ***very much*** (Watson et al.,

1988).

The PANAS differs from the BISBAS scales in that the PANAS asks respondents to indicate to what extent they *experience* each affect in day to day life. The BISBAS aims to assess a *vulnerability* to a particular arousal experiences. The PANAS also taps a range of specific positive and negative emotions (Carver & White, 1994).

Validity of the PANAS

The PANAS correlates with other measures of affective state. The Beck Depression Inventory (BDI; Beck et al., 1961) is a self-report questionnaire assessing mild to moderate levels of depression. With a sample size of 880, the NA scale correlated .56 with the BDI and -.35 with the PA scale of the PANAS. These results suggest that depression involves both the lack of pleasurable experience (low PA) in addition to anger, apprehension, guilt, and distress (high NA). The A-State subscale from the State-Trait Anxiety Scale (STAI; Spielberger, Gorsuch, & Lushene, 1970) is a scale designed to assess negative responses to a variety of stressful and aversive events. With a sample of 203 individuals, the PANAS NA scale correlated .51 with the A-State and the PANAS PA correlated -.35 with the A-State. Many of the items on the A-State tap moods traditionally associated with anxiety, such as feeling tense, upset, worried, anxious, nervous, and jittery. Others reflect pleasant, high PA states, such as, feeling joyful, pleasant, self-confident, and rested. The advantage of the PANAS over both of these instruments is that it assesses both positive and negative affective states separately (Watson, et al., 1988).

When the PANAS was used to assess intraindividual mood fluctuations, it was sensitive to changing circumstances. In two studies, Watson (1988) had subjects complete the PANAS either each evening for 5- to 7- weeks or every three waking hours for a week.

At each assessment, the individuals also rated their social activity and the level of stress that they had experienced over the previous appropriate time epoch. As expected, in both studies the within-subject variations in perceived stress were strongly correlated with NA, but not PA. Social activity was more highly related to PA than to NA. Positive Affectivity rose in the morning, remained steady during the rest of the day, and declined during the evening. Negative Affectivity did not exhibit a diurnal pattern.

In a study examining EEG activation, the PANAS (Watson et al., 1988), and the AIM (Larsen & Diener, 1987) were administered to 90 undergraduate women. Researchers found that greater relative left frontal activation was associated with increased PA and decreased activation with NA. Among those who completed the PANAS at the same time as their EEG was assessed, the correlation between frontal asymmetry and the PA-NA differences score was significant, $r = .31, p < .05$. Among the women whose anterior temporal asymmetry was stable over time, mean EEG asymmetry predicted subsequent PA scores obtained between 6 and 15 months after EEG recordings were made, $r = .49, p < .005$ (Tomarken et al., 1992).

Reliability and Stability of the PANAS

Normative and reliability data were developed using largely independent samples and seven different temporal instructions. A total of over 4000 college students and 164 university employees rated how they felt either ***right now***, ***today***, ***during the past few days***, ***during the past week***, ***during the past few weeks***, ***during the past year***, or, ***in general*** (Watson et al., 1988). No large or consistent sex differences were found. Subjects reported more PA than NA over all of the time frames.

Assessments of internal consistency showed that Cronbach's alpha ranged from

.86 to .90 for PA and from .84 to .87 for NA. The reliability of the scales was unaffected by the time instructions used. The correlation between the PA and NA scales was low. They shared between 1% (for mood *today*) and 5% (for mood in the *past year*) of their variance. In a factor analysis of the scale items, two dominant factors emerged. Correlations demonstrating convergent validity within a factor ranged from .89 to .95, whereas discriminant correlations between factors were low, ranging from -.02 to -.18.

Test-retest reliability, based on 101 students who completed ratings for each of the seven time frames on two different occasions, eight weeks apart showed no significant differences. But, the retest stability tended to increase as the time frame lengthened because ratings over the longer time periods were implicit aggregations (Watson et al., 1988).

The PA and NA scales also showed long-term stability. Students, who were tested during college and retested six to seven years later showed significant rank-order stability in the PA and NA experienced. The correlation between Negative Affect at the two times was $r = .43, p < .01$. The correlation between Positive Affect at the two times was $r = .36$, $p < .01$. The researchers suggested that PANAS measures of Positive and Negative Affect showed substantial stability as trait measures across time (Watson & Walker, 1996).

Hypotheses about the PANAS

I am hypothesizing that the PANAS scale will correlate positively with overall activity. Individuals with either high PA or high NA will be aroused and therefore will also show high levels of motor activity. As well, those with low levels of PA and NA will be the least aroused and show the least motor activity.

Based on the research findings that show greater left activity was associated with

contentedness or happiness in infants and greater right activity was associated with fussing and crying (McKeen, 1995), I am hypothesizing that self-reported PA will correlate negatively with dextral activity (i.e., greater left activity), while NA will correlate positively with dextral activity (greater right activity). I am also hypothesizing that if relatively more happiness is related to greater left-sided activity, then the PA-NA difference score will relate negatively to the dextral activity measure.

Dichotic Listening Task

The DL task was initially developed to simulate the attentional problem that air traffic controllers face when they are required to listen to flight information from more than one aircraft at the same time. Kimura (1961a, 1961b) showed that subjects with right-hemisphere language representation were more accurate recalling items from the left ear, while those with left-hemisphere language were more accurate in recalling items from the right ear. Kimura's data showed that in normal people, regardless of handedness, the majority show a REA for language. Her initial studies were followed by others which showed that most people display a LEA for melody, environmental sounds and emotional stimuli (Bryden, 1988a; Koenig, 1990).

There are two general views as to why laterality effects are observed in the DL task. The classic explanation is an argument based on biological structure. The argument is that the contralateral pathways are larger and functionally stronger than ipsilateral pathways. Moreover, language-based information that reaches the right hemisphere has to be transferred across the corpus callosum to the left-hemisphere for processing. This indirect transfer makes for a less efficient process than the direct contralateral path (Hugdahl, 1995). In addition, nervous activation in contralateral pathways may block or

inhibit activation in ipsilateral ones (Kimura, 1967). Individual differences are thought to occur because the degree of lateralization depends upon a given task and differences in prior experience or biological tendencies for responding to the task.

The second view is the argument that the anticipation of a verbal stimulus primes the left hemisphere, which increases arousal in the (left) language-specialized hemisphere and causes an individual to attend to the contralateral stimulus. Thus, a listening asymmetry in normal people may be a manifestation of a tendency to shift attention to the side contralateral to the more highly activated hemisphere (Kinsbourne & Hiscock, 1983). Individual differences are thought to arise from the relative degree to which a specific task activates either one hemisphere or the other.

According to Bryden (1988a), the current evidence indicates that neither view is completely correct. One problem for the attentional mechanism theory is that it does not predict the empirical occurrence of both right- and left-hemisphere activation at the same time for non-verbal and verbal material, respectively. On the other hand, attentional factors do appear to be a component in producing dichotic laterality effects. When either adults or children are asked to attend to what they hear in one ear, they are more accurate in the ear that is attended, although the dominant ear score is more resistant to attentional manipulation (Asbjornsen & Hugdahl, 1995; Harper & Kraft, 1986).

Validity of the Dichotic Listening Technique

One of the most reliable ways of validating verbal tasks in DL performance is to compare DL results on a verbal task of language function after the administration of amobarbital sodium (Sodium Amytal) to one hemisphere (Hugdahl, 1995). Sodium Amytal is a barbiturate which suppresses function in the hemisphere that receives the

drug. When it is administered to the hemisphere that controls language expression, the individual loses the ability to speak for the several-minute duration of the drug's effect. The speech testing, also called the Wada test, is sometimes given to epileptic patients who are to undergo surgery as a treatment for their condition (Wada & Rasmussen, 1960). It is also sometimes given to normal people for experimental control purposes (Strauss, 1988). Performance asymmetry on the DL test is then examined in these individuals who have known-language function in order to check the validity of the DL test.

Several empirical studies have shown that only a few people are misclassified on the basis of DL tests. Geffen and Caudrey (1981) tested 37 patients of known speech lateralization. Of the 29 who showed a REA, 27 (93%) were left-hemispheric for speech. Of the seven who showed a LEA, four were right-hemispheric, two had bi-hemispheric speech, and one was left-hemispheric for speech. Thus, the DL technique correctly classified 35/37 patients (95%) in this study. The main problem for correct classification using the DL test is that a LEA is less reliable and not necessarily predictive of right-hemisphere speech.

Despite the fact that at least 95% of right-handers have language represented in the left hemisphere according to the Wada test (Rasmussen & Milner, 1977), traditional verbal DL tasks produce a REA in 60 to 85% (Segalowitz, 1986) to 90% (Hugdahl, 1995) of right-handed subjects. Thus, the DL technique identifies about 5% to 35% fewer right-handers with left-hemisphere language dominance than does the Wada technique. Seventy per cent of left-handers had left-hemisphere language dominance, 15% had right-hemisphere dominance, and 15% had mixed dominance in one amobarbital study (Rasmussen & Milner, 1977). The DL task identified 5% fewer left-handed persons with

left-hemisphere language dominance than did the Wada test.

Besides the Wada method, there are other means used to validate the DL technique. In terms of biological structural differences, verbal DL measures show that those people with a REA (left-hemisphere language dominance) are more likely to have a larger left posterior sylvian region, which is associated with language processing. Those with a LEA (right-hemisphere speech dominance) are more likely to have a larger right posterior sylvian region. A LEA (right-hemisphere speech) is also associated with a corpus callosum larger by about 25% when compared with patients who have either left hemisphere or bilateral speech dominance (Strauss, 1988).

Finally, Davidson and Hugdahl (1996) report that asymmetries in EEG activity predict DL performance. Participants performed the DL task 4 months after the EEG testing. The pattern of data indicated that individuals with a larger REA on a verbal task showed more left-sided activation in the temporal-parietal region. A larger REA was also associated with decreased EEG activation in the left-prefrontal region and increased activation in the right prefrontal area. Davidson and Hugdahl (1996) suggest that auditory lateralization is probably not related to a single mechanism, so they were not surprised that there were low correlations among measures in other perceptual modalities that putatively reflect hemispheric specialization. They also noted that asymmetries along the rostral-caudal plane may be of as much relevance as the right-left dimension. This last study (Davidson & Hugdahl, 1996) is exciting because it is among a few to find a significant relation between a physiological measure and a behavioural measure.

Reliability of Dichotic Listening Tasks

Dichotic listening techniques have included a range of stimuli that require the perception of nonsense syllables, digits, and lists of words (which tend to produce a REA in most individuals), and environmental sounds, music, synthesized sounds and emotional tone recognition (which tend to produce a LEA in most individuals). Response procedures include reporting orally or on paper, either free recall or matching a set of choices, directing attention to one ear or the other, reporting whether or not a word belongs to a particular semantic category, or indicating when a particular target word is heard (Segalowitz, 1986).

Bryden (1988a) maintains that the REA is a very robust effect, no matter what variations have been introduced in methodology. The original procedure involved the presentation of lists of words or digits. Subjects were told to recall as many of the stimuli as possible in any order, and the strategy of attending to and reporting was left to the preference of the subject. Therefore, if the subject reports items from the right ear first, the individual must retain those items from the left ear in memory for a longer period of time. Thus, hemispheric lateralization may not be the only factor affecting the magnitude of the REA. There may be a memory component as well. Bryden (1988a) maintains that with standard DL procedures, speech lateralization is correctly assessed 85% of the time.

Hugdahl (1995) reported that 28 of 32 subjects (87.5%) maintained a REA using a consonant-vowel (CV) task when retested after one year. Other researchers suggest that the DL technique is not that reliable. In their review of eight studies from the seventies and early eighties, Hiscock and Decter (1988) estimate that even over a short test-retest interval in adults, the reliability is no greater than about 0.70. Teng (1981) reported test-

retest correlations that ranged from -.11 to +.60 in an adult study that spanned an interval of one to six months. On the other hand, Bryden (1988a) reports that much higher reliabilities have been found. For example, McKeever, Nolan, Diehl and Seitz (1984) showed a DL task reliability of 0.88, and Speaks, Niccum and Carney (1982) one of 0.90.

Several methodological differences may account for the discrepancies in reported reliabilities. Modern sound equipment provides better control over the quality, loudness, and timing of stimulus presentations. A second change is that, rather than being left free to choose their own strategy for attending to one ear or the other, subjects now are often asked to attend to one particular side or to one particular target sound or emotional tone. These changes have resulted in reduced between-participant variance and better reliability (Bryden, 1988a).

The REA for verbal DL tasks continues to be a consistent and robust finding (Bryden, 1988a). The DL task used in Zatorre's (1989) study is considered more reliable than the original one used by Kimura (1961a) (Strauss, 1988). Zatorre (1989) and others (Wexler & Halwes, 1983) used a verbal DL task made up of consonant-vowel-consonant (CVC) monosyllables that rhyme (e.g., cow-pow). This type of verbal DL task is called a fused rhymed words test (Wexler & Halwes, 1983).The Kimura-type DL task consists of different one-syllable words (e.g., rot-mop). A second methodological change involves having the subject deliberately attend to one ear or the other and report only those items presented to that ear. Bryden, Munhall and Allard (1983) found that this procedural change, called a directed attention procedure, gives the same REA as the free recall method. However, it also results in a reduced between-subject variance, thus improving reliability. A third methodological change involves monitoring a target word (e.g. dog)

which occurs randomly at the left or right ear. In Geffen and Caudrey's (1981) study, for example, subjects were asked to keypress every time they heard the target word. This method is amenable to signal detection analyses.

Sex differences in DL. Bryden (1988a) summarizes studies relating sex to dichotic performance in right-handers. In studies involving 423 men and 437 women using three different dichotic procedures, 81% of men and 74% of women show an REA, a difference that is marginally significant. There are no studies showing a greater proportion of REA's in women than in men. Bryden (1988a) suggests that there are sex differences in DL performance, although they are small and of marginal significance.

Lateralization of Affect in DL Tasks

In addition to showing a left hemisphere superiority for the perception and processing of language-based material, dichotic listening tasks can be used to identify differences in the lateral perception of emotion. As a result of a generalized right hemisphere involvement in the perception of affect, right-handed individuals usually show a LEA for the perception of affective stimuli (Bryden, 1988b). However, there is some argument over whether or not DL tasks can distinguish a superiority for valence of affect between right and left ears.

Two recent studies have addressed the problem by using DL tasks that simultaneously present stimuli that can be used as either verbal or emotional stimuli, depending on the instructions (Bulman-Fleming & Bryden, 1994; Obrzut, Bryden, Lange, & Bulman-Fleming, 1997). The first study employed four different two-syllable words (***bower, tower, dower, and power***) spoken in four different affective tones (***happy, sad, angry, and neutral***). One hundred twenty-eight participants were given a specific token to

identify (e.g., *dower* spoken in an *angry* voice). Any given target combination of word and emotion was presented at the left ear for nine trials and at the right ear for nine trials. Another 126 trials were either trials on which an affirmative response was incorrect (i.e., a nontarget word was spoken in the target affect, both components of the target were present but presented at the non-target ear, only the target word was present, only the target affect was present, or neither target word or target affect was present). Participants correctly identified their target on 66% of the trials, and gave false alarms on 13% of trials in which the target was not present. Participants made significantly more false alarms when the target *affect* was at the left ear than when it was at the right ear, $F(1,124) = 10.78, P < .001$. They made significantly more false alarms when the target *word* was at the right ear than when it was at the left ear, $F(1,124) = 11.24, P < .001$. They also made more false alarms when both components of the target were presented, but at different ears, $F(1,124) = 19.62, P < .001$. More individuals made false positive errors when the affective component was presented to the left ear than to the right ear (45% versus 27%), $z = 2.19, P < .05$. More individuals made false positive errors when the verbal component was presented to the right ear than to the left ear (33% versus 20%), $z = 1.95, P < .05$. Participants made more false alarm errors to *happy* and *sad* targets than to *neutral* or *angry* ones, meaning that *happy* and *sad* were more easily confused with other emotions. The data from this study provide little support for a valence by ear interaction. The left hemisphere was not differentially involved in processing positive affect, nor was the right hemisphere more involved in processing negative affect (Bulman-Fleming & Bryden, 1994).

The second study (Obrzut et al., 1997) involved the same dichotic stimuli with a

sample of 72 right-handed children in Grades One, Three, and Five. The children were instructed to listen for a target word (*bower* or *tower*) or a target emotion (*happy, angry, sad*, or *neutral*) for 72 trials each. The results showed a Task by Ear interaction, $F(1,58) = 49.17, p < .001$. Similar to the adults, when words were the target, subjects were more accurate on the right than on the left. When emotions were the target, subjects were more accurate on the left than on the right ear. Emotional stimuli were easier to process than word stimuli for the children, $F(1, 58) = 4.72, p < .04$. *Sad* was reported more accurately than *happy*, $F(1,52) = 26.92, p < .001$.

Although the studies have demonstrated a left hemisphere advantage for words and a right hemisphere advantage for emotion, they have not typically found a valence by ear interaction effect. However, the technique of using simultaneous emotion and verbal tasks is new, and it may be the case that valence effects can be demonstrated with the new DL method. In this dissertation, a copy of the same DL tape that Bulman-Fleming and Bryden (1994) and Obrzut et al. (1997) used in their studies will be used. Both verbal and emotional DL function will be examined to get a measure of lateral ear advantage for both words and emotions.

Hypotheses about the DL Task

According to the literature, a REA has been found for the perception of verbal material and a LEA has been found for the perception of emotional material (Bryden, 1988a). I predict the same results in Study 2. The finding of a lateral difference in the particular valence of emotions has been more elusive to find with the DL method (Bryden, 1988b; Obrzut et al., 1997). I predict, albeit optimistically, that the data will show a laterality for valence. *Happy* will show a REA and that *sad* and *angry* will show a LEA.

There are no hypotheses for the relation between the DL task and overall activity. However, I am hypothesizing a relation between the DL data and lateralized activity. If there is a REA for *happy*, and dextral activity also is negatively associated with *happy*, then there should be a significant negative relation between the REA and dextral activity. Similarly, if there is a LEA for *sad*, and *angry*, dextral activity also is positively associated with *sad*, then there should be a significant positive relation between the LEA and dextral activity.

Summary of Hypotheses

The hypothesized relations among activity, arousal, and emotion described above are outlined in Table 6. To summarize, overall activity will relate to measures of general arousal. Higher levels of activity will be associated with higher levels of arousal (as reflected by Positive Affect, Negative Intensity and Negative Reactivity on the AIM, the Behavioural Activation scale on the BISBAS, SE and MO on the PTS, and both PA and NA on the PANAS). Lower levels of activity will be associated with lower levels of arousal (SI on the PTS, the BIS scale on the BISBAS, and Serenity scale on the AIM). I do not expect any relation between overall activity and any of the lateral preferences, including the DL measure.

Lateralized activity (the dextrality measures) will relate more specifically to the nature of the affect experienced by the individual. I expect that there will be a right-left movement difference related to affect. Specifically, movement in the contralateral left arm will relate to negative emotional information processed in the right hemisphere. Movement in the right arm will relate to positive affect processed in the left hemisphere. What is less obvious is whether one might expect greater or lesser movement as a result

of the activated contralateral hemispheres. Based on empirical results from previous studies (e.g., McKeen, 1995), I have assumed that the emotionally activated hemisphere inhibits contralateral arm movement. Thus, I am hypothesizing that relatively greater right-sided arm activity (more dextral) will be positively correlated with negative affect, as defined by Negative Intensity or Negative Reactivity on the AIM, Negative Affect on the PANAS, and BIS on the BISBAS. Conversely, I am hypothesizing that relatively less right-sided activity (less dextrality) will be negatively correlated with positive affect, as defined by Positive Affect on the AIM, Positive Affect on the PANAS, and as BAS on the BISBAS. With respect to emotional perception, I am hypothesizing a positive relation between dextral activity and a REA for negative emotional perception (*angry* and *sad* conditions on the DL task). Conversely, I am expecting a negative relation between dextral activity and a REA for positive emotional perception (*happy* on the DL task).

Table 6. *Summary of predicted relations.*

Other Measures	Activity Measures			
	Overall AL		Dextral AL	
	Actometer	CSA	Actometer	CSA
Demographics				
Sex	--	--	--	--
Age	--	--	--	--
PANAS				
PA	pos	pos	neg	neg
NA	pos	pos	pos	pos
PA-NA	--	--	neg	neg
Lateral Preferences				
DL	--	--	--	--
Words	--	--	--	--
Happy	--	--	neg	neg
Sad/Angry	--	--	pos	pos
AIM				
Positive Affect	pos	pos	neg	neg
Negative Intensity	pos	pos	pos	pos
Serenity	neg	neg	neg	neg
Negative Reactivity	pos	pos	pos	pos
PTS				
SE	pos	pos	--	--
SI	neg	neg	--	--
MO	pos	pos	--	--
SE/SI	pos	pos	--	--
BIS/BAS				
BIS	neg	neg	pos	pos
BAS	pos	pos	neg	neg
BAS-BIS	pos	pos	neg	neg

pos = positive correlations predicted. neg = negative correlations predicted.

METHOD STUDY 2

Procedures

The procedures in Study 2 were similar in format to that of Study 1, except that participants did not have their limbs measured nor did they complete an Activity Diary. To assess motor activity, participants wore one actometer and one accelerometer on each wrist, the same as in Study 1. They provided demographic information, participated in a dichotic listening (DL) task, and completed various questionnaires in the laboratory. To assess temperamental arousal and emotional traits, students completed the PTS (Newberry et al., 1997a), the BISBAS (Carver & White, 1994), and the AIM (Larsen & Diener, 1987). To assess emotional state or mood, participants completed the PANAS (Watson et al., 1988). To assess lateral preferences, participants completed the LPI (Coren, 1993). To assess verbal and emotional perception, participants carried out a dichotic listening task (Bulman-Fleming & Bryden, 1994).

The participants attended an initial appointment during which they completed most of the questionnaires. During a second appointment, the activity monitors were strapped to each wrist to measure the participants' motor activity for the next 24-hour period. At that time, participants also were given instructions on the care of the instruments, had their weight and height taken, and were asked for demographic information. Participants were also given instructions on completing three mood (PANAS) inventories while they were wearing the instruments. Twenty-four hours later, participants returned for a third appointment, at which time they returned the activity monitors, and completed one final PANAS mood inventory and the LPI.

Sample size determination. I estimated that the effect sizes of the correlations I would be testing were moderate in size (r = .30). Based on the results of Study 1 and the literature in the area, I did not expect significant sex differences in activity level, self-report temperament, mood scales, the lateral preference inventory, nor in the dichotic listening task. Using statistical power analyses (Cohen, 1969), given a correlation of .30, an alpha of .05, and two-tailed testing procedures, a sample size of 80 was needed in order to have an 80% or higher chance of identifying the hypothesized correlations.

Participants. The participants for Study 2 were recruited from the Introductory Psychology classes of the 1998 University of Manitoba Spring and Summer sessions. A total of 85 undergraduate university students participated in Study 2, 45 females and 40 males. For their participation, they received credits towards their Introductory Psychology course grade mark. One male completed only part of the requirements for the study, and was dropped from further analysis, resulting in a final sample of 84, 45 females and 39 males.

RESULTS STUDY 2

The mean age of the participants was 22 years (SD = 5.8), although the age range was from 16 to 49 years. Table 7 shows the basic descriptive characteristics of the sample.

Table 7. *Demographic and Descriptive Information.*

	Mean	*SD*	*SE*	Min	Max
		Whole Sample (n = 84)			
Age (Years)	22.33	5.80	0.63	16.89	49.60
Height (cm)	170.31	10.35	1.13	148.10	190.60
Weight (Kg)	71.69	15.15	1.65	48.20	113.45
Ponderal Index	1.46	0.30	0.03	1.01	2.74
Sleep (Hrs)	7.58	1.34	0.15	4.00	11.00
		Males (n = 39)			
Age (Years)	21.01	4.32	0.69	17.87	39.12
Height (cm)	178.36	6.60	1.06	166.00	190.60
Weight (Kg)	77.67	12.48	2.00	56.55	105.60
Ponderal Index	1.37	0.18	0.03	1.08	1.80
Sleep (Hrs)	7.78	1.31	0.21	5.00	11.00
		Females (n = 45)			
Age (Years)	23.47	6.67	0.99	16.89	49.60
Height (cm)	163.34	7.56	1.13	148.10	181.40
Weight (Kg)	66.51	15.47	2.31	48.20	113.45
Ponderal Index	1.53	0.37	0.05	1.01	2.74
Sleep (Hrs)	7.40	1.35	0.20	4.00	10.00

Note. Min = Minimum; Max = Maximum; Ponderal Index = 100000 * Weight/ Height^3; Sleep = Self-reported hours of sleep.

Actometers: Overall

Preliminary assessment. Two females produced very high right-arm movement scores, 3.8 and 3.1 *SD* above the mean. They both indicated verbally that they were very

active. One had been bicycling for 1.5 hours and the other had been at work in a daycare centre. Therefore, their measured activity corresponded with their highly active lifestyle. After the overall mean movement of both limbs was calculated, only the daycare worker's movement score remained above 3 *SD* (3.4). Given the context of her daily activity, I did not alter her data.

Actometer measure. As in Study 1, I calculated a movements per hour rate measure for each limb. This rate measure includes the time the individuals spent sleeping, as well as the time they spent carrying on their everyday activities. The correlation between the left and right arms was significant, $r = .66, p < .0001$. Therefore, I used the mean from the two limbs as the overall activity variable. This mean rate measure is the first of the two key outcome variables for the actometer measure.

Descriptive statistics. Participants produced an average of 810 movements per hour. However, individual differences in movement levels were evident. Table 8 shows the descriptive statistics for the actometer data. Ample variability in mean actometer activity scores is apparent. The intercorrelation matrix for the actometer measures shows that these individual differences are consistent across limbs (see Table 9).

Table 8. *AL Measure Descriptive Statistics, Whole Sample and by Sex.*

	Actometers				Accelerometers			
Descriptives	All	L	R	Dex	All	L	R	Dex
				Whole Sample (n = 84)				
Mn	810	891	729	44.1	999	971	1042	51.3
SD	344	363	392	9.9	317	341	382	3.3
SE	38	40	43	1.1	35	37	42	0.4
Minimum	263	297	143	14.8	471	444	446	40.3
Maximum	1989	2018	2201	67.2	2003	2358	2346	59.1
				Males (n = 39)				
Mn	744	893	595	39.5	886	853	918	50.7
SD	278	346	274	9.7	256	248	293	4.0
SE	45	55	44	1.6	41	40	47	0.6
Minimum	263	350	143	14.8	471	444	446	40.3
Maximum	1483	1864	1420	58.8	1591	1538	1644	56.8
				Females (n = 45)				
Mn	868	890	846	48.1	1097	1073	1149	51.8
SD	386	381	442	8.3	335	379	419	2.5
SE	58	57	66	1.2	50	56	63	0.4
Minimum	394	297	281	29.3	546	552	541	46.4
Maximum	1989	2018	2201	67.2	2003	2358	2346	59.1

Note. Actometer measure is in movements per hr; Acceleration measure is in CSA acceleration units per min. N = 84 = All; Dex = Dextrality ratio, 100xR/R+L, the asymmetry measure; L = Left-arm measure; R = Right-arm measure.

Table 9. *Intercorrelation Matrix for the Actometers.*

Activity Measures	Mn	RA	LA	Dex
		Whole Sample (n = 84)		
Mean AL (Mn)	---			
Right Arm (RA)	.92*****	---		
Left Arm (LA)	.90*****	.66*****	---	
Dextrality (Dex)	.22**	.56*****	-.18*	---
		Males (n = 39)		
Mean AL (Mn)	---			
Right Arm (RA)	.86*****	---		
Left Arm (LA)	.92*****	.60*****	---	
Dextrality (Dex)	.14	.59*****	-.24	---
		Females (n = 45)		
Mean AL (Mn)	---			
Right Arm (RA)	.94*****	---		
Left Arm (LA)	.92*****	.76*****	---	
Dextrality (Dex)	.18	.46***	-.18	---

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

Mean actometer and demographics correlations. Overall activity was significantly correlated with participants' reports of having participated in a sports activity, $r = .43$, $p < .0001$. However, activity was not significantly correlated with age, $r = .02, p < .85$, weight, $r = -.18, p < .10$, or height, $r = -.14, p < .22$, nor number of hours of sleep, $r = -.11$, $p < .31$. For this sample, females showed a non-significant trend of being more active than males, $t(82) = -1.67, p < .10$.

Accelerometers (CSA): Overall

Preliminary data management. The mean acceleration for each individual's right and left arms was calculated for every minute the participants wore the instruments. This resulted in a data set containing 115,432 observations based on the 1-min recordings of 84 individuals. Using the Summary Procedure in SAS, this sample size was reduced from 115,432 to 84 observations, one for each participant, by calculating a mean acceleration score based on each 1-min sample for each arm.

Preliminary assessment. In assessing the CSA data for Study 2, I found four instances of aberrant or missing data, two instances of faulty right-arm data, and two instances of faulty left-arm data. In each of the four cases, I used mean proportional substitutions to estimate the aberrant limb data. For the two participants with aberrant left-arm CSA data, I estimated a mean left-arm value that was 0.9394 (the mean proportional difference) of their right-arm data. For the two with aberrant right-arm data, I estimated a right-arm CSA value of 1.0645 times their left-arm values. For all four individuals, the overall mean CSA values were calculated as the mean of the estimated limb score on one arm and the actual limb score on the other arm. The same two individuals who had exhibited the highest activity scores on the actometer data were outliers on the CSA data. In these cases, I moved their mean CSA values in toward the mean by 1 *SD*, so that they still maintained their ranking within the data set, but were not as extreme. This procedure moved one individual from a mean CSA value of 2196 g/counts to 1843 g/counts and the other from 2352 g/counts to 2003 g/counts.

Accelerometer measure. The correlation between the left- and right-arm CSA measures was significant for the whole sample, $r = .83$, $p < .0001$. Therefore, a mean

overall limb score was calculated, based on the mean of participants' mean right- and left-arm acceleration scores. Thus, the overall CSA value is based on a mean of mean accelerations per min. This rate measure includes the time the individuals spent sleeping, as well as the time they spent carrying on their every-day activities. This overall mean CSA value is used as one of the two key CSA outcome variables.

Descriptive statistics. Table 8 shows the descriptive statistics for the CSA measure. Unexpectedly, the mean acceleration rate for females is significantly higher than for males, $t(82) = -3.25, p < .01$. Because the distributions of the data by gender for mean acceleration were quite normal, a mean difference provides a fair comparison of the data. Using an arcsine transformation for proportional data (Cohen, 1969), the proportional mean difference *ES* estimate (*h*) between the males and females was calculated to be $h = 0.16$ (Cohen, 1969, p. 176-179). Cohen (1969) describes this estimate as a small difference between proportions or a small *ES*. As with the actometer measure, there was considerable variability in acceleration among individuals in the whole sample and within gender (see Table 8). Table 10 shows the intercorrelations among the CSA variables.

Mean acceleration and demographics correlations. Overall acceleration was not significantly correlated with age, $r = .17, p < .13$, but was correlated with sports participation, $r = .42, p < .0001$, and the number of hours of sleep reported, $r = -.22$, $p < .05$. Weight was not correlated with overall acceleration, $r = -.16, p < .14$, but height was, $r = -.34, p < .01$. However, when the influence of gender was partialled from the correlation between acceleration and height, the correlation became non-significant, $r = -.17, p < .13$.

Table 10. *Intercorrelation Matrix for the CSA Accelerometers.*

CSA Measures	Mean CSA	Right Arm	Left Arm	Dexrality
		Whole Sample (n = 84)		
Mean CSA	---			
Right Arm	.96*****	---		
Left Arm	.93*****	.83*****	---	
Dextrality	.09	.26**	-.14	---
		Males (n = 38 - 39)		
Mean CSA	---			
Right Arm	.96*****	---		
Left Arm	.94*****	.79*****	---	
Dextrality	.02	.26	-.26	---
		Females (n = 42 - 45)		
Mean CSA	---			
Right Arm	.96*****	---		
Left Arm	.92*****	.82*****	---	
Dextrality	.02	.22	-.22	---

Note. Dextrality = Dextral CSA Index, 100*Right/Right + Left.
*p < .10, **p < .05, ***p < .01, ****p < .001, *****p < .0001.

Actometers: Dextral Index

The dextral actometer measure. As in Study 1, I calculated a lateral index of dextrality based on the difference between the activity the right and left arms, 100*Right-Arm Activity/(Right-Arm Activity + Left-Arm Activity). A value less than 50 indicates greater left-arm activity, a value greater than 50 indicates greater right-arm activity, and a value of 50 indicates symmetry of movement. In general, positive correlations involving

this lateral index refer to greater right-arm activity, and negative correlations to greater left-arm activity.

Descriptive statistics. A repeated measures ANOVA (with right- or left- arm movement as the repeated factor and sex as the between-participant factor) showed a significant lateral effect, $F(1,82) = 29.4, p < .0001$. Left-arm movement frequency was greater than right-arm movement frequency. The lateral (left-right) by sex interaction was also significant. Males were significantly more left-sided in the frequency of their arm activity than females, $F(1,82) = 16.2, p < .0001$. Table 8 shows the descriptive statistics for the dextral actometer variable. Table 9 shows the intercorrelations among the actometer variables. The correlation between the dextral actometer variable and the overall mean actometer variable was significant, $r = .22, p < .05$, indicating that those with more overall movement also showed more right-arm activity. However, the correlations of dextral actometer-measured activity with the overall mean activity were not significant when males, $r = .14, p < .38$, and females, $r = .18, p < .25$, were considered separately.

Dextral actometer index and demographics correlations. Dextral activity was significantly correlated with weight, $r = -.30, p < .01$, and height, $r = -.38, p < .001$. In other words, heavier people and taller people move their left arms relatively more than their right arms. Given that males showed significantly greater relative left-arm movement, and males tend to be taller and heavier than females, gender differences likely provide a simpler account of the relations between dextrality, height, and weight. When gender was statistically partialled from weight and height, correlations with the dextrality index were indeed non-significant for weight, $r = -.09, p < .41$, and for height, $r = -.18, p < .12$. Older

participants, $r = .18, p < .10$, and those with less sleep, $r = -.20, p < .07$, showed a trend towards exhibiting relatively greater right-arm movement. The dextral actometer index was not significantly correlated with self-reported participation in a sports activity, $r = -.10, p < .34$. None of these demographic variables were significant when examined by gender.

Accelerometers (CSA): Dextral Index

The dextral accelerometer index. The dextral index created with the CSA data is the same as that created with the actometer data, 100*Mean Right-Arm Acceleration per min/(Mean Right-Arm Acceleration per min+ Mean Left-Arm Acceleration per min). As with the actometer dextrality index, a value less than 50 indicates greater left-arm acceleration, a value greater than 50 indicates greater right-arm acceleration, and a value of 50 indicates symmetry of acceleration. In general, positive correlations involving this lateral index usually referred to greater right-arm acceleration, negative correlations to greater left-arm acceleration.

Descriptive statistics. Unlike the actometer index, acceleration was greater on the right arm with an overall mean dextrality index of 51.29. The repeated measures ANOVA (arm by gender) showed a significant lateral effect, $F(1,78) = 8.3, p < .01$. The lateral (left-right) by gender interaction was not significant, $F(1,78) = 0.07, p < .80$, so both males and females showed a similar right bias in arm acceleration. Table 8 shows the descriptive statistics for the CSA dextrality index. Table 10 shows the intercorrelations among the CSA measures. The overall mean CSA measure was uncorrelated with the CSA dextral index, $r = .10, p < .38$.

Dextral accelerometer index and demographics correlations. Age and number of hours of sleep correlated with dextral acceleration scores, but these relations varied by gender. The dextral CSA index did show a trend significance level with age, $r = .18$, $p < .10$. This trend was mainly due to the correlation between dextral CSA scores and age for males, $r = .33, p < .05$. Older males demonstrated relatively more right-sided CSA activity. Females did not show a significant relation between CSA asymmetry and age, $r = .02, p < .86$. Dextral CSA activity also was correlated with the number of hours of sleep, $r = -.31, p < .01$ for the whole sample. However, the relation with duration of sleep was due mainly to the females, $r = -.40, p < .01$, rather than to males, $r = -.22, p < .17$. For females, greater right-sided CSA activity was related to having fewer hours of sleep. Dextral CSA activity was not significantly correlated with self-reported participation in a sports activity, $r = -.10, p < .40$, weight, $r = -.04, p < .76$, or height, $r = -.12, p < .31$.

Relation between Actometers and Accelerometers

Actometers and accelerometers each measure different aspects of activity. Actometers measure frequency of movement and accelerometers measure acceleration. One of the benefits of having the participants wear both types of activity measuring instruments (actometers and CSA accelerometers) was to be able to examine the relationship between the two types of instruments. I expected that the two measures would be significantly correlated, both for the mean levels of movement and for the right-left-indices. Table 11 shows the correlations between the actometer variables and the CSA variables.

Overall activity-measure intercorrelations. The correlation between the mean CSA and mean actometer variables was statistically significant, $r = .70, p < .0001$, indicating

that although the two instruments are measuring different aspects of movement, mean frequency of movement was related to mean acceleration of movement. The correlations were similar for both males and females (see Table 11).

Table 11. *Actometer and Accelerometer Activity Measure Correlations.*

	Accelerometers			
	Mean CSA	Right Arm	Left Arm	Dextrality
Actometers	Whole Sample (n = 80-84)			
Mean AL	**.70*******	.66*****	.71*****	.08
Right Arm	.66*****	**.64*******	.64*****	.14
Left Arm	.62*****	.57*****	**.66*******	.00
Dextrality	.24**	.28***	.14	**.28****
	Males (n = 38-39)			
Mean AL	**.73*******	.72*****	.66*****	.14
Right Arm	.71*****	**.74*******	.60*****	.20
Left Arm	.61*****	.57*****	**.59*******	.04
Dextrality	.18	.26*	.06	**.28***
	Females (n = 42-45)			
Mean AL	**.68*******	.62*****	.72*****	-.02
Right Arm	.58*****	**.55*******	.60	.02
Left Arm	.69*****	.62*****	**.76*******	-.05
Dextrality	.06	.12	-.02	**.16**

Note. Bolded items are correlations between counterpart measures.
*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

Dextral activity-measure intercorrelations. A somewhat different picture emerged for the dextrality measures. Table 11 shows that for the whole sample, the actometer/CSA

dextral indices were significantly correlated, $r = .28, p < .05$. The correlations between the two instruments were significantly lower between the dextral indices than between the mean values, $r = .28$ vs $r = .70, z = 3.70, p < .0001$. This rather low correlation between the actometer and accelerometer lateral indices was not expected.

Instrument differences in dextrality. The mean values (see Table 8) show that frequency of movement (actometer measure) was higher on the left arm than the right, while acceleration was lower on the left arm than the right arm. Thus, a left-arm bias was present for the actometer measure, while a right-arm bias was present for the accelerometer measure. Handedness, as reported on the LPI, was not significantly related to the actometer dextrality measure, $r = -.06, p < .55$, but was related at the trend level to the accelerometer measure of dextrality, $r = .19, p < .09$.

Instrument differences in categorical asymmetry. As in Study 1, a categorical left bias in frequency of movement was present in Study 2. Seventy-five per cent of the participants showed a significant sinistral asymmetry, $\chi^2(1, n=80) = 22.1, p < .001$. In contrast, 70 per cent of participants showed a significant dextral asymmetry in acceleration, $\chi^2(1, n=80) = 12.8, p < .001$. There was no significant interaction between the two asymmetry classifications, $\chi^2(1, n=80) = 0.95, p < .34$. In other words, a categorical bias in movement frequency was unrelated to a categorical bias in acceleration.

Actometer categorical asymmetry by gender. As with the continuous dextral index, when actometer-measured activity was categorized into those with either greater right- or greater left- activity, significant gender differences emerged. Males were more strongly left lateralized than females. For the whole sample, 89 per cent of males and 63 per cent of

females showed greater left-arm movement. For the 80 right-handers (37 males, 43 females), a two (male, female) by two (greater left movement, greater right movement) chi square test was significant, $\chi^2(1, n=80) = 7.39$, $p < .01$. Only five per cent of right-handed males showed greater right-arm movement, while 20 per cent of right-handed females showed greater right-arm movement, as measured by actometers.

Accelerometer asymmetry by gender. Table 8 shows that the continuous accelerometer dextrality index did not differ for males, $M = 50.7$ and females, $M = 51.8$, $t(82) = -1.41$, $p < .16$. When participants were classified into dichotomous categories according to whether they showed a greater left- or greater right- acceleration bias, males and females showed no differences in their lateral classification. Males (68 per cent) and females (70 per cent) showed similar percentages of relatively greater right-armed CSA movement. A two by two chi square test (gender by arm of greater movement) was not found to be statistically significant, $\chi^2(1, n=80) = 0.05$, $p < .84$.

As described earlier, several different questionnaires were used to assess the psychological concepts of arousal and emotional experience. These included the PTS, the BISBAS, the AIM, and the PANAS. I will describe the results of each of these scales in turn, and report on the relation of the scales to motor activity.

The AIM

The AIM measures. The AIM is a 40-item questionnaire designed to assess the typical intensity with which individuals experience their emotions. It will be recalled that participants rate their emotionality on a 6-point scale, with answer choice ranging from *never* to *always*. I used the same AIM four-factor subscales as I did in Study 1, derived

and interpreted by Weinfurt et al. (1994). These include *Positive Affect, Negative Intensity, Serenity, and Negative Reactivity*. I also included a Total AIM score as part of the descriptive statistics for the questionnaire. Positive Affect consists of 17 items, Negative Intensity consists of 10 items, Serenity consists of 7 items, and Negative Reactivity consists of 6 items.

Initial data assessment. The four AIM subscales and Total AIM scores were normally distributed. There were no outliers apparent for any of the scales. In the bivariate relations with the movement variables, no outliers appeared. However, four individuals (three females and one male) were missing instrumented activity data on one of their limbs. Although I used a weighted mean in estimating their limb asymmetry, I did not want to include their lateral data in the correlations with the other psychological measures. Therefore, for the tables describing the relations between dextral movement and the AIM subscales, I used a reduced sample, $N = 80$.

AIM Descriptive statistics. The AIM's basic descriptive statistics appear reasonable (see Table 12). Cronbach's (1951) coefficient for each of the subscales ranged from 0.73 for Negative Intensity to 0.93 for Positive Affect, indicating acceptable reliability. The items with the highest correlation with the total for Positive Affect were, ***When I'm happy I feel like bursting with joy***, $r = .80$, ***My happy moods are so strong that I feel like I'm "in heaven,"*** $r = .78$, and ***When something good happens, I am usually much more jubilant than others***, $r = .75$. The items with the highest correlation with the total for Negative Intensity were, ***My friends would probably say I'm a tense or "high strung" person***, $r = .52$, ***My emotions tend to be more intense than those of most people***, $r = .51$,

and '*Calm and cool' could easily describe me* (reflected), $r = .50$. The items with the highest correlation with the total for Serenity were, *I would characterize my happy moods as closer to contentment than to joy*, $r = .70$, *When I am happy the feeling is more like contentment and inner calm than one of exhilaration and excitement*, $r = .69$, and *When I feel happiness, it is a quiet type of contentment*, $r = .60$. The items with the highest correlation with the total for Negative Reactivity were, *When I feel guilty, this emotion is quite strong*, $r = .66$, *When I do something wrong I have strong feelings of shame and guilt*, $r = .60$, and *Sad movies deeply touch me*, $r = .59$. Unexpected gender differences were present in two of the AIM subscales (see Table 12). Negative Reactivity showed a significant sex difference, $t(82) = -3.63, p < .001$, and Positive Affect showed a trend sex difference, $t(82) = -1.95, p < .06$. In both cases, the females reported higher scores than the males, with females reporting higher Positive Affect and Negative Reactivity than males. These sex differences were similar to the results of Weinfurt et al. (1994).

Table 12. *AIM Descriptive Statistics for Study 2.*

AIM & AIM Subscales	*M*	*SD*	Min	Max	Reliability
Total Sample					
Positive Affect	4.23	0.78	2.41	5.94	0.93
Negative Intensity	3.50	0.66	1.70	5.00	0.73
Serenity	3.76	0.81	2.29	5.86	0.84
Negative Reactivity	4.08	0.97	1.67	6.00	0.82
Total AIM Score	3.85	0.54	2.15	5.10	0.90
Males					
Positive Affect	4.05	0.68	2.47	5.29	0.90
Negative Intensity	3.38	0.68	1.70	5.00	0.78
Serenity	3.65	0.85	2.29	5.71	0.86
Negative Reactivity	3.69	0.96	1.67	5.67	0.80
Total AIM Score	3.71	0.50	2.15	4.65	0.88
Females					
Positive Affect	4.38	0.83	2.41	5.94	0.94
Negative Intensity	3.62	0.64	2.20	4.90	0.68
Serenity	3.85	0.77	2.29	5.86	0.80
Negative Reactivity	4.41	0.85	1.67	6.00	0.78
Total AIM Score	4.01	0.55	2.45	5.10	0.90

Note. Maximum score possible is 6 on each subscale. Min= Minimum. Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency. The 4 AIM subscales are based on Weinfurt et al.(1994) factors. Total Sample $N = 84$. Males $n = 39$. Females $n = 45$.

AIM Intercorrelations. Table 13 shows the intercorrelation matrix for the AIM subscales for the whole sample. Significantly positive correlations among Positive Affect,

Negative Intensity, and Negative Reactivity indicate that those who were intense in their emotionality were intense, irrespective of the valence of the emotion. Serenity was the only subscale that showed a different relation to the other subscales, as might be expected for a calmness factor. The intercorrelation matrix by sex shows that the patterns of correlations were similar for both males and females (see Table 14).

Table 13. *AIM Intercorrelation Matrix.*

	Positive Affect	Negative Intensity	Serenity
Negative Intensity	.29***		
Serenity	-.21*	-.10	
Negative Reactivity	.44*****	.38****	.14

Note. N=84.

*p < .10, **p < .05, ***p < .01, ****p < .001, *****p < .0001.

Table 14. *AIM Intercorrelation Matrix by Sex.*

	Positive Affect	Negative Intensity	Serenity	Negative Reactivity
Pos Affect	----	.24	-.20	.48****
Neg Intensity	.30*	----	-.23	.30**
Serenity	-.30*	-.02	----	-.02
Neg Reactivity	.29*	.40**	.22	----

Note. Males (n = 39) are below the diagonal; Females (n = 45) above.

*p < .10, **p < .05, ***p < .01, ****p < .001, *****p < .0001.

AIM and demographics correlations. Several significant correlations among the AIM subscales and demographic variables emerged, most of which were gender specific. Positive Affect was positively related to the number of hours of sleep for males at the

trend level, $r = .32, p < .06$, but showed a non-significant negative relation to sleep for females, $r = -.24, p < .13$. Ponderal Index, a measure of weight relative to height, was negatively related to Positive Affect for males at the trend level, $r = -.28, p < .10$, but showed a non-significant positive relation for females, $r = .24, p < .12$. Thus, in this sample, slight males reported less Positive Affect than heavier males. Negative Intensity and Serenity showed no significant demographic correlates, except that Age was correlated with Serenity for females, $r = .30, p < .05$. Thus, older females reported more calmness than younger females, but there were no significant relations between age and calmness for males, $r = -.05, p < .76$. Negative Reactivity was negatively related to height for females, $r = -.34, p < .03$, but not for males, $r = -.24, p < .15$. Thus, shorter females reported greater Negative Reactivity. Also, for females, Negative Reactivity was positively related to participation in sports events, $r = .30, p < .05$, but the relation did not hold for males, $r = -.21, p < .21$. Although many of these male - female correlations are of similar magnitude they are in the opposite direction, and statistically they do not differ from each other. The lack of significant difference could be due to a lack of statistical power. Alternately, they could be due to sample specific findings or Type I error that may not replicate. It is surprising that females who participate in sports reported greater Negative Reactivity. These results may suggest that physical activity represents psychologically different meanings for males and females.

Table 15. *Summary of Predicted Relationships with Movement Measures.*

	Overall AL				Dextral AL			
	Actometer		CSA		Actometer		CSA	
Other Measures	**P**	**All**	**P**	**All**	**P**	**All**	**P**	**All**
Demographics								
Sex	--	.18*	--	.33**	--	.44*****	--	.18
Age	--	.02	--	.17	--	.18*	--	.18*
AIM (*n*=80)								
Positive Affect	pos	.18	pos	.13	neg	.12	neg	-.03
Neg Intensity	pos	-.01	pos	.06	pos	.10	pos	-.07
Serenity	neg	**-.19***	neg	.06	neg	.02	neg	.15
Neg Reactivity	pos	.08	pos	**.28****	pos	.16	pos	.08
PTS								
SE	pos	-.13	pos	-.04	--	.02	--	-.08
SI	neg	.02	neg	-.10	--	.08	--	-.12
MO	pos	-.06	pos	-.02	--	-.08	--	-.10
SE/SI	pos	-.08	pos	.08	--	-.04	--	.03
BISBAS (*n*=80)								
BIS	neg	-.18	neg	-.10	pos	.04	pos	-.18
BAS	pos	.12	pos	-.02	neg	.11	neg	-.02
BAS-BIS	pos	**.21***	pos	.06	neg	.04	neg	.07
PANAS								
PA	pos	**.22****	pos	.14	neg	-.06	neg	.20*
NA	pos	-.01	pos	.02	pos	-.04	pos	-.02
PA-NA	--	.14	--	.08	neg	-.04	neg	.14
Dichotic Listening								
Words	--	.14	--	-.01	--	.08	--	-.09
Happy	--	.06	--	.05	neg	.06	neg	-.12
Angry *n*=39-42	--	-.12	--	-.06	pos	-.02	pos	**.36****
Sad *n*=41-42	--	-.12	--	-.18	pos	-.14	pos	-.21

Note. P=Predicted. Bolded entries are significant in predicted direction. AL = Activity Level. $N = 84$, except where indicated otherwise. *$p < .10$, **$p < .05$, ****$p < .001$, *****$p < .0001$.

AIM and mean activity correlations. I predicted that overall movement should be positively correlated with higher levels of arousal, as defined by the AIM Positive Affect, Negative Intensity, and Negative Reactivity subscales. A negative correlation should exist between overall movement and Serenity. Table 15 shows these predictions and the resulting correlations between the movement measures and the AIM for the whole sample. Only two of eight possible correlations (two instruments each with four subscales) were significant in the predicted direction. In support of the arousal-movement prediction, Serenity was negatively correlated with actometer-measured movement at the trend level, $r = -.19, p < .10$, and Negative Reactivity was positively correlated with overall acceleration, $r = .28, p < .05$. The remaining non-significant results may have been due to some gender discrepancies among the relations between movement and the AIM subscales.

AIM and mean activity correlations by sex. Four of the eight predictions involving the AIM subscales and overall movement showed non-significant relations, perhaps due to opposite AIM-Activity Level relations for males and females. Table 16 shows the correlations between the AIM subscales and movement by sex. For females, Positive Affect showed a positive trend relation to overall actometer-measured movement, $r = .26, p < .10$, but not for males, $r = .01, p < .94$. For males, Negative Reactivity showed a positive relation to overall CSA acceleration, $r = .33, p < .04$, but not for females, $r = .00$, $p < .77$. However, when these male-female correlations were compared, neither the Positive Affect gender difference, $z = 0.30, p < .77$, two-tailed, nor the Negative Reactivity comparison, $z = 0.34, p < .73$, two-tailed were significantly different. If these correlational

trends held with a larger sample size, these gender differences would probably be significant. Alternatively, the differences could be due to sample specific influences or Type 1 error. Nonetheless, collapsing across gender would interfere with the identification of within-gender relations.

Study 1 and Study 2 combined. In Study 1 no significant sex differences emerged when movement and AIM subscales were correlated. However, in Study 2, sex differences figure prominently and produced results that appear far from conclusive. Because the participants in Study 1 had completed the same AIM questionnaire and provided the same movement data as in Study 2, I combined the two data sets and correlated the movement measures with the AIM subscales ($N = 105$, males $n = 49$, females $n = 56$). Several changes in the relations occurred as a result. For overall activity, only the actometer measure showed a non-significant trend with Serenity, $r = -.18$, $p < .06$. This result was due mainly to the relation between actometer-measured activity and Serenity in males, $r = -.34, p < .02$, rather than in females, $r = -.08, p < .55$. Overall accelerometer-measured activity did not relate to any of the AIM subscales.

Table 16. *Motor Activity and Other Measures. Correlations by Sex*

Other Measures	Activity Measures							
	Overall AL				Dextral AL			
	Actometers		CSA		Actometers		CSA	
	M	F	M	F	M	F	M	F
Demographics								
PI	-.10	-.14	.01	.07	-.12	-.12	.12	-.08
Age	-.03	-.01	.10	.12	.18	.06	.33**	.02
AIM								
Positive Affect	-.01	.26*	.08	-.05	.00	.06	-.34**	.20
Neg Intensity	.11	-.14	.22	-.20	-.01	.08	-.22	.04
Serenity	-.28*	-.14	-.08	.22	-.08	.06	.18	.08
Neg Reactivity	.08	.01	.33**	.00	-.00	.01	.02	.04
PTS								
SE	-.11	-.16	.26	-.23	.05	-.05	-.16	-.04
SI	.28*	-.07	.12	-.20	.18	.12	.12	-.36**
MO	.18	-.08	.34**	-.16	.00	-.08	-.15	-.15
SE/SI	-.26	-.04	.12	-.00	-.10	-.16	-.17	.20
BISBAS								
BIS	-.04	-.28*	.18	-.34**	.00	.01	-.21	-.12
BAS	.31*	.01	.18	-.14	.26	.02	-.06	-.10
BAS-BIS	.22	.24	-.03	.19	.15	.00	.12	.03
PANAS								
PA	.23	.22	.11	.14	-.09	-.10	.28*	.18
NA	.14	-.12	.19	-.08	-.14	.18	.00	.08
PA-NA	.08	.18	-.03	.10	.03	-.24	.10	.12
Dichotic Listening								
Words	.08	.16	-.12	-.04	.10	.14	-.04	-.19
Happy	-.12	.24	-.12	.16	.04	.00	.16	-.08
Angry	.25	-.05	-.12	.24	.16	-.20	.61**	.10
Sad	-.40	-.00	-.30	-.23	-.38	-.05	-.22	-.18

Note. M=Males, n=37-39. F=Females, n=42-45, except for Sad and Angry DL tasks where Males n=19-20, Females n=22-23. DL tasks (Accuracy), have Task Order and Earphone statistically partialled. *$p < .10$, **$p < .05$, ***$p < .01$.

AIM and dextral activity correlations. Based on the hypothesis that greater dextral movement would reflect more negative affect, I predicted that dextral movement would relate positively to Negative Intensity or Negative Reactivity, but negatively to Positive Affect and possibly Serenity (reflecting more left-side movement). These hypotheses were left largely unconfirmed in Study 2 (Table 15).

AIM and dextral activity correlations by sex. Examination of the dextral movement-AIM relations by sex were not much more informative (see Table 16). The only predicted result was that between Positive Affect and dextral acceleration in males, $r = -.34, p < .05$. In males, greater left-arm acceleration was related to positive emotional experiences. For females, movement asymmetry showed little relation to any of the AIM subscales.

Study 1 and Study 2 combined. For the whole sample, the dextral accelerometer measure was significantly positively related to both Serenity, $r = .20, p < .05$, and to Negative Reactivity, $r = .23, p < .03$. I had expected that dextral movement would relate positively only to the negative AIM subscales. The actometer dextral score was also positively related to Negative Reactivity, $r = .20, p < .05$, confirming the accelerometer result. The accelerometer results for the whole sample were due primarily to the relation with the AIM subscales for males, $r = .28, p < .05$, for both Serenity and for Negative Reactivity, $r = .25, p < .09$. All of the correlations between dextral activity and the AIM subscales were close to zero for females.

The PTS

The PTS measures. The PTS was constructed so that 22 items make up each of three subscales, *Strength of Excitation* (SE), *Strength of Inhibition* (SI), and *Mobility* of Nervous (MO) processes subscales. The dependent measures for this study included these three subscales, as well as a ratio of SE to SI.

Initial data assessment. The univariate distributions for the PTS subscales and the ratio score are all normally distributed. Bivariate plots with the key activity variables were examined for outliers. Two individuals who showed both high activity levels and low to moderate PTS subscale values were possible outliers. However, no Cook's *d* statistic was greater than 0.24, indicating that none of the individuals were troublesome bivariate outliers (Kleinbaum, et al., 1988).

PTS descriptive statistics. Table 17 describes the basic statistics for each of the PTS subscales, SE, SI, MO processes, as well as the Ratio score. Cronbach's alpha coefficient of reliability for each of the three subscales was adequate, ranging from 0.77 to 0.88. The items with the highest correlation with total for the SE subscale included, ***Sudden danger does not discourage me***, $r = .58$, ***My performance suffers in an environment with a lot of distractions*** (negative), $r = .56$, ***I can't work if I'm surrounded by hustle and bustle*** (negative), $r = .55$, and ***I keep cool if I'm under a lot of time pressure***, $r = .52$. High scores on the SE subscale represent individuals who are not easily flustered, distracted, or fatigued, and who can concentrate in spite of noise or conversation going on around them. The items with the highest correlation with the total in the SI subscale included, ***It's hard for me to suppress my annoyance, even when it's***

necessary (negative), $r = .53$, *It's difficult for me to interrupt something I'm doing even if someone asks me to* (negative), $r = .43$, and *It is hard for me to control my curiosity when I have the chance to look at someone else's things or notes* (negative), $r = .41$. High scores on the SI subscale represent individuals who can control their feelings of annoyance, impatience, and curiosity with or about other people. The items with the highest correlation with the total for the MO subscale included, *I don't have any trouble changing quickly from one activity to another*, $r = .68$, *I quickly get used to new working conditions*, $r = .66$, and *when my job changes, I'm quick to adust*, $r = .58$. High scores on the MO subscale represent individuals who quickly adapt to change or unexpected events in their daily lives with little stress, and who do not find it difficult to shake off a bad mood.

PTS Intercorrelations. Theoretically, the subscales are orthogonal, but empirically, they show some dependencies. Table 18 shows the intercorrelation matrix for the PTS subscales. Strength of Inhibition and SE were not significantly correlated, nor were SI and MO. However, SE and MO were correlated. These results are similar to Newberry et al.'s (1997) findings which show a correlation of 0.59 between SE and MO, although they also found a significant but smaller correlation of 0.22 between SE and SI.

Table 17. *PTS Descriptive Statistics.*

PTS Subscales	*M*	*SD*	Min	Max	Reliability
Whole Sample ($n = 84$)					
Excitement (SE)	2.63	0.37	1.68	3.55	0.83
Inhibition (SI)	2.48	0.33	1.45	3.32	0.77
Mobility (MO)	2.24	0.34	1.45	3.23	0.86
Males ($n = 39$)					
Excitement (SE)	2.61	0.31	2.00	3.36	0.72
Inhibition (SI)	2.52	0.30	1.73	3.32	0.74
Mobility (MO)	2.26	0.28	1.64	2.95	0.80
Females ($n = 45$)					
Excitement (SE)	2.65	0.41	1.68	3.55	0.87
Inhibition (SI)	2.44	0.36	1.46	3.18	0.80
Mobility (MO)	2.22	0.38	1.46	3.23	0.89

Note. Maximum score possible is 4. Min= Minimum; Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency for items comprising each subscale.

PTS measures and demographics correlations. Older participants reported lower SI subscale scores than younger participants, both with the outliers removed, $r = -.32$, $p < .01$, and without outliers removed, $r = -.33$, $p < .01$. However, there were no other significant correlations between any of the PTS subscales and height, weight, hours of sleep, or self-reported participation in a sports activity. There were no significant gender relations in any of the PTS subscales in this study, although in other literature, gender differences have been observed (males higher on the SE, Newberry et al., 1997).

Table 18. *PTS Intercorrelation Matrix.*

PTS Subscales	Excitation	Inhibition	Mobility
Whole Sample (n = 84)			
Excitement (SE)	----		
Inhibition (SI)	.10	----	
Mobility (MO)	.60*****	-.03	----
Males (n = 39)			
Excitement (SE)	----		
Inhibition (SI)	.08	----	
Mobility (MO)	.56****	.22	----
Females (n = 45)			
Excitement (SE)	----		
Inhibition (SI)	.12	----	
Mobility (MO)	.64*****	-.18	----

**p < .05, ***p < .01, ****p < .001, *****p < .0001.

PTS and mean activity correlations. Activity was predicted to be positively correlated with both SE and MO, and negatively with SI. These predictions and the resulting correlations between activity and PTS variables are presented in Table 15. No support was found for any of these predictions, using either actometer- or accelerometer-measured activity.

PTS and mean activity correlations by sex. Interesting PTS-Activity relations did emerge when examined by gender. Table 19 shows the correlations between the PTS subscales and the overall activity measures by gender. Mobility in males was correlated with overall acceleration rate, as predicted. However, contrary to the prediction, SI was

positively correlated at the trend level with actometer-measured frequency of movement among males. In females, none of the PTS subscales were significantly related to overall actometer-measured movement or acceleration rates.

PTS and dextral activity correlations. No predictions were made regarding the relation of dextral movement to the PTS scales. Table 19 shows the correlations between the PTS scales and the dextral actometer and accelerometer measures. No significant dextral relations emerged.

PTS and dextral activity correlations by sex. An examination by gender revealed an interesting relation. Inhibition was negatively related to dextral acceleration in females (see Table 19). This trend indicated that greater Inhibition was related to greater left-arm acceleration in females, but not in males.

Table 19. *AL Measures and PTS Correlations, Whole Sample and by Sex.*

	Overall AL		Dextral AL	
PTS subscales	Actometers	CSA	Actometer	CSA
		Whole Sample		
Excitement (SE)	-.13	-.04	.02	-.08
Inhibition (SI)	.02	-.10	.08	-.12
Mobility (MO)	-.06	-.02	-.08	-.10
Mean (66 items)	-.08	-.08	.01	-.14
		Males		
Excitement (SE)	-.11	.26	.04	-.15
Inhibition (SI)	.28*	.16	.18	.12
Mobility (MO)	.18	.34**	.00	-.15
Mean (66 items)	.15	.35**	.11	-.08
		Females		
Excitement (SE)	-.16	-.23	-.04	-.04
Inhibition (SI)	-.07	-.20	.12	-.36**
Mobility (MO)	-.16	-.16	-.10	-.04
Mean (66 items)	-.19	-.28*	-.02	-.20

Note. AL is Activity Level. CSA refers to the Accelerometer measure of AL. $N = 84$; Males, $n = 38$-39. Females, $n = 42$-45.
*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

The BISBAS

The BISBAS measures. The BISBAS is a 20-item questionnaire consisting of two subscales, the *Behavioural Inhibition Scale* (BIS) and the *Behavioural Activation Scale* (BAS). The BAS scale itself has three subscales, *BAS Reward Responsiveness*, *BAS Drive*, and *BAS Fun Seeking*. Individuals high in behavioural inhibition are vulnerable to

states of negative affect and are sensitive to social signals of punishment. Those high in behavioural activation are typically extraverts who show positive affect and are particularly sensitive to social signals of reward. To analyze additional hypotheses, a standardized difference score was created by subtracting the *z*-transformed BIS scale score from the *z*-transformed BAS scale score. Positive BAS-BIS difference scores reflect relatively greater BAS activity.

Initial data assessment. The SAS univariate procedure showed that the BISBAS subscales and Difference scores were normally distributed. There were no univariate outliers or bivariate outliers with activity apparent for any of the scales.

BISBAS descriptive statistics. Table 20 describes the basic statistics for each of the BISBAS subscales. The mean BIS score was 2.95, and the mean BAS score was 3.04 (Range 1 - 4). Cronbach's (1951) alpha coefficient for each of the subscales was adequate for the two key subscales for the BIS (7 items) and for the BAS (13 items), see Table 20. The BAS subscales varied in their reliability, adequate except perhaps for the BAS Reward subscale, $r = .55$. The three BAS subscales consisted of 4 or 5 items each. The items with the highest correlation with the total for the BIS subscale included, ***I feel pretty worried or upset when I think or know somebody is angry at me***, $r = .66$, ***If I think something unpleasant is going to happen, I usually get pretty 'worked up,'*** $r = .50$, and ***Criticism or scolding hurts me quite a bit***, $r = .49$. The items with the highest correlation with the total for the complete BAS subscale included, ***I go out of my way to get things I want***, $r = .60$, ***I crave excitement and new sensations***, $r = .56$, and ***When I want something, I usually go all-out to get it***, $r = .54$. For the BAS Responsivity to Reward

subscale, the best item was, *It would excite me to win a contest*, $r = .42$. For the BAS Drive subscale, the best item was, *When I want something, I usually go all-out to get it*, $r = .74$. For the BAS Fun-seeking subscale, the best item was, *I will often do things for no reason other than they might be fun*, $r = .55$.

Table 20. *BISBAS Scale Descriptive Statistics.*

BISBAS Subscales	*M*	*SD*	**Min**	**Max**	**Reliability**
BIS	2.95	0.49	1.86	4.00	0.77
BAS	3.04	0.39	2.25	4.00	0.80
BAS Reward	3.30	0.35	2.40	4.00	0.55
BAS Drive	2.85	0.61	1.50	4.00	0.83
BAS Fun Seeking	2.99	0.52	2.00	4.00	0.72
Mean BISBAS	3.00	0.32	2.19	3.74	0.77
Difference Score (BAS-BIS)	0.09	0.61	-1.36	1.54	----

Note. $N = 84$. Maximum score possible is 4. Min= Minimum; Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency.

BISBAS intercorrelations. The intercorrelations among the BISBAS subscales (see Table 21) are similar to those of Carver and White (1994) and Sutton and Davidson (1997). The BIS subscale was not significantly correlated to the overall BAS subscale, $r = .05$, $p < .64$, indicating that the concepts are independent. However, the BIS was significantly related to one of the BAS subscales, Responsivity to Reward, $r = .30$, $p < .01$. This means that the individuals in this study were sensitive to both BIS characteristics, such as novelty and punishment, as well as to BAS characteristics, such as signals of reward and nonpunishment.

Table 21. *BISBAS Subscales Intercorrelation Matrix.*

	BIS	BAS	Reward	Drive	Fun	Diff
BIS	----					
BAS	.05	----				
Reward	.30***	.66*****	----			
Drive	-.02	.80*****	.27**	----		
Fun Seeking	-.06	.82*****	.48*****	.44*****	----	
BAS-BIS	-.77*****	.59*****	.17	.52*****	.58*****	----
Mean BISBAS	.80*****	.64*****	.64*****	.47*****	.44*****	-.24**

Note. $N = 84$.

**$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

BISBAS and demographics correlations. There were no significant correlations among any of the BISBAS subscales and height, weight, hours of sleep, nor self-reported participation in a sports activity. Although there were gender differences (BIS and BAS Reward Responsiveness scores higher among females) in the original development of the BISBAS scale (Carver & White, 1994), there were no gender differences among any of the subscales in this study. Age was significantly negatively correlated with overall BAS, $r = -.34, p < .01$, and its subscales, BAS Reward, $r = -.28, p < .05$, BAS Drive, $r = -.23$, $p < .04$, and Fun Seeking, $r = -.30, p < .01$. Although 75 per cent of this sample were between the ages of 18 and 22, and only nine individuals were older than 31 years of age, an age relation still emerged. Younger participants tended to engage in goal-directed efforts and attend to the cues of reward more so than older participants.

BISBAS and mean activity correlations. I had hypothesized that higher BAS scores would represent higher arousal, which would relate positively to movement. Higher BIS scores would represent lower arousal and relate to lower movement levels. Table 15 shows the predictions and the resulting correlations between the BISBAS scales and activity. Across the whole sample, only the BAS Drive and the Difference score showed trend level support in the predicted direction for overall actometer-measured movement only (see Table 22). More specifically, relatively greater BAS than BIS scores (BAS-BIS Difference score), and responsiveness to rewards and achievement behaviours (BAS Drive) predicted more frequent limb movements. None of the BAS subscales showed significant correlations with the CSA-measured acceleration.

BISBAS and mean activity correlations by sex. The relations between the BISBAS subscales and overall movement did show some distinct differences when analyzed by sex. For example, the BIS subscale showed little relationship with overall movement for males for either actometer-measured movement, or for overall acceleration (see Table 22). However, for females, the BIS was significantly negatively related to overall acceleration as predicted and to overall actometer-measured movement at a trend level. These male/female correlations were not statistically different in the case of actometer-measured movement, $z = 1.22, p < .23$, two-tailed, but did show a trend level difference in the correlation between BIS and accelerometer-measured activity, $z = 1.74$, $p < .08$, two-tailed. For males, the BAS Drive scale was significantly related to overall actometer-measured movement, $r = .44, p < .01$, but not for females, $r = .04, p < .79$. However, this gender difference was not statistically significant, $z = 0.30, p < .75$, two-

tailed. The relations between BAS Drive and acclerometer-measured activity showed a similar pattern but did not reach significance for either males or females.

BISBAS scales with age partialled. Because age was unexpectedly significantly related to the BAS subscales, I examined the BAS-activity correlations partialling age for the whole sample and by sex. The pattern of results was similar. With age partialled, the BIS was still significant for females for both overall actometer-measured movement, $r = -.32, p < .05$, and for CSA-measured acceleration, $r = -.37, p < .02$. With age partialled, for males, the BAS Drive subscale (with items pertaining to the persistent pursuit of desired goals) was positively related to overall actometer-measured movement, $r = .38$, $p < .02$. Drive was not related to actometer-measured movement for females, $r = -.01$, $p < .98$. In sum, for females, the BIS (considered a punishment sensitivity scale) was salient to both the overall frequency and acceleration of movement. For males, the BAS seemed more salient to movement than the BIS.

BISBAS and dextral activity correlations. For the overall sample, most of the predicted hypotheses between dextral movement and the BISBAS scales were not supported. Table 22 shows the correlations among the BISBAS scores and the dextral movement measures. There was one significant negative correlation between BAS Fun Seeking and dextral acceleration, indicating that Fun Seeking was associated with more left-sided acceleration, as predicted.

Table 22. *BISBAS and AL Measure Correlations, Whole Sample and by Sex.*

	Overall AL		Dextral AL	
BISBAS subscales	Actometers	CSA	Actometers	CSA
	Whole Sample			
BIS	-.17	-.10	.04	-.14
BAS	.11	-.02	.10	-.08
BAS Reward	-.02	-.08	.00	-.16
BAS Drive	.18*	.00	.14	.12
BAS Fun Seeking	.04	-.02	.06	-.22**
Difference (BAS-BIS)	.21*	.06	.04	.07
Mean BISBAS	-.06	-.10	.10	-.16
	Males			
BIS	-.04	.18	.00	-.21
BAS	.31*	.18	.26	-.06
BAS Reward	-.04	.08	.01	-.18
BAS Drive	.44***	.24	.34**	.26
BAS Fun Seeking	.12	.03	.12	-.31*
Difference (BAS-BIS)	.22	-.03	.15	.12
Mean BISBAS	.16	.26	.16	-.20
	Females			
BIS	-.28*	-.34**	.01	-.12
BAS	.01	-.14	.02	-.10
BAS Reward	-.00	-.18	.00	-.14
BAS Drive	.04	-.14	.02	-.04
BAS Fun Seeking	-.01	-.06	.01	-.08
Difference (BAS-BIS)	.24	.19	.00	.04
Mean BISBAS	-.20	-.34**	.02	-.15

Note. AL = Activity Level. N = 80-84; Males, n = 38-39; Females, n = 42-45.
*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

BISBAS and dextral activity correlations by sex. I examined the BAS-dextral activity correlations by sex, as well as partialling age. This more fine-grained analysis revealed some male-specific correlates. For males, the overall BAS was significantly correlated with actometer-measured movement, $r = .42, p < .01$, as I had predicted. This may have been due to one particular BAS subscale, the BAS Drive, which was positively correlated to both actometer-measured dextral movement, $r = .47, p < .01$, and to dextral acceleration, $r = .38, p < .02$. For females, the correlations between BAS subscales and dextral movement with age partialled remained resolutely close to zero. Because there were no significant sex differences in the univariate distributions for either the BISBAS scales or the CSA dextral measure, I can attribute the sex difference found here to differences in the asymmetric movement of males and females in their response to arousal (or differences in arousal leading to different asymmetric movement responses).

The PANAS

The PANAS is a self-report scale that consists of 20 adjectives describing the individual's mood. Study participants rated themselves on 10 negative mood descriptors and 10 positive mood descriptors using a 5-point scale, ranging from *very slightly or not at all* to *very much*. Each participant completed a total of five assessments over the 24-hours that they were wearing the activity monitors; these included a baseline assessment at the start of the data collection, followed by three more assessments completed around meal times and bedtime during activity-data collection, and a final assessment at the end of the data collection.

The PANAS measures. After discarding the initial PANAS baseline measure, which had no time-linked activity data, the final four assessment times were used to create four PANAS intervals for each individual. For each individual, each of these four intervals was based on the period of time between the previous assessment and the current one. In calculating time intervals, I included a PANAS assessment for any given interval if it was done within a particular five-hour window of time. Thus, a PANAS assessment was included in Interval 1 if it was completed between 06:29 am and 11:29 am (morning). Interval 2 was between 11:29:01 am and 16:29 pm (afternoon), Interval 3 between 16:29:01 pm and 21:29 pm (evening), and Interval 4 was between 21:29:01 pm and 02:31 am (night). The measures created for each individual included a *Negative Affect* (NA) score, a *Positive Affect* (PA) score, and a *Difference* score based on the difference between the standardized means (PA-NA) for each interval. Finally, the means for each interval were combined to create one overall mean PA, NA, and Difference score for each individual for the whole 24-hour period.

Initial data assessment. The mean Positive Affect and Difference scores were approximately normal in their distribution; however, the mean Negative Affect score was not normally distributed. It was quite positively skewed, indicating that most individuals rated negative mood descriptors as ***very slightly or not at all***, $M = 1.39$, $SD = .34$, *Median* = 1.27. I examined the stem and leaf distribution of the NA scores after re-expressing the data using several mathematical transformation methods (e.g., logarithms, square roots, reciprocal square root, square root of the reflected scores, as *per* Tukey, 1977). However, the distribution was not visibly improved, so I decided to keep the raw

NA scores. There were no univariate outliers apparent for any of the PANAS scores, and no outliers appeared in observing the bivariate plots between the overall movement variables and the PANAS scores.

PANAS descriptive statistics by interval. The descriptive statistics for the PANAS for each time interval separately are presented in Table 23. The reliability of these interval scores was very good, with Cronbach's (1951) alphas ranging from 0.77 to 0.92. Interestingly, the mean PA mood scores changed throughout the day. Positive Affect was highest in the afternoon and lowest in the late evening. Afternoon PA ratings were significantly higher than morning and late evening PA ratings, $t(1, 319) = 3.65, p < .05$, using Tukey's HSD test to control for experimentwise error. Early evening PA ratings also were significantly higher than the late evening ratings. Although an intriguing result, subsequent interval analyses were restricted to mood-activity relations, the focus of this study.

Mean PANAS descriptive statistics. Descriptive statistics of the mean PANAS scores collapsing across all intervals are presented in Table 24. Cronbach's (1951) alpha for PA and NA was 0.90 for the whole sample, showing that the correlation with total was very good. For the whole sample, the items with the highest correlation with the total for Positive Affect were ***enthusiastic***, $r = .78$, ***attentive***, $r = .76$, and ***determined***, $r = .74$. The items with the highest correlation with the total for Negative Affect were ***scared***, $r = .84$, ***afraid***, $r = .74$, and ***nervous***, $r = .72$.

Table 23. *PANAS Descriptive Statistics by Time of Day.*

PANAS Subscales	*M*	*SD*	Min	Max	Reliability
Whole Sample					
Interval 1 (Morning: 6:30 am - 11:30 am) (*n* = 82)					
Positive Affect (PA)	2.32	0.77	1.00	3.80	0.88
Negative Affect (NA)	1.36	0.44	1.00	3.00	0.82
Difference (PA-NA)	0.96	0.83	-1.10	2.60	----
Interval 2 (Afternoon: 11:30 am to 4:30 pm) (*n* = 74)					
Positive Affect (PA)	2.70	0.78	1.00	4.80	0.88
Negative Affect (NA)	1.44	0.58	1.00	4.10	0.87
Difference (PA-NA)	1.26	1.00	-1.50	3.80	----
Interval 3 (Early Evening: 4:30 pm - 9:30 pm) (n = 82)					
Positive Affect (PA)	2.57	0.82	1.00	4.90	0.90
Negative Affect (NA)	1.46	0.60	1.00	4.10	0.88
Difference (PA-NA)	1.10	1.04	-1.90	3.50	----
Interval 4 (Late Evening: 9:30 pm - 2:30 am) (*n* = 80)					
Positive Affect (PA)	2.07	0.88	1.00	4.60	0.92
Negative Affect (NA)	1.32	0.38	1.00	2.90	0.77
Difference (PA-NA)	0.76	0.92	-0.80	3.00	----

Note. Maximum score possible is 5. Min= Minimum; Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency.

Table 24. *PANAS Descriptive Statistics.*

PANAS Subscales	*M*	*SD*	Min	Max	Reliability
Whole Sample (n = 84)					
Positive Affect (PA)	2.53	0.56	1.02	4.30	0.90
Negative Affect (NA)	1.39	0.34	1.00	2.58	0.90
Difference (PA-NA)	1.14	0.63	-0.64	2.89	----
Males (n = 39)					
Positive Affect (PA)	2.51	0.47	1.64	3.54	0.88
Negative Affect (NA)	1.47	0.39	1.02	2.58	0.91
Difference (PA-NA)	1.04	0.60	-0.36	2.48	----
Females (n = 45)					
Positive Affect (PA)	2.55	0.63	1.02	4.30	0.92
Negative Affect (NA)	1.32	0.28	1.00	2.24	0.86
Difference (PA-NA)	1.23	0.65	-0.64	2.89	----

Note. Maximum score possible is 5. Min= Minimum; Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency.

PANAS intercorrelations. Because the PANAS NA distribution was very positively skewed, I used Spearman rank order correlations for all of the PANAS analysis. Table 25 shows the intercorrelations among the three mean PANAS subscales. In theory, PA and NA subscales are orthogonal, and this was the case in Study 2.

PANAS and demographics correlations. There were no significant correlations among any of the mean PANAS subscales and gender, height, weight, hours of sleep, nor self-reported participation in a sports activity. For males, however, age was associated

with the PANAS Difference score, $r = .36, p < .03$, indicating that older males reported greater discrepancies between their PA and NA scores than did the younger males.

Table 25. *PANAS Intercorrelation Matrix.*

PANAS Subscales	Positive Affect	Negative Affect
	Whole Sample (n = 84)	
Positive Affect (Pos)	----	
Negative Affect (Neg)	.10	
Difference (Pos-Neg)	.84*****	-.38****
	Males (n = 39)	
Positive Affect (Pos)	----	
Negative Affect (Neg)	.00	
Difference (Pos-Neg)	.74*****	-.60*****
	Females (n = 45)	
Positive Affect (Pos)	----	
Negative Affect (Neg)	.20	
Difference (Pos-Neg)	.90*****	-.16

**$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

Table 26. *PANAS and CSA Activity Pearson Correlations by Time of Day, Whole Sample and by Sex.*

PANAS Subscales	**Males**		**Females**		**Whole Sample**	
	AL	Dex	AL	Dex	AL	Dex
Interval 1 (Morning) (*n* = 38-39 males, 40-43 females, 78-82 whole sample)						
Positive Affect	.20	.31*	-.00	.03	.10	.16
Negative Affect	.09	-.18	-.36**	.21	-.18	.02
Difference	.12	.33**	.10	.00	.12	.16
Interval 2 (Afternoon) (*n* = 37 males, 34-37 females, 70-74 whole sample)						
Positive Affect	-.00	-.18	.28*	.11	.16	.03
Negative Affect	-.12	.02	.06	.16	-.06	.08
Difference	.06	-.15	.28*	.00	.20*	-.00
Interval 3 (Early Evening) (*n* = 36-37 males, 42-45 females, 78-82 whole)						
Positive Affect	.23	.25	.02	-.08	.14	.08
Negative Affect	.24	-.03	.10	.10	.11	-.00
Difference	.02	.16	-.04	-.18	.05	.02
Interval 4 (Late Evening) (*n* = 37-38 males, 40-42 females, 77-80 whole)						
Positive Affect	-.04	.37**	.20	.02	.08	.20*
Negative Affect	.40**	.06	-.16	-.10	.13	.00
Difference	-.28*	.28*	.26*	.00	.00	.16

Note. AL=CSA acceleration activity. Dex= CSA Dextrality Index

*$p < .10$, **$p < .05$, ***$p < .01$.

PANAS intervals and mean activity correlations. I predicted that overall movement should be positively correlated with both positive and negative affect, as defined by the PA and NA subscales. I first examined the activity-measure correlations

with the PANAS subscales by interval as well as by gender. Table 26 shows these correlations for the whole sample and by sex for each interval. When correlations were examined separately by gender, NA in females was negatively related to overall movement, but during the morning hours only. Among males, NA was significantly positively correlated with overall CSA activity in the late evening. However, statistically significant male-female differences in the PANAS-AL correlation patterns by interval were minimal. Only the correlations in Interval 1 between overall CSA activity and NA for males and females differed at the trend level, $z = 1.73, p < .09$, two-tailed.

Mean PANAS and mean activity correlations. Table 27 shows the mean PANAS subscales collapsed across intervals. This table shows that overall actometer-measured movement was significantly correlated with PA but not with NA. However, overall CSA acceleration was not significantly correlated with either PA, nor NA. Thus, when time of day was ignored, the data indicated that only positive mood related to overall frequency of movement, but not negative mood.

Although this finding of a significant relation between actometer-measured activity and Positive Affect was intriguing, it was only one significant result in an expected pattern of significant results. Therefore, it is quite likely the result of Type I error.

Table 27. *PANAS and AL Measure Correlations, Whole Sample and by Sex.*

	Overall AL		Dextral AL	
PANAS subscales	Actometers	CSA	Actometers	CSA
		Whole Sample		
Positive Affect	.22**	.14	-.06	.20*
Negative Affect	-.00	.02	-.04	-.02
Difference (Pos-Neg)	.14	.08	-.04	.14
		Males		
Positive Affect	.23	.11	-.09	.28*
Negative Affect	.14	.20	-.14	.00
Difference (Pos-Neg)	.08	-.04	.03	.10
		Females		
Positive Affect	.22	.14	-.10	.18
Negative Affect	-.12	-.08	.18	.08
Difference (Pos-Neg)	.18	.10	-.24	.12

Note. Correlations are Spearman coefficients. $N = 80\text{-}84$. Male $n = 38\text{-}39$. Female $n = 42\text{-}45$. *$p < .10$, **$p < .05$, ***$p < .01$,****$p < .001$, *****$p < .0001$.

PANAS intervals and dextral activity correlations. The prediction was that PA would correlate with greater left-arm acceleration (i.e., would show a negative correlation with dextral activity), and that NA would correlate with greater right-arm acceleration (i.e., would show a positive correlation with dextral activity). These predictions were not supported by the data. Table 26 shows the correlations of the PANAS subscales with the dextral CSA activity measures by interval for males and females and for the overall sample. Females, in particular, showed no evidence of any pattern. Males showed a pattern opposite to that predicted. In three of the four intervals, males showed positive

correlations between PA and dextral CSA activity, at a trend level for Interval 1, significant for Interval 4, and in the same direction, but not significant for Interval 3.

Mean PANAS and dextral activity correlations. Based on the hypothesis that greater dextral movement would reflect more negative affect, I had predicted that dextral movement would relate positively to NA. I also had predicted that dextral movement would relate negatively (reflecting more left-side movement) to PA. These predictions were not supported by the data. Table 27 shows the correlations between the dextral movement variables and the mean PANAS subscales for both the overall sample and by sex after collapsing across intervals. At a trend level, PA correlated positively with dextral CSA activity, indicating that greater right-arm movement was associated with PA rather than NA. For actometer-measured dextral activity, the data showed no significant correlations with any of the PANAS scales.

The LPI

The LPI measures. The LPI is a 16-item self-report questionnaire designed to reflect an individual's hand, foot, eye, and ear preferences. Four items assess each of these common lateral preferences, and scores range from -4 (completely left preferenced) to +4 (completely right preferenced) (Coren, 1993a). Four lateral preference variables were created from the 16 items, reflecting each of the four lateral preferences. For descriptive purposes, each of the four lateral preferences were classified into right-left categories. Left-side preference was classified as any score less than zero, and right-side preference was any score greater than or equal to zero.

Initial data assessment. All of the preference subscales were negatively skewed,

indicating that there were many more right-than left-side preferences indicated. Table 28 shows the number of participants who showed a right- or left- preference. *Earedness* showed the least right-sided preference (68 per cent of participants). *Handedness* showed the most right preference (95 per cent). There were no sex differences among the lateral preferences (*Earedness* or *Eyedness*), except that more males than females tended to be right-eyed, $t(82) = 1.69, p < .10$. Sixty-nine per cent of females reported a right-eye preference, while 87 per cent of males reported a right-eye preference.

Table 28. *Number of Participants Grouped by Side of Lateral Preference.*

	Number of Participants with Greater Preference:	
LPI Preference	at Left	at Right
Handedness	4	80
Footedness	13	71
Eyedness	19	65
Earedness	27	57
Mean LPI score	6	78

Note. $N = 84$. Lateral preference categories are based on LPI score for each subscale. Scores can range from -4 through to +4. For each subscale, those <= 0 are categorized as having a left preference. Those with a score > 0 are categorized as having a right preference.

LPI descriptive statistics. Table 29 shows the LPI descriptive statistics for the whole sample and by sex. All of the lateral-preference subscales were reasonably reliable (Range of Cronbach's alpha = 0.63 to 0.88). Footedness was the least reliable, and Eyedness the most reliable. For the whole sample, the item with the highest correlation

with the total for Handedness was, *Which hand removes the top card when you are dealing from a deck?*, $r = .86$. The item with the highest correlation with the total for Footedness was, *If you wanted to pick up a pebble with your toes, which foot would you choose?*, $r = .62$. For Eyedness, the item with the highest correlation with the total was, *Which eye would you use to sight down a rifle?*, $r = .86$. For Earedness, the item with the highest correlation with the total was, *Into which ear would you place the earphone of a transistor radio?*, $r = .76$.

Table 29. *LPI Descriptive Statistics.*

LPI Preference	*M*	*SD*	Min	Max	Reliability
Whole Sample (n = 84)					
Hand	3.3	1.4	-4	4	.68
Foot	2.4	1.6	-2	4	.63
Eye	2.0	2.7	-4	4	.88
Ear	1.6	2.3	-4	4	.75
Males (n = 39)					
Hand	3.4	1.3	2	4	.62
Foot	2.5	1.5	-1	4	.69
Eye	2.5	2.5	4	4	.87
Ear	1.5	2.3	4	4	.72
Females (n = 45)					
Hand	3.2	1.5	4	4	.72
Foot	2.3	1.6	2	4	.58
Eye	1.5	2.9	-4	4	.88
Ear	1.6	2.3	4	4	.78

Note. Scores range from -4 to +4. Above 0 is considered a right preference. Min= Minimum; Max=Maximum. Reliability = Cronbach's alpha, a measure of internal consistency.

LPI intercorrelations. Table 30 shows the intercorrelations among the four LPI subscales for the whole sample and by sex. Handedness was significantly correlated with footedness and eyedness, but the other lateral preferences were not significantly related.

LPI and demographics correlations. There were no significant correlations among any of the subscales with gender, height, weight, hours of sleep, nor self-reported

participation in a sports activity.

Table 30. *LPI Subscales Intercorrelation Matrix.*

LPI Subscales	Hand	Foot	Eye	Ear
Whole Sample (n = 84)				
Hand	----	.38****	.25**	.14
Foot		----	.16	.10
Eye			----	.18
Males (n = 39)				
Hand	----	.14	.24	-.16
Foot		----	.10	-.08
Eye			----	.06
Females (n = 45)				
Hand	----	.54*****	.24	.37**
Foot		----	.18	.25*
Eye			----	.28*

*p < .10, **p < .05, ***p < .01, ****p < .001, *****p < .0001.

LPI and mean activity correlations. No particular relations between lateral preference and movement were predicted. Table 31 shows the correlations between the activity measures and the LPI subscales. There were no significant correlations between overall actometer-measured movement and lateral preference.

LPI and dextral activity correlations. The LPI measure of lateral preference was used in this study as a check to indicate how typical this sample was compared to the lateral preference percentages found in the population. I did not offer any *a priori* hypotheses regarding movement and lateral preference. Table 31 shows that greater right-

earedness was related to greater frequency of right-arm movement. Greater right-hand preference was correlated at the trend level with greater right-arm acceleration.

Table 31. *LPI and AL Measure Correlations, Whole Sample and by Sex.*

	Overall AL		Dextral AL	
LPI subscales	Actometers	CSA	Actometers	CSA
		Whole Sample		
Hand	.14	-.00	-.06	.19*
Foot	.06	-.07	-.02	-.06
Eye	.04	.11	.10	.13
Ear	.12	.10	.28***	-.02
		Males		
Hand	.18	.06	-.30*	.30*
Foot	.26	.32*	-.12	-.14
Eye	.06	.26	.26*	.16
Ear	.19	.17	.38**	-.05
		Females		
Hand	.14	-.00	.19	.11
Foot	-.03	-.28*	.12	.08
Eye	.08	.15	.17	.22
Ear	.06	.04	.20	.02

Note. Positive values on the LPI indicate greater right-sided preference. Thus, positive correlations reflect the relation of the activity measures wit right-sided preferences. $N = 80\text{-}84$. Males $n = 38\text{-}39$. Females $n = 42\text{-}45$.

*$p < .10$, **$p < .05$, ***$p < .01$.

The Dichotic Listening (DL) Task

The DL task was administered to assess participants' accuracy in perceiving auditory stimuli presented to each ear simultaneously. All participants were asked to attend to 216 stimuli through stereo earphones. All participants listened for *verbal* stimuli (the word *Dower*, 72 trials) and *Happy* sounding stimuli (any word, 72 stimuli). Conceptually, both *Anger* and *Sadness* can be classified as representing negative affect and therefore should show the same pattern of DL results. However, empirically, negative affect has sometimes been represented by anger (Harmon-Jones & Allen, 1998) and sometimes by fear or disgust (Davidson, 1995) or sadness (Obrzut et al., 1997) . Because of the exploratory nature of Study 2, it was decided that both angry and sad stimuli would be used, with the expectation that results from the both stimuli could be combined in later analysis. Consequently, half the participants attended to *Angry* sounding words and half to *Sad* sounding words (72 stimuli). Thus, each individual listened for three of the four possible stimuli. The order in which participants attended to each of the three stimuli was counterbalanced, as was the earphone placed on the participants' right ear.

The DL measures. From the four DL tasks, I created two sets of dependent variables for each individual. The calculations were based on percentages because each individual did not necessarily receive the same number of correct stimuli for each set of trials. The first set consisted of Accuracy scores assessed for each type of stimulus. Accuracy was calculated by subtracting the per cent of false positives (participant wrongly indicated that he or she had heard the target stimuli) from the per cent of correctly answered stimuli. Because the false positive errors could have occurred at either

the left- or right- ear, no within-individual lateral score can be obtained for the Accuracy variables. Therefore, Accuracy is an overall score that included both right and left responses. A second set of dependent variables consisted of within-individual lateral difference scores, calculated by subtracting the per cent of stimuli correct at the left ear from the per cent correct at the right ear for each stimulus. Thus, each individual had a lateral per cent correct score and an overall accuracy score for three stimuli (the word *Dower*, the *Happy voice*, and either the *Sad or Angry voice*).

Initial data assessment. All of the mean per cent Accuracy variables and Lateral Difference scores were reasonably normally distributed. There were no extreme univariate outliers apparent for any of the scores. None of the Accuracy nor Lateral Difference scores showed significant sex differences (no t value > 1.16, nor p value < 0.26). None of the Accuracy or Lateral Difference scores were obvious outliers in bivariate plots with both actometer and accelerometer measures of activity. I examined ear of presentation side (Earphone) and stimulus order (Order) to assess the possibility that either of these procedures influenced the DL scores. There were certain instances where the influence of Earphone at right ear by Order was statistically significant. Accuracy scores showed an Earphone by Order interaction for both the *Sad*, $F(2, 36) = 3.26, p < .05$, and *Angry* tasks, $F(2, 36) = 4.07, p < .03$. The Lateral Difference scores also showed an Order by Earphone between-subjects effect for the *Happy* and *Word* conditions, $F(5, 72) = 3.46, p < .01$. Therefore, the correlations between activity measures and dichotic measures were calculated after statistically partialling out the effects of earphone and order of stimuli.

DL Accuracy descriptive statistics. Table 32 shows the mean percentages for

each of the DL tasks. Among the participants who were given the *Word*, *Happy*, and *Sad* tasks, Accuracy for the *Happy* task was significantly worse than for the *Word* task, $F(1,72) = 5.63, p < .03$. Accuracy in the *Happy* task also was significantly worse than Accuracy for the *Sad* task, $F(1, 41) = 11.28, p < .01$. Accuracy for the *Word* and *Sad* tasks did not differ significantly, $F(1, 41) = 0.41, p < .53$. Among the participants who were given the *Word*, *Happy*, and *Angry* tasks, Accuracy did not differ significantly by task.

Table 32. *DL Measures Mean Percent by Task for both Ears.*

		Mean Percent for DL Measures							
		Correct		False Pos		Accuracy		R - L	
DL Task	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word	84	76	14	8	9	68	15	17	28
Happy	84	67	20	6	10	62	22	-14	26
Sad	42	78	18	8	12	71	24	-12	21
Angry	42	72	18	8	11	62	22	-16	27

Note. Correct= Mn % Correct, False Pos= Mn % False Positive, Accuracy=Mn % Correct-Mn % False Positive, R-L= Asymmetric Mn % Correct (Right-Left). For the R-L measure, a negative value indicates a left ear advantage. A positive value indicates a greater right ear advantage.

Lateral DL descriptive statistics. The *Word* stimulus showed a right ear advantage (REA), and all of the emotional stimuli (*Happy*, *Sad*, and *Angry*) showed a left-ear advantage (LEA). The REA for the word stimulus is consistent with the literature on DL tasks, and is thought to indicate that verbal stimuli are better processed by the left hemisphere in most individuals. The literature is somewhat less consistent on DL

emotional stimuli. It could be that all emotional stimuli show a LEA (are better processed in the right hemisphere). It could also be that only negative stimuli show a LEA, in which case, negative stimuli would be better processed in the right hemisphere and positive stimuli in the left hemisphere. Table 33 shows that in this study all of the emotional stimuli showed a LEA, irrespective of valence.

Table 33. *DL Task, Percent of Participants Grouped by Side of Greater Number of Correct Trials.*

		Percent of Participants with More Correct Trials	
DL Task	*N*	at Left Ear	at Right Ear
Word 'Dower'	84	18	82
Happy Voice	84	67	33
Sad Voice	42	62	38
Angry Voice	42	71	29

Note. Participants are grouped by the ear at which they showed the greater number of correct responses.

DL Intercorrelations. Table 34 shows the intercorrelations among the DL Accuracy scores for the whole sample. Individuals who accurately perceived the *Happy* voice also accurately perceived the *Sad* voice. Otherwise task Accuracy scores were relatively independent among the stimulus types. The lateral difference scores were not so independent. Table 35 shows the intercorrelations among the Lateral Difference scores. This table shows that without regard for right-left direction, those individuals who made more correct responses on one emotional listening task tended also to make correct responses on the other emotional tasks.

DL measures and demographics correlations. There were no significant correlations (before or after partialling out the effects of Earphone and Order) among either Accuracy or Lateral Difference scores and gender, height, weight, nor self-reported participation in a sports activity. Partialling out the effects of Earphone side and Order of tasks, the number of hours of sleep reported by participants was negatively correlated with the Anger Accuracy score, $r = -.33, p < .05$ and positively correlated with the Sad Accuracy score, $r = .36, p < .03$. That is, the less sleep participants had on the night that they were wearing the instruments, the more accurate they were at recognizing the Angry tone, and the less accurate they were at recognizing the Sad tone. No other significant correlations were found among the other Accuracy scores or any of the DL Lateral Difference variables and demographic variables.

Table 34. *DL Task Intercorrelations, Percent Accuracy, Both Ears.*

	Percent Accuracy Both Ears			
DL Task	Word	Happy	Sad	Angry
Word	----	.21*	.02	.00
Happy		----	.58*****	.24
Sad			----	†

Note. Percent Accuracy = Mn% Correct-Mn% False Positives, irrespective of ear of stimulus at each trial. All participants were given the Word and Happy tasks, $N = 84$; $n = 42$ for correlations involving Sad or Angry.

† Participants were given either a Sad task or an Angry task, not both.

*$p < .10$, *****$p < .0001$.

Table 35. *DL Task Intercorrelations, R-L Percent Correct, Both Ears.*

	Lateral Difference (R - L)			
DL Task	Word	Happy	Sad	Angry
Word	----	.14	.27*	.43***
Happy		----	.38**	.40***
Sad			----	†
Angry				----

Note. Lateral Difference = % R correct - % L correct. $N = 84$ for Happy and Word conditions; $n = 42$ for Sad or Angry condition.

† Participants were given either a Sad task or an Angry task, but all participants were given the Word and Happy tasks.

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$, *****$p < .0001$.

DL scales and mean activity correlations. I had offered no predictions in the relation between overall activity and the DL subscales. The correlations between the activity measures and DL Accuracy measures are presented in Table 15. None of the correlations with overall activity (actometer- or accelerometer-measured) were statistically significant at $p < .05$. An examination of the correlations by sex was no more rewarding. None of the correlations by sex between overall activity and Accuracy or Lateral Difference scores was significant. None of the correlations between males and females were significantly different from each other. Table 36 shows the correlations by sex between the activity measures and the DL variables, both Accuracy and Lateral Difference measures.

Table 36. *DL Accuracy Correlations with AL by Sex.*

Dichotic Listening	Activity Measures: Overall AL				Dextral AL			
	Actometers		CSA		Actometers		CSA	
	M	F	M	F	M	F	M	F
DL Accuracy								
Words	.08	.16	-.12	.04	.10	.14	-.04	-.19
Happy	-.12	.24	-.12	.16	.04	.00	.16	-.08
Angry	.25	-.05	-.12	.24	.16	-.20	.61***	.10
Sad	-.40	-.00	-.30	-.23	-.38	-.05	-.22	-.18
DL Lateral Difference								
Words	.25	-.12	.17	-.07	.20	.12	.08	.02
Happy	-.12	.01	.00	.12	.24	-.00	.12	-.14
Angry	.08	.08	-.17	.02	.44*	-.38	.04	-.20
Sad	-.41	.10	-.30	.09	-.48**	.44**	-.50**	.11

Note. AL = Activity Level. CSA = Accelerometer measure of activity. M=Males F=Females. Males *N*=37-39. Females *N*=42-45, except for the Sad and Angry DL tasks where males *n*=19-20, females *n*=22-23. Accuracy = Total % Correct - % False Positives for both ears. Lateral Difference = % Correct at Right Ear - % Correct at Left ear. *$p < .10$, **$p < .05$, ***$p < .01$.

DL scales and dextral activity correlations. I predicted that emotional DL perception would be related to lateralized motor activity. If happiness is better analyzed in the left hemisphere, then the right arm should be differentially active (either more or less than the left-arm). Similarly, if negative emotion is better processed in the right hemisphere, and if, as I proposed, lateralized arm movement is linked to lateralized brain activation, then lateralized arm activity should be evident in the relation of activity to either the emotional (*Sad* or *Angry)* voices. In the whole sample, there was very little

evidence that DL performance was related to lateralized movement (see Table 15). Only CSA-measured dextral activity was related to the Accuracy of *Angry* perception, $r = .36$, $p < .03$. This result is perhaps clarified in Table 36 with the results shown by sex. Using an r-to-z transformation, males and females did not differ significantly, $z = 0.42$, $p < .67$, two-tailed, with respect to the relation between CSA-measured lateral activity differences and the Accuracy of *Angry*. However, the males probably accounted for most of the relationship in the overall sample between dextral activity and the Accuracy perception of *Angry* in the predicted direction. With respect to actometer-measured dextral activity, Table 36 also shows a trend difference in the correlation between males and females in their DL perception of *Sad*, r-to-z transformation, $z = 1.92$, $p < .06$, two-tailed.

The majority of participants (62%) were more frequently correct for the left-ear DL stimulus, regardless of gender. For the typical female participant, the more often they were correct when *Sad* was at their left ear, the more often they moved their left arms. For males, the opposite was true. The more often the males were correct when *Sad* was at their left ear, the more often they moved their right arms. This significant sex difference in perception of *Sad* and the non-significant difference evident for males in the correlations between dextral actometer-measured activity and both *Angry*, and *Sad*, $z = -1.86$, $p < .07$, two-tailed, r-to-z transformation, indicates that *Sad* and *Angry* can not be simply combined in to one negative emotion variable. I should note that the sample sizes were quite small for the *Angry* and *Sad* DL conditions and therefore even large correlations were not significantly different from each other.

Factor Analysis of PTS, BISBAS, AIM, and PANAS Subscales

Although the questionnaires used in Study 2 are based on several different theoretical constructs (i.e., affect intensity in the AIM, biological reactivity in the PTS, activation and inhibition in the BISBAS, mood in the PANAS), all can be subsumed under two basic independent constructs that describe emotion. The first construct describes emotional valence, as identified by the positive and negative nature of the emotion (e.g., Positive Affect and Negative Reactivity or Negative Intensity in the AIM, Negative and Positive Affect in the PANAS). The second describes the arousal level of the emotion (e.g., Strength of Excitation/Inhibition and Mobility in the PTS, Serenity in the AIM). It is unclear, however, whether some of the measures are best described as belonging to either a valence or an arousal construct. For example, the BISBAS subscales might be subsumed under arousal if activation or reactivity were key, but under valence if the affective tone were key to their understanding. A similar situation occurs with the Strength of Inhibition and Excitation subscales in the PTS, and the Negative Reactivity and Negative Intensity subscales of the AIM. Empirically, these scales might describe either arousal or valence.

Theoretically, emotion and affect are typically described in terms of their valence and/or their arousal (e.g., Heller, 1993; Russell & Barrett, 1999; Watson, Wiese, Vaidya, & Tellegen, 1999). These two theoretical constructs are usually extracted as independent entities in the empirical data. In Study 2, few of the hypothesized relationships among the individual affect and arousal measures and motor activity were confirmed. By themselves, the questionnaire subscales did not provide convincing evidence of the hypothesized

pattern of association, with either overall movement or lateralized movement. It may be the case that if the individual variables were combined in some way, the data might be more informative, with respect to the relationship between emotion or arousal and motor activity. For example, the linear combination of variables into a few coherent factors might provide a more effective means by which to examine the relationship between emotion and movement. Two questions arise. Does the data fit the 2-factor solution typically found in studies of emotion, or is it possible that a factorial solution extracts four separate factors, two for valence (negative and positive) and two for arousal (high and low). The second question is, do the factors derived relate to overall or lateralized motor activity?

To address these issues, I carried out an exploratory factor analysis (FA). Specifically, the FA was an attempt to identify coherent factors that might reflect at least two underlying processes, arousal and valence, and to provide an indication of how they interact with each other. The FA also allowed me to reduce the larger number of observed variables to a smaller number of derived factors in order to improve the reliability of the measures. By themselves, the questionnaire subscales did not provide convincing evidence of the hypothesized pattern of association, with either overall movement or lateralized movement. The linear combination of variables into a few coherent factors might provide a more effective means by which to examine the relationship between emotion and movement.

Exploratory factor analysis plan. In the FA conducted, I included all of the subscales of the questionnaires used in Study 2 [PTS (3 subscales), BISBAS (4

subscales), AIM (4 subscales), and PANAS (2 subscales)] as variables, with the aim of deriving two to four interpretable factors. I then correlated the derived factors with the movement variables. According to the theoretical literature, I expected that the FA would yield at least two factors, an arousal and a valence factor, and possibly four factors, reflecting low arousal, high arousal, positive valence, and negative valence.

Preparatory evaluation of data for factor analysis. I first examined the data for evidence of multicollinearity by examining the intercorrelation matrix of the 13 subscales (Table 37). None of the 13 subscales were highly intercorrelated. Strength of Excitement (PTS) with both Behavioural Inhibition (BIS), $r = .59, p < .0001$, and Mobility (PTS), $r = .60, p < .0001$, were the highest correlations of the matrix. All of the subscales except for Negative Affect on the PANAS were normally distributed, and no data were missing. A sampling of 22 bivariate plots between various questionnaire subscales showed no obvious outliers or problems of curvilinearity. However, two of the 13 subscales, Negative Affect from the PANAS and Serenity from the AIM, did not correlate significantly (had no r values > .22, nor p values < .05) with any of the other variables in the set. Therefore, these two variables were dropped from the subsequent factor analysis. The final set of intercorrelations consisted of a 11 x 11 variable matrix.

Table 37. *Intercorrelation Matrix for Factor Analysis, 13 x 13*

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 AIM Positive Affect	--												
2 AIM Neg Intensity	.29	--											
3 AIM Serenity	-.21	-.10	--										
4 AIM Neg Reactivity	***.44***	*.38*	.14	--									
5 BISBAS BIS	.15	***.44***	.02	***.38***	--								
6 BISBAS Reward	*.36*	.16	-.11	-.04	.30	--							
7 BISBAS Drive	.18	.19	-.08	.00	-.02	.27	--						
8 BISBAS Fun	.21	-.04	-.18	-.23	-.06	***.48***	***.44***	--					
9 PANAS Positive	***.52***	.04	-.06	.28	-.10	.22	.34	.19	--				
10 PANAS Negative	-.02	.22	.08	.02	.22	.14	.06	.12	.06	--			
11 PTS SE	.06	.20	.08	.32	***.59***	.09	-.20	-.29	-.25	-.04	--		
12 PTS SI	.04	.33	-.11	-.08	.26	.24	***.54***	.27	-.04	.12	.10	--	
13 PTS Mobility	-.22	.14	.06	.14	***.42***	-.12	-.26	***-.40***	-.32	-.02	***.60***	-.03	--

Note. $N = 84$. Correlations above .21 are statistically significant at $p < .05$, above .28 at $p < .01$, above .35 (*italicized*) at $p < .001$, above .38 (***bolded and italicized***) at $p < .0001$.

Initial analysis by sex. An initial FA was conducted to determine if the factor analysis could be based on the combined sample of males and females. Because there were only 39 males and 45 females in the sample, an analysis separately by gender was likely to be minimally reliable. However, because some of the observed variables originally showed gender differences, it was important to examine the FA separately by sex initially. Whether two or four factors were derived, for both males and females, the factor structures were similar. The main difference between the male and female pattern of factors was that for males, the first factor was a Negative Arousal factor, followed by the Positive Arousal factor. For the females, the loadings were reversed. The first factor was a Positive Arousal factor, followed by a Negative Arousal factor. Because the content of the factors for the males and females were similar, I decided to combine the male and female groups and conduct the FA on the whole group.

FA on the whole sample. Table 38 shows the results of the FA based on the whole sample, $N = 84$. Principal components extraction using the SAS Factor procedure was used initially to estimate the number of viable factors from eigenvalues and the Scree plot. Four factors met this initial criteria. Two-, three-, and four-factor extractions then were examined for the best solution, using both a principal components with varimax rotation. Squared multiple correlations (SMC's) were used on the diagonal matrix for the communality estimates.

Criteria used to evaluate the factor analysis. Apart from examining the Scree plot and having all factor eigenvalues greater than 1, there were three other criteria used to determine the best factor solution. The first criterion is a factor analysis *rule of thumb*

used by Thurstone (E. Schludermann, personal communication, Feb 2000) that the *n*th factor should contain *n* raw variables. The four-factor solution did not meet this criterion, as Factor 4 of the rotated solution contained only two significantly loaded variables. The second *rule of thumb* is based on the notion that all of the variables together entered into the factor analysis should theoretically account for 100 % of the variance, that each variable should account for 1/*n*th per cent of that variance, that each factor derived should have at least two variables loaded onto it to make it a legitimate factorial construct, and that therefore each factor should account for at least 2/*n* variables per cent of the variance. The first *rule of thumb* is combined with the second *rule of thumb*, in this case indicating that the fourth factor should account for 4/*n* % of the variance. This criterion [100/11 variables = 9.1% each x 4 (4 variables should make up the fourth factor) = 36.4%] was not met in the four-factor solution (which accounted for only 19% of the variance). The final criterion is that the variables loading on each factor should be unique to that factor. Complex loadings, in which a variable loads significantly on more than one factor are to be avoided. Although the three-factor solution met the first two criteria (Scree plot and eigenvalue > 1), and the first two rules of thumb, it did not meet the final criterion. Negative Reactivity loaded complexly on both on both Factor 1 and Factor 3. Another difficulty was that the three-factor solution was not obviously interpretable. First, the third factor split Factor 2 variables. Factor 3 was comprised of variables that showed correlation linkages to both Factor 1 and Factor 2. Secondly, the variables comprising Factor 3 did not themselves correlate with each other. Therefore, it was thought likely that this solution was an artifact unique to this sample. Thus, the two-factor model, derived with varimax

rotation, was chosen as the final solution. The two factors accounted for all 11 variables. It met most of the criteria, including interpretability, except that Mobility (PTS) loaded significantly on both Factor 1 and Factor 2 (see Table 38). Together, the two factors accounted for 40.8% of the variance. Factor 1 can be described as a Positive Arousal factor and Factor 2 can be described as a Negative Arousal factor (see Table 38).

FA factors and demographics correlations. The two factors derived from the FA were first examined for significant correlations with the demographic variables to check for potential confounds. Age was significantly related to Factor 1, $r = -.27, p < .05$. Older participants reported higher Positive Arousal scores. As well, heavier individuals (heavier relative to their height) reported greater Positive Arousal, $r = .26, p < .05$.

Table 38. *Principal Components Factor Analysis, Whole Sample, Varimax Rotation*

Scale	Subscale	Factor Loadings	
		Factor 1	Factor 2
BISBAS	BAS Drive	***.66***	-.05
BISBAS	BAS Fun	***.60***	- .24
AIM	Positive Affect	***.56***	.26
BISBAS	BAS Reward	***.55***	.18
PANAS	Positive Affect	***.54***	-.08
PTS	Strength of Inhibition	***.42***	.22
BISBAS	BIS Inhibition	.07	***.77***
PTS	Strength of Excitement	-.24	***.74***
PTS	Mobility	-.47	***.54***
AIM	Negative Reactivity	.12	***.54***
AIM	Negative Intensity	.26	***.52***
Percent Variance Explained		43	40

Note. Italicized, bolded entries are the ones interpreted for each factor. $N = 84$.

FA factors and mean activity correlations. Table 39 shows the correlations between activity and the two factors derived from the FA on the whole sample. The variance due to both age and hand preference were statistically partialled from all of the correlations. None of these whole-sample correlations showed a significant association with overall activity. However, there were some gender differences. For females, Factor 2 (Negative Arousal) was correlated negatively with overall activity, for both actometer-

measured activity, $r = -.32, p < .04$, and accelerometer-measured activity, $r = -.38, p < .02$. Therefore, for females Negative Arousal was associated with reduced motor activity. For males, Negative Arousal showed a trend opposite to that of the females. Factor 2 (Negative Arousal) was positively correlated, but only at a trend level, with overall accelerometer-measured activity, $r = .31, p < .06$, but Factor 2 was not correlated with overall actometer-measured activity, $r = .00, p < .98$. However, the difference between the male and female correlations ($r = -.38$ vs $r = +.31$) was statistically significant, $z = 2.09$, $p < .05$, two-tailed).

FA factors and dextral activity correlations. As with the overall activity correlations, the variances due to both age and hand preference were statistically partialled from the correlations. For dextral activity in the whole sample, no significant correlations emerged for either instrument. Correlations by sex showed some interesting differences, particularly with respect to dextral activity (see Table 39). For males, greater right-arm actometer-measured activity was associated with Factor 1 (Positive Arousal). For females, neither of the factors showed a significant relation with dextral activity.

Table 39. *Activity and FA Factors Correlations, Whole Sample and by Sex.*

	Overall Activity		Dextral Activity	
Two FA Factors	Actometers	CSA	Actometers	CSA
		Whole Sample		
1. Positive Arousal	.08	.04	.19*	.08
2. Negative Arousal	-.16	-.04	.06	-.10
		Males		
1. Positive Arousal	.14	.14	.51***	.08
2. Negative Arousal	-.00	.31*	.04	-.14
		Females		
1. Positive Arousal	.00	-.08	.03	.02
2. Negative Arousal	-.32**	-.38**	-.10	-.09

Note. FA = Factor Analysis. CSA = accelerometer measure of activity. Both Age and Hand preference have been partialled from all correlations. Whole sample $N = 80$. Males $n = 38$. Females $n = 42$. *$p < .10$, **$p < .05$, ***$p < .01$.

DISCUSSION STUDY 2

In Study 2, I examined the relationship among motor activity, emotion, and arousal. Two objective measures of motor activity were used. Each used different technologies to measure the movement of individuals as they went about their daily routines. Over a 24-hour period, the actometers measured frequency, and the CSA accelerometers measured acceleration of spontaneous arm movement. Participants also completed several questionnaire measures designed to assess their current emotional states and longer term traits of arousal. The study attempted to examine whether individual differences in movement relate to individual differences in emotional and temperamental characteristics of arousal.

I had hypothesized that mean arm movement would show a pattern of positive correlations with temperament and mood measures of arousal, irrespective of emotional valence. That is, the greater the levels of arousal or emotional intensity experienced by the participants, the greater the levels of overall movement they would demonstrate. I also had hypothesized that lateral differences in movement would relate to emotional measures, showing an effect related to emotional valence, the positive or negative disposition of the emotion. That is, greater relative right-arm movement would relate to higher levels of negative affect, and greater relative left-arm movement would relate to higher levels of positive affect. Although there were instances in which the hypotheses were supported (see Table 15), in general, the results did not confirm the hypothesized patterns for either mean activity or lateralized activity.

Gender Differences in Arousal, Mood, and Perception

Because gender differences were apparent in Study 2, at least with respect to their relation to activity, some discussion of gender differences in the self-report measures and the activity measures is useful. Gender differences in the self-report measures are discussed first.

Overall, the gender difference was very limited in the univariate situation. Only the AIM questionnaire showed some gender differences on two of its subscales. Females acknowledged greater Negative Reactivity than males, with a mean standardized difference (Cohen's *d*) of 0.74. Females also acknowledged greater Positive Affect than males at the trend level, resulting in mean standardized difference (Cohen's *d*) of 0.42. These findings are consistent with previous studies (e.g., Weinfurt et al., 1994), which

have shown that females declare a greater breadth of emotional experience than do males, irrespective of the emotional valence, positive or negative.

In Study 2, there were no univariate gender differences found among the questionnaire subscales on the PTS, BISBAS, PANAS, or DL tasks. In the literature, some gender differences have been found, although they are not necessarily consistent. Newberry et al. (1997) found that in their study of 452 college students, the males rated themselves significantly higher on the PTS SE (Excitation) subscale, but not on the SI (Inhibition) or MO (Mobility) subscales. The SE scale includes items on emotional composure under threat or pressure, perseverence in the face of danger or risk, and susceptibility to distractions while working. Carver and White (1994) found that in their sample of 732 college students, females had higher BIS (Inhibition) and BAS (Reward Responsiveness) scores than males. Their finding indicates that females rate themselves as more sensitive to anxiety-provoking stimuli and also more sensitive to signals of reward. In the PANAS, as in Study 2, no consistent sex differences in mood ratings have been found (Watson, Clark, & Tellegen, 1988). In the DL task, sex differences have been reported, with males typically more lateralized for language than females (Bryden, 1988b). Bulman-Fleming and Bryden (1994) however, did not find gender differences in either the verbal or emotional DL tasks in their study of 128 young adults. Generally, males and females show a left-ear advantage for verbal material and a right-ear advantage for emotional material, as was found in Study 2. Those studies finding gender differences seem to have relatively large sample sizes. A likely interpretation is that the gender differences in the questionnaires used in Study 2 are relatively small in magnitude.

In Study 2, the lack of gender differences on the PTS and BISBAS scales by themselves indicates that both males and females are ranking their arousal levels in a similar manner. Moreover, a lack of gender differences on the PANAS mood rankings indicates that over the 24-hour data collection period, males and females did not differ in their positive or negative mood rankings. Thus, it does not appear that the females in general inflated (or males deflated) their ratings. The similarity of scoring on the arousal scales and mood rankings, coupled with the differences on the AIM responses to positive and negative affect traits, indicates that females may be more aware of their emotional traits or are truly more emotionally intense than males.

Surprisingly, the general hypothesis, that arousal, as represented by the PTS (SE, SI, and MO), the AIM (Positive Affect, Negative Intensity, Negative Reactivity, and serenity), the PANAS (PA and NA), and the BISBAS (BAS: Reward, Drive and Fun-seeking, and BIS subscales) scales would be related to motor activity, was not found in Study 2. Only two subscales supported the general prediction. On the PTS, only the MO subscale was significantly related to overall movement (only for the accelerometers) and only for the males. In other words, for males, MO (the ability to adjust quickly to new activities, working conditions, or jobs) is related positively to CSA-rated movement. Male actometer-measured activity was also correlated with the BAS scale, especially the BAS Drive subscale. Given the number of correlational analyses conducted on the data, it is possible that the significant results are the result of Type I error. It is also possible that greater levels of BAS Drive (e.g., going "all-out" to get something desired) are associated with greater movement in males. Female movement may be reflected more by the level of

BIS in the BISBAS. Both activity measures show that BIS (e.g., getting upset or worried when someone is angry at me) is negatively related to movement in females (see Table 22). For females, the greater the SI (Strength of Inhibition), the less overall movement.

An intriguing aspect of the data is that in emotion/arousal and activity level, the male-female differences appear only with respect to their relation with activity. There were no significant univariate gender differences in either the BISBAS or PTS scales. The occurrence of this sex difference only in the bivariate case is of importance because it indicates that although the underlying biological systems may be similar, the resulting behavioural reactions may not be. That is, although there may not be gender differences in temperament and typical levels of arousal and emotional responses, males and females may be cued to respond to different aspects of their environment. In this study, the salience of male movement is reflected in the PTS Mobility and BISBAS Drive scales. These scales reflect the approach mechanisms, such as engaging in goal-directed behaviour, a sensitivity to the possibility of attaining reward, being able to react to unexpected environmental changes, and positive feelings, such as hope, elation, and happiness. For females, movement was salient only with respect to a sensitivity to BIS. Behavioural Inhibition is a withdrawal mechanism responsive to punishment cues and more negative emotional cues, such as anxiety, fear, frustration, and sadness.

To some extent, the data from this study reflect a stereotype of what a typical male or female might do when they are emotionally aroused and upset. Picture a negatively aroused male pounding away with a hammer and nails or a punching bag and a female sitting quietly at home in front of the television with a box of ice cream. Why

males and females would have different correlates of movement is a matter of speculation.

The results are consistent with recent evolutionary-based theories of gender differences, that sex differences in patterns of emotional responses are related to the different reproductive strategies and motives of men and women (Bjorklund & Kipp, 1996; Geary, 1998). Females may have benefitted from an adapted ability to inhibit impulsive behaviour and control their emotional expressiveness and arousal as a way to negotiate their social environment. Geary (1998), for example, suggests evolutionary adaptability has enabled females to show somewhat greater skill at strategically managing the expression of social cues and the subtleties of social dynamics than males. Thus, females could better manage relationships with physically larger and potentially more aggressive males in order to encourage a secure child-rearing environment and maintain social stability among friends and kin. For example, it may have been the case in the evolutionary past, that during episodes of negative arousal, such as would occur during situations of threat to a woman or her offspring, survival depended upon her remaining still and quiet. For males, survival might have depended upon an active approach to the negative arousal situation (e.g., fighting or fleeing). Thus, different behavioural responses for males and females might have emerged from similar emotional or arousal responses.

The point to be emphasized is that the results of Study 2 show that although the males and females did not differ in their levels of arousal and emotional valence, they did appear to respond differently in terms of their motor activity. Many researchers have not found significant gender differences in emotional responsiveness or behavioural inhibition

(Bjorklund & Kipp, 1996). Therefore, it could be the case that males and females do not differ to any great degree in their underlying physiological or biological makeup, but have adapted differentially in their behavioural responses, specifically their motor activity responses, to emotion and arousal.

The data cannot speak to direction of causation, so that although we might believe that emotional arousal causes us to change our activity level, that is not necessarily the case. If emotions are generally adaptive (Nesse, 1998), then it could be that motor activity helps us to regulate, express, or maintain our emotional arousal. The intuitive common-sense view is that we respond to emotional arousal with movement. Emotion or arousal precedes the bodily response to it. However, it might also be the case that movement helps us to regulate, evoke, or maintain our mood or arousal levels to help us adapt. In other words, in a Jamesian way, emotional arousal may be a consequence of our actions (James, 1950).

Gender Differences in Overall Movement

In terms of motor activity, there were no sex differences in actometer-measured frequency of movement in either Study 1 or Study 2. In fact, when the two study samples were combined, mean actometer-measured activity showed no significant sex differences, $t(1,103) = -1.3, p < .20, N = 105$. This finding is consistent with a previous actometer field study (Eaton et al., 1998) of 79 adults in which no significant sex differences were found.

In Study 2, females did show greater CSA-rated acceleration than males, resulting in an *ES* of 0.67 *SD*s. The significant sex difference in acceleration is surprising, given that there were no significant differences in the numbers of males and females who indicated

that they had participated in sports during the time that they were wearing the instruments, $r = .08, p < .45$. Thirty per cent of the males and 36 per cent of the females had participated in a sporting activity. In addition, when Study 1 and Study 2 data were combined, a significant sex difference in acceleration still was present with females showing more acceleration than males, $t(1,103) = -2.1, p < .05$. This sex difference in CSA-measured acceleration resulted in an *ES* of 0.40 *SD*s. An *ES* of 0.40 means that 65.5 per cent of the female values exceed 50 percent of the male acceleration values in this sample, a small to medium effect (Cohen, 1969, p. 20, p. 179).

This unexpected sex difference in CSA-rated acceleration is interesting though, because the finding of greater movement in females is unusual in the literature. One possible reason for the significant sex differences found in this study is that the females had more active lifestyles. They were older on average by two years, and the age range was larger for females than males. Participants were given an opportunity to describe some of their daily activities when they were shown a graph of their days' activity on a computer screen at the end of data collection. Anecdotally, it seemed the case that in this sample, many more of the females had part-time or full-time work in addition to their studies. For example, the two individuals who showed the highest acceleration in Study 2 were both females. One was the mother of three children who carried out her normal housework during the period in which she wore the instruments. The other worked in a daycare and went about her usual activities the day that she wore the instruments. The third highest female worked as a cleaner in the residences on campus. The two most active males participated in sports during data collection, one who roller-bladed home and

another who was involved in wrestling. Many more of the males however, did not mention having been at work during the time that they were wearing the activity monitors. Those who did, mentioned work in sales or on computers. Typically, the males went home after class to watch television, read, or sleep. Their activity may have been more deliberate (e.g., playing sports), but less consistent than the females in the study.

Overall Activity and Factor Analysis of Questionnaire Data

The exploratory factor analysis was an attempt to combine individual questionnaire subscales into fewer coherent factors, which might provide a clearer picture of the relation between movement and emotion/arousal. For the sample as a whole, neither of the two interpreted factors derived in the factor analysis were significantly related to overall movement, as measured by either actometers or accelerometers (see Table 39). However, when correlations between the two factors and movement variables were carried out separately for males and females, some interesting relations emerged between activity and Factor 2.

Factor 2 is a Negative Arousal factor, composed of subscales from the BISBAS (BIS), the PTS (SE and MO), and the AIM (Negative Intensity and Negative Reactivity). To individuals, this factor reflects the salience of anxiety and worry (BISBAS Inhibition), a susceptibility to feeling guilty, nervous, and ***highly strung***, (AIM Negative Intensity), and being easily aroused emotionally (AIM Reactivity); yet, they enjoy sensation-seeking activities, thrive in the hustle and bustle of daily life (PTS SE), and adapt easily to new situations or activities (PTS MO).

For females, Factor 2 (Negative Arousal) was significantly negatively correlated

with overall movement. Both actometers and accelerometers showed the same results (see Table 38). For males, the results were not as clear. Males showed a positive trend correlation between actometer-measured activity and Negative Arousal. Thus, it appears that males and females may have different behavioural responses to Negative Arousal.

It is also interesting that the negative valence of the factor focuses on anxiety and worry more than on anger. This result makes sense given the 24-hour snapshot of emotional mood obtained in Study 2. Participants indicated very low levels of negative mood (with a positively skewed distribution) on the PANAS Negative emotion subscale. However, the PTS and BISBAS scales that reflect longer term feelings, including worry and anxiety, were normally distributed. Thus, individuals were more likely to admit to more general feelings of anxiety or worry than they were to admit currently experiencing any particular negative mood, such as distress, hostility, irritability, shame, or fear. One implication is that immediate ratings of emotions, particularly negative emotions, even rated over the course of 24-hours, may be quite unreliable. It may be important to obtain ratings over more than a single day to obtain an adequately distributed sampling of emotions. It might also be worthwhile to use an experimental emotion induction procedure to obtain a range of emotions, rather than depend upon the randomness of the field situation.

Lateralized Activity

Lateralized activity was calculated as a dextrality index, a function of right-arm movement relative to left-arm movement (Right-arm movement/ (Right-arm movement + Left-arm movement). This dextrality index is a quantitative, continuous variable,

reflecting the relative amount of right-armed activity. For ease of interpretation, the variable was calculated such that a score of 50 represents symmetry of movement in both arms. A score of less than 50 represents a left-armed bias, and a score of greater than 50 represents a right-armed bias. The Pearson product-moment correlations calculated in the studies were based on this continuous variable, and in general, negative correlations involving the lateralized activity variables represent greater left-armed movement, and positive correlations represent greater right-armed movement.

As in Study 1, one purpose of Study 2 was to replicate previous findings of a left-lateral bias in actometer-measured movement, as found by Eaton et al. (1998). As the results show, students once again produced a left-movement bias in actometer-measured movement frequency. No definitive assessment can be made on the lateral movement bias among left-handers. There were only four individuals (two males and two females) in Study 2 who were classified as left-handers on the LPI questionnaire. For these left-handers, as assessed by the actometers, one male and one female showed greater left-arm activity, and one male and one female showed greater right-arm activity. With this latest replication, a left bias in actometer-measured movement has been found in three separate studies (Eaton et al., 1998; Study1; Study 2), infants (McKeen, 1995), preschoolers (McKeen, 1997), and school-aged children and adolescents (McKeen, Eaton, Campbell, & Mitsutake, 1999).

A second purpose of both Study 1 and Study 2 was to assess the lateral bias as measured by the accelerometers and compare the two instruments. Despite the consistency of a sinistral bias in actometer-measured movement, the acceleration showed

a dextral or right-sided bias. I will discuss this finding and comment on possible interpretations of it later in the General Discussion.

Gender Differences in Lateralized Movement

In Study 2, the actometer measure of movement showed that categorically more males were left biased than females, and that males were also more strongly lateralized than females. The size of this proportional mean difference, however, is small (Cohen, 1969). Therefore, although statistically significant, this result may be somewhat sample-specific. Eaton et al. (1998) did not find that males and females differed in the magnitude of this movement asymmetry.

Lateralized Activity and Factor Analysis of Questionnaire Data

I had hypothesized that lateral differences in movement would relate to emotional arousal measures. More specifically, I had predicted that lateral differences in arm movement would show contrasting effects related to emotional valence, the positive or negative disposition of the emotion. That is, greater relative right-arm movement would relate to higher levels of negative affect, and greater relative left-arm movement would relate to higher levels of positive affect. Measures of general arousal without an emotional context (e.g., the PTS subscales) would not be related to lateralized movement. Those measures which tap both emotional and arousal aspects of temperament, such as the AIM and the BISBAS were predicted to be related to lateralized activity according to the emotional valence inherent in the particular subscale. For example, the BAS subscale of the BISBAS should relate to lateral movement in the same way that a positive emotion subscale would do, and the BIS should relate to lateral movement the way that a negative

emotion subscale would. Table 15 shows the specific hypothesized relationships between dextral activity and the emotion/ arousal variables and the correlational results. There was only one instance in which the hypotheses were confirmed. Accuracy on hearing the Angry tone of voice on the DL task was positively correlated with right-arm movement, as measured by the CSA accelerometers, $r = .36, p < .03$. However, in general, the results did not confirm the hypothesized patterns for lateralized activity.

An examination of lateralized movement with statistically derived factors produced few results. For the sample as a whole, their were no significant results between either factor and either of the lateralized measures of activity. For males, asymmetric acceleration was positively related to Factor 1, indicating that greater right-arm movement was related to the linear combination of variables making up the Positive Arousal factor. Neither factor related significantly to lateralized movement in females. Factor 2 (Negative Arousal) related to overall activity in females, but not to lateralized activity.

How do these results fit with other studies of emotion, arousal, and lateral differences? Generally, right-hemisphere activation has been associated with negative emotion and left-hemisphere activation with positive emotion (Davidson, 1995). In terms of limb movement, one could expect that contralateral right-arm movement would be associated with positive emotion and left-arm movement with negative emotion. Two recent experimental studies involving facial movement provide motor examples. In one study, unilateral right-sided facial contractions were related to persistence in solving insolvable puzzles. The researchers hypothesized that persistence represents positive emotion and suggested that right-sided facial contractions activated the contralateral left

hemisphere associated with positive emotion (Schiff, et al., 1998) and approach behaviours (Schiff & Bassel, 1996). In Study 2 of the dissertation, the female results show no relationship with lateralized activity, while male results appear consistent with findings relating hemisphere differences and emotion.

GENERAL DISCUSSION

Study 1 was a pilot study designed to examine the measurement issues involved in the use of two activity-measuring instruments. The results showed that gender, size of limb, height, or weight were not significant correlates of motor activity. An Activity Diary provided convergent validity that the instruments were measuring motor activity. Study 1 also showed some initial support for the notion that emotional temperament was related to lateral asymmetries in movement. Study 2 extended the findings of Study 1 with a larger sample, and more comprehensive ratings of emotion, temperament, and mood. In Study 2, a gender difference in acceleration was found, with females being more active than males in overall movement and also more right-biased than males. More important was the finding that males and females appeared to differ in how movement relates to their emotional characteristics. A discussion of the more salient study results follows, along with a discussion of the limitations of the dissertation studies, future directions to take the research, and the usefulness of the activity monitors as research tools.

Activity Measures

One of the purposes of using both actometers and accelerometers to measure movement in both studies was to assess motor activity simultaneously from two different perspectives, frequency and acceleration. Because the two types of activity monitors were

used at the same time at the same site, it was possible to compare the two instruments, both as they measure overall activity and lateralized activity. In order to examine issues of external validity, both studies also included other measures of activity, such as an Activity Diary. The measurement issues related to overall activity will be discussed first and then the issues related to lateralized activity.

Overall Mean Activity

In terms of overall mean activity, the actometers and accelerometers show a very strong positive relationship. The correlation between mean actometer-measured activity and mean accelerometer-measured activity was quite high in Study 2 ($r = .70, p < .0001$ in Table 11), and is quite similar in magnitude when Study 1 and Study 2 data were combined, $r = .65, p < .0001$. Thus, individuals who ranked highly in their frequency of movement, also tended to rank highly in their movement acceleration. As well, the distributions between actometers and accelerometers showed quite remarkable similarities in shape (negative skews), and range of mean activity scores over the 24-hour period. It can be concluded that while the two instruments assess motor activity in different ways, over a 24-hour period there is a high correspondence between mean frequency of movement and mean acceleration of movement generally.

Other measures of activity show consistent support for activity as an entity or construct that describes how much people move generally. In Study 1, the Activity Diary allowed participants to track their various activities over the day. Participants indicated when they were sleeping and rated their waking activities from *very light* to *very hard*. The results showed a significant positive relationship between both frequency of

movement (actometers), movement acceleration (accelerometers), and the mean diary activity score (see Table 3). In Study 2, a *yes-no* response to a question about participation in a sports activity resulted in a positive correlation with mean activity as measured by both instruments. Those who had participated in a sports activity moved more frequently and with greater acceleration over the day than those who had not participated. Moreover, the greater the number of hours of sleep at night, the less the mean acceleration score. Frequency of movement, although in the same direction, was not significantly related to the amount of sleep individuals experienced. Thus, based on three separate sources of information about the nature of daily activity, the Activity Diary, reports of participation in a sports activity, and the amount of sleep reported, the activity monitors do provide a good means by which to measure motor activity.

Potential Applications of this Measurement Approach

The CSA accelerometers appear to have great potential in objectively measuring the movement of individuals in that they associate movement with time and provide flexible measures of movement. The daily ebb and flow of activity could be examined (Kerkhof, 1985). For example, the circadian rhythm of movement patterns could be assessed (Hur, Bouchard, & Lykken, 1998). This information would be of particular import to individuals who must change their wake-sleep habits in the course of work-related shift changes (Reinberg, et al., 1988).

Along similar lines, the accelerometers would make ideal instruments to assess individuals who are having sleep problems. In the dissertation studies, it was usually evident from the visual plot of activity by time, when the participants fell asleep. Even

reading in bed could be distinguished from the 'flat line' pattern of sleep. Knowing the exact nature of the sleep problem being experienced would allow physicians to understand the problem without having to have their patients come in to a hospital environment for diagnosis. The elderly, for example, often develop difficulties with their sleep habits (Mason, 1992). If they were to wear the accelerometers for a few nights, a quite precise estimate of their sleep interruptions would be evident.

Both the accelerometers and actometers are ideal instruments for assessing the typical levels of activity in individuals of any age, from the very young to the very old. Greater activity levels are associated with longevity and the maintenance of independent functioning (Sallis & Owen, 1999). A means to measure motor activity across the lifespan is of great value to those who are identifying the relations of activity to chronic diseases, life satisfaction, and longevity (DuRant, Thompson, Johnson, & Baranowski, 1996; Katzmarzyk, Malina, Song, & Bouchard, 1998; Puhl, 1989; Saris, 1986).

The value of physical activity in health and fitness is currently a topic of prime interest in the research literature. While questionnaire methods comprise the major means of assessing estimates of physical activity (Paffenbarger et al., 1993), some studies find only low levels of variance in physical fitness is explained by physical activity variables (Katzmarzyk et al., 1998). Objective instruments would prove to be useful because they measure all of the motor activity produced, and not just that produced in specific exercise workouts. It may be that long-term fitness depends more upon a consistent level of energy expenditure across all activities, rather than on more sporadic, but intense exercise regimes.

The instruments may also be useful in determining gender differences in activity. Females have been found to be quite unreliable in reporting their leisure activity and their strenuous activity (Weller & Corey, 1998). This underestimation of motor activity could be related to the items on questionnaires, which emphasize male-dominated leisure activities, or a reluctance on the part of the females to admit that they are involved in strenuous activities. In Study 1, the Activity Diary showed a gender difference in mean activity, but the instruments did not. The conclusion was that females had under-reported their activity level in Study 1. Anecdotally, some of the most active females in Study 1 had been shopping, rather than involved in sports. Shopping was classified on their diary as only a moderate energy-expenditure activity. It may be that some non-sport activities may be just as strenuous as sports games, but that questionnaires do not reflect that reality.

Psychological Meaning of Activity

More difficult to answer is the question, "do actometer-measured movement and accelerometer-measured movement mean the same thing, psychologically speaking?" My attempt to answer that question, based on a predicted pattern of relations among activity and the emotion- and arousal-based questionnaire scales, ultimately was unsuccessful. There were too few statistically significant relations between activity and emotional arousal subscales to substantiate the predicted pattern of correlations.

One of the key factors in many of the null results was low statistical power. There were a relatively large number of unexpected, but statistically significant bivariate relations between gender and the various questionnaire subscales. If there was a pattern of

results present in the data, it was that many of the questionnaire subscale correlations were in the opposite direction for males and females. However, because the sample consisted of 45 females and 39 males, many of these correlations were not significant when examined separately by gender; nor, in many cases were they significantly different from each other.

The pattern of null relations between overall activity and emotional or arousal correlates was broken only on two occasions. Male activity was positively related to BAS positive arousal, and female activity was negatively related to BIS anxiety (see Table 16). This finding was confirmed by the results of the factor analysis which showed that Factor 2 (Negative Arousal) was negatively related to female movement. In other words, males tend to be more active in response to positive arousal, and females tend to be less active in response to negative arousal.

The best generalization that can be made is that there are subtle indications that the movement of males and females may differ in response to either arousal or emotional feelings, or alternatively, that arousal or emotions may produce differing movement responses in males and females. Why a behavioural inhibition system might be salient for females and a behavioural activation system for males is not known. It is certainly plausible that movement is associated with emotional arousal. One can speculate that in our evolutionary past, the ability of females and their children to survive was related to their ability to inhibit their behavioural responses, a withdrawal bias. Males might have been better served by a motor responsiveness to arousal, an approach bias, which would be associated with an inclination to explore new situations.

As it happens, in Study 1 and Study 2, the sample size was too small to make any reliable statement about how arousal and emotion relates to overall movement. If the *ES* for the relation between emotional and arousal correlates is approximately 0.20 (based on a perusal of the correlations between the questionnaire results and activity measures), and the harmonic mean sample size is 42 (2 * n1 * n2 / n1 + n2), then the power to detect a true statistically significant result is 25 per cent (Cohen, 1969, p. 89). With this *ES*, and using a one-tailed criterion alpha at .05, it would be necessary to have a sample size of 117 males and 117 females to have a 70 per cent chance of finding a statistical significance (Cohen, 1969, p. 98). Using the same criteria, but with the originally predicted *ES* of 0.30, the number necessary to detect a true effect would have been 102 (51 males and 51 females). Of course, without significant gender differences, the number necessary to attain a power of 70 per cent would be cut in half. Thus, the lack of correspondence between males and females, although often not statistically significant, resulted in a picture of the data that did not confirm the predicted relationships.

In both Study 1 and Study 2, participants wore two activity monitors, one on each wrist. Thus, it is possible to assess within-individual lateral asymmetries in movement with each type of instrument. The resulting lateral measures of movement showed relationships with arousal and emotion variables that did not simply mirror the relationships found with the overall measure of activity. There are a couple of key measurement issues involving the asymmetry of arm movement. These are discussed next.

Lateralized Activity

The dextrality index was based on the difference between the activity of the right and left arms, relative to total arm movement. Thus, the index is a continuous measure of right-arm movement relative to total movement. For analyses involving a right-left categorical dichotomy, a continuous value equal or greater than 50 was classified as *right*- and a value less than 50 was classified as *left*-biased.

Descriptively, in Study 2 the distributions of the dextral measures of the actometers and accelerometers were not as similar as are the overall mean activity distributions. The median value of the actometers was 45 per cent, while the median value for the accelerometers was 51.6 per cent. The distribution range was 52 percentage points for the actometer index, but only 19 percentage points for the accelerometer index. To generalize, it appears that the actometer index is more variable and centred below 50 per cent, indicating a left bias in frequency of movement. The accelerometer index is less variable and centred slightly above 50 per cent, indicating a slight right bias in acceleration of movement.

In comparing the actometers and accelerometers on the dextrality indices, two striking features emerge. The first is that, while significantly correlated, the correlation is still only modest (see Table 11) and significantly less than the correlations between the overall mean values of the monitors. When Study 1 and Study 2 are combined ($N = 101$), the correlation between the two dextral indices is quite modest, $r = .30, p < .003$. The implication is that, for the correlational analyses between the psychological measures and the dextrality indices, the pattern of results can be expected to diverge for the two

measures of lateral movement. The relatively low correlation between the two dextral measures, particularly for the females, could indicate that dextral movement may represent different psychological meanings for the two sexes. From the data it is difficult to determine if this implication is empirically the case. Many of the expected predictions of relationships between lateral movement and the arousal and emotional subscales did not emerge for either instrument.

The second striking feature is that the actometers show higher frequency of movement on the left arm, and the accelerometers show a higher acceleration of movement on the right arm. The finding deserves comment. In Study 2, as assessed by accelerometers, 69 per cent of all right-handed individuals showed greater right-arm movement, and 31 per cent showed greater left-arm movement, the reverse of what the actometer data showed. However, this reversal in asymmetric movement patterns does not reflect a simple shift or cross categorization between the two instruments. The chi square test for an interaction between the instruments by side of greatest movement was not significant, and therefore those who moved more on the left by actometer recording were not those who necessarily moved more on the right by accelerometer recording. The result is surprising. What might account for such instrument differences?

One explanation is that the movements may be qualitatively different. If movement frequency is greater on the left, yet at the same time, acceleration is greater on the right, it could be the case that the left-arm movements are slower or of smaller amplitude. Right-arm accelerations, although they might occur less frequently, could be of greater amplitude. The implication is that, for the correlational analyses between the

psychological measures and the dextrality indices, the pattern of results can be expected to diverge for the two measures of lateral movement.

A second possible explanation is that the two instruments measure movement at different levels of sensitivity. Actometers may be more accurate at measuring larger limb movements than small ones. They move one 'second' or one activity unit for approximately every five changes of direction (Eaton et al., 1996). Small movements, such as those involved in fine motor tasks are not necessarily recorded as motor activity. Thus, actometers may provide an 'overview' measure of movement frequency. Accelerometers provide a measure of average acceleration per minute, and are probably more sensitive to smaller movements.

In the natural setting of both studies, the instruments were measuring all kinds of every-day movements that included both skilled and unskilled activities. Thus, the movement biases recorded were not closely related to the handedness reported by the participants. However, the slight right-sided bias of movement acceleration recorded by the accelerometers is consistent with Marchant et al.'s (1995) finding that hand-use in natural settings is consistently, but weakly right-sided in various cultures.

The left bias in frequency of movement as recorded by the actometers may in part be due to a combination of missing the smaller fine motor movements, such as might be involved in writing or typing, and the possibility that we use our right- and left- limbs for different functions. If, as Guiard (1987) suggests, we use our right hands to hold onto objects and our left hands to define "the spatial reference vital to the elaboration of motion of the right hand" (Guiard, 1987, p. 502), then many of our bimanual movements

may include differentiated manual gestures. As happens when we write with our skilled hand, we usually orient the paper on which we are writing with the lesser skilled hand. Our writing hand makes smaller scale movements at the same time that our non-writing hand is making larger scale movements. These larger, usually left-biased movements would be recorded by the actometers, and would account for a left-bias in frequency of movement. The left movement bias is not simply a function of skilled hand movements, however. Other processes may account for it, as demonstrated by the fact that the left-arm bias is also present in infants and preschoolers. These populations are not typically engaged in the many skilled activities of the adult.

In terms of measurement issues, it is important to note that the accelerometer variable calculation was based on the relative difference per minute in acceleration between the left- and right-arms. By using the ratio of right-left movement based on mean accelerations per minute, the acceleration in the right arm was yoked to acceleration in the left arm every minute. Calculating the dextral ratio over other lengths of time (e.g., 30 min., 1 hr, or the entire 24-hr period to mention a few) can produce different outcomes. For example, a separate analysis of Study 1 data involved calculating two dextral ratios. One was based on per cent right-arm movement for each 10-sec interval, and the other was based on per cent right-arm movement for each quarter-hour interval. These two methods of calculating a dextral index produced different categorical results. The 10-sec method resulted in 3 of 22 participants showing a left-greater than right movement bias. The quarter-hour method resulted in 10 of 22 participants showing a greater left-than-right bias. Therefore, the issue of data aggregation is particularly important to the mean

acceleration measure. In Study 1 and 2, the difference per minute calculation was used because it was available and seemed like the most conservative measure to use. The question remains though. What is the most appropriate unit of aggregation to use in studying the psychological meaning of lateralized movement?

The instruments have been commercially available at reasonable prices only recently, and I am unaware of any literature using accelerometers to create a lateral index. Therefore, it is not known which interval of time might be best able to capture lateral differences in movement which are also psychologically meaningful. It could be, for example, that lateral movement differences are best aggregated over a longer period of time in order to capture movement differences related to mood, arousal, or other emotions. In this case, individual arm movements would be summed over longer periods of time before creating an index of dextrality. Thus, from both a measurement perspective and a psychological perspective, it will be important in future studies to investigate methodically the properties of each way of defining the lateral index.

Limitations of the Dissertation Studies

These dissertation field studies were designed to examine the meaning of the everyday movement of individuals with respect to their levels of arousal and emotional characteristics. General hypotheses consisted of predictions regarding the relationship of overall mean activity to arousal characteristics and of emotional valence to lateralized activity. Significant findings are sparse, and it is evident that there are certain limitations to the studies carried out and described above.

One limitation is a problem typically found in field studies, and that is that there is

no experimental control over either the activities carried out by participants or in the moods and other emotional characteristics experienced by the participants over the 24-hour data-collection period. In the case of the PANAS Negative Affect, for example, very few individuals expressed even moderate levels of negative mood over the time period of the study. Thus, the data analysis of negative mood in Study 2 is quite unreliable. Similarly, the movement of the participants was dictated by the day-to-day routines of the individuals in the studies, and these routines varied greatly. It is probably the case that individual differences in both overall movement and lateralized movement depend not so much on the common activities typically carried out by everyone in the study, but by the activities carried out during free time. In Study 2 particularly, some individuals were working full time and had almost no free time, while others had almost all of their day free. It might have helped the outcome of the studies if the participants generally had similar opportunities to engage in free time and pursue their natural emotional behavioural activities.

A second limitation of the studies is the low power to detect a true underlying effect. Sample size was determined on the expectation that there would not be significant gender differences in either movement or in the reporting of arousal and emotional experience. In fact, gender differences rarely occurred in the univariate situation. It was only in the bivariate cases, in the relationships of arousal and emotion with movement, that the surprising gender differences appeared. Thus, the non-significant relations that emerged in the studies may be due to low power. To attain sufficient power to detect significant relationships with activity, the sample sizes would have to be at least doubled.

A third limitation of the studies is the reliance on young adult participants. It may be, for example, that many first-year university students are not very knowledgeable or are in a state of flux regarding self-reports of their temperament or emotional feelings. Older individuals might provide a more mature, or at least consistent, picture of their emotional life. It could also be that those whose activity declines greatly with age are those who are at greater risk for developing emotional or health problems. It would be in this older population that an objective activity measure might be of most benefit.

A related issue involves the reliability of the questionnaires administered to the participants in the studies. Although the data on the whole showed normal distributions in these studies and good internal reliability of items on the questionnaires, self-reports are not necessarily the best means to assess behaviour. Quasi-experimental behavioural tasks might provide a better way to assess responses to emotional arousal (e.g., laboratory manipulations and assessments of mood and limb movement patterns).

One further limitation of the dissertation studies was that a clear empirical distinction between emotion and arousal was not achieved. The theoretical distinction in the literature defining emotion in terms of valence, orthogonal from arousal and activation (Heller, 1993; Watson et al., 1999), was not found. In Study 2, for example, the BISBAS and PTS scales, designed to assess physiological arousal, and the PANAS and AIM scales, which focus on emotional characteristics, were all included in each significant factor derived from the factor analysis.

While these limitations are important, the great advantage of the studies is that they were able to assess individuals' typical levels of movement over a 24-hour period

without restriction. Individuals were able to carry on their usual activities, as the instruments were unobtrusive and not inconvenient for most participants. Simultaneously, two types of activity data were collected, frequency and acceleration of movement, so a comparison of the data was possible. The assessment of the limitations and benefits of the activity studies provide a basis on which to explore ideas for future directions in the study of movement. To these I turn next.

Future Directions

With smaller than anticipated effect sizes, and in anticipation of sex differences in the relation between emotion and movement, a simple option for a future study would be to double the sample size. In addition, having participants wear the instruments for a two- or three- day period would provide some benefits. Reliability of the instruments from day to day could be estimated, and a broader sample range of mood estimations could be obtained. A further refinement relates to the temperament or personality variables that might influence overall movement. In transitioning from childhood to adulthood, activity changes from a primary dimension of temperament to a facet of extraversion in adult personality (Eaton, 1994). Extraverts, therefore, may be more active than introverts. Therefore, a measure of personality would make a beneficial addition to a study protocol.

What might be even more effective than a replication study however, is to use an experimental approach to the study of arousal and emotion. For example, instead of relying upon individuals to report a normal distribution of mood scores, it might be more effective to use experimental mood induction procedures, or tasks that can be manipulated for failure or success, to produce positive or negative moods. Movement

could then be examined within the context of emotional valence.

The original experimental studies by Kimura (1973a, 1973b) would constitute a good model on which to develop such a study. Kimura assessed lateral movements in the context of a conversation. If a mood induction procedure was given prior to a conversation occurring, it would be possible to test the hypothesis that mood influences movement. The accelerometers would be ideal instruments to use for restricted time intervals, because they associate movement with real time on a minute-to-minute basis. Thus, right- and left- hand movements can be yoked by time, and lateral differences assessed easily. Although handedness did not have a significant influence on the current studies, experimental studies could use more homogenous handedness groups.

The above study would address the effects of emotion on movement, but to some extent, it assumes a directional effect. It could be that movement influences emotion or arousal rather than emotion influencing movement. There is evidence, for example, that movement or exercise can improve an individual's mood (Hays, 1999; McCauley, Talbot, & Martinez, 1999). However, lateral differences in movement could be tested more precisely. One way to assess the influence of movement on emotion is to prescribe the movement and let the emotion vary. For example, Schiff and Lamon (1989) asked participants to contract one side of their facial muscles for one minute and then asked participants to indicate how they were feeling. A similar procedure could be carried out by using an asymmetric limb movement procedure and assessing mood afterwards.

Another less experimental method would be to assess movement in clinical populations. Depressed individuals or bipolar mood disorder individuals might provide a

sample group who show extreme affective states. The hypothesis is that individuals would show changes in their lateral movement patterns depending on their emotional state. With the accelerometer, changes in movement could be tracked continuously over weeks, days, or hours. Circadian rhythm patterns of movement could be examined, along with measures of emotion, arousal, and cognitive-task performance.

In summary, in the dissertation studies, I have measured individuals' typical levels of activity in a free-living field situation, and have examined the possibility that movement is meaningful and plays an important role in the expression or regulation of emotion and arousal. Although the results are far from conclusive, I am not yet ready to abandon the theory. The hypothesis that limb movement would in any way be related to temperament and emotion was a risky one, and for the results to provide even nominal success is somewhat surprising. With the knowledge that males and females differ in their behavioural responses to emotional experience, it may be possible to find that meaning in motor activity.

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Appendix A

Study 1: Instruments and Forms

Recruitment

Consent form

Monitor and Anthropometric form

Activity Monitor Instructions

Activity Diary

Activity Examples

Activity Diary Example

Affect Intensity Measure (AIM)

AIM reference and Weinfurt's scoring

Lateral Preference Inventory (LPI)

LPI reference and scoring

Feedback form

RECRUITMENT OF PARTICIPANTS

SPONTANEOUS MOTOR ACTIVITY

People move spontaneously all the time, both day and night, and they often show a level of movement that is uniquely typical for them. I am beginning a series of studies on the significance of an individual's typical level of motor activity for their mood and temperament.

If you participate in this study, you will wear ***Activity Monitors*** on each wrist for 24 hours. These monitors measure your activity as you go about your normal day. You will also complete several personality, temperament, and mood questionnaires before, during, and after you wear the activity monitors.

You must come for ***three appointments***. Usually, at the first appointment, you will complete several personality and temperament questionnaires. At the second appointment, you will be fitted with the activity monitors, and I will give you instructions on how to care for them. I will also take a few physical measures - your height, and weight, and ask you a few questions. You will also do a dichotic listening task, in which you will be asked to listen for particular words and emotional tones of voice, and a pegboard task to assess your manual dexterity.

At the final appointment, 24 hours later, you will return the activity monitors and finish the questionnaires. *I will show you a computer graph of your activity as it was recorded by the monitor over the previous day.*

It is not hard, but it requires that you wear the instruments for one day and keep track of your moods. I have only enough instruments for four people per day to participate, so it is *very important that you be able to return for your final appointment exactly 24 hours after the second one*. Otherwise the next person scheduled will be unable to take part in the study.

The first two appointments should take about ***1 hour each.*** The third will take about ***30 minutes***.

Consent Form

I, _____ agree to participate in a research study of motor activity conducted by Nancy McKeen, Department of Psychology, University of Manitoba (474-9338). I understand that I am under no obligation to participate, and that I may withdraw from the study at any time. I understand that any information I provide for the study will be kept confidential to protect my privacy.

Date: _____ Signature: _____

Telephone: Home: _____ Work: _____

****

Name of a Contact Person: _____

(Contact person who might get a message to you)

Relationship to you:(e.g., parent, mate, friend) _____

Telephone Number of Contact Person: _____

Name:_____ **Birthdate:** (DDMMMYY) _ _ _ _ _ _ _ _ ID___

START DATE: (DDMMMYY:hh:mm) _ _ _ _ _ _ _ _ : _ _ : _ _

END DATE: (DDMMMYY:hh:mm) _ _ _ _ _ _ _ _ : _ _ : _ _

Accelerometers: Epoch (hh:mm:ss) _ _ : _ _ : _ _

CSA Right # _____ CSA Left # _____

Actometer Readings: Acto Set ___ Right Acto # _____ Left Acto # _____

ACTO START READING: (hh:mm:ss)

Right arm: _ _ : _ _ : _ _ Left arm: _ _ : _ _ : _ _

ACTO FINAL READING: (hh:mm:ss)

Right arm: _ _ : _ _ : _ _ Left arm: _ _ : _ _ : _ _

BEGIN TIME (Acto & CSA): (DDMMMYY:hh:mm)

Right: _ _ _ _ _ _ _ _ : _ _ : _ _ Left: _ _ _ _ _ _ _ _ : _ _ : _ _

END TIME:(Acto & CSA) (DDMMMYY:hh:mm)

Right: _ _ _ _ _ _ _ _ : _ _ : _ _ Left: _ _ _ _ _ _ _ _ : _ _ : _ _

Height (cm): Height1 _____ Height2 _____

Weight (lbs): Weight1 _____ Weight2 _____

Arm Length: Shoulder to elbow (cm): Right 1 _____ Right 2 _____

Left 1_____ Left 2 _____

Elbow to Wrist (cm): Right 1 _____ Right 2 _____

Left 1 _____ Left 2 _____

Hand Length (cm.): Right 1 _____ Right 2 _____

Left 1 _____ Left 2 _____

Wrist Breadth (cm.): Right 1 _____ Right 2 _____

Left 1 _____ Left 2 _____

Shoulder bag? (L= 1 Both=2 R=3): ____

'Morning' or 'Evening' Person? (in energy level, easiness in rising) _____

(am=1 ?=2 pm=3)

Activity Instrument Instructions

So... you're wearing motion recorders...

1. **Make sure the instruments fit snugly,** enough so that they do not flop around on your wrist.

2. **Wear them as much as possible**, including when you sleep. We want to get as complete a measure of your overall activity as possible.

3. **Do not wind the watches**.

4. **The instruments are not waterproof**, so... if you must bathe or swim or wash your dishes ... *take them off both wrists*. They are not delicate, but they should not be hit hard. If you are doing something like playing volleyball, please remove them. With these few exceptions, we urge you to **continue your normal activities** while wearing the instruments.

5. **Put each instrument back on the same wrist from which it was removed**. Each instrument is labeled as "Right" or "Left". If they are removed, return each to the appropriate wrist.

6. **If you have a problem or a question**, call Nancy McKeen at 474-6955.

Summary of Procedure

1. Get on with your life.

2. Record any occasions when the instruments are not worn (for showers, etc.)

Day	Real Time (HH:MM am/pm)		Reason for removal
	Off	On	

ID ____ Activity Diary DATE: ____ : ____ : ____

1 SLEEP	2 VERY LIGHT	3 LIGHT	4 MODERATE	5 HARD	6 VERY HARD

ACTIVITY LEVEL

6 v hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
5 hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
4 mod.	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
3 light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
2 v light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
1 sleep	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
TIME	12	1	2	3	4	5	6	7	8	9	10	11	12

6 v hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
5 hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
4 mod.	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
3 light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
2 v light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
1 sleep	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
TIME	12	1	2	3	4	5	6	7	8	9	10	11	12

6 v hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
5 hard	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
4 mod.	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
3 light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
2 v light	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
1 sleep	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o	o o o
TIME	12	1	2	3	4	5	6	7	8	9	10	11	12

Activity Examples

VERY HARD ACTIVITIES (6)

Occupational tasks: Very hard physical labour - Digging or Chopping with heavy tools, Carrying heavy loads, such as bricks or lumber or sandbags, Farming

Household tasks: Digging or hoeing a garden, Carrying loads uphill or upstairs

Sports or leisure: Jogging or Running, Singles Tennis, Badminton, Racquetball or Squash, Soccer, Wrestling, Step Aerobics or Aerobic Dancing, Skipping, Rowing, Basketball, Skiing, Skating, Tobogganing

HARD ACTIVITIES (5)

Occupational tasks: Physical labour: Heavy carpentry, Construction work

Household tasks: Heavy housework: Scrubbing floors, Unloading groceries, Window washing (removing windows), Lifting boxes or Moving furniture, Vacuuming, Raking the lawn, Snow shoveling (few inches)

Sports or leisure activities: Doubles tennis, Cycling (fast), Dancing (e.g. folk, square, line dancing), Weightlifting (heavier weights)

MODERATE ACTIVITIES (4)

Occupational tasks: Mail Delivery, Patrolman, Waiting tables, Housepainter, Wallpapering, Truck driving (making deliveries and lifting and carrying light objects)

Household tasks: Sweeping, Dusting, Mopping, Doing Laundry, Making beds, Cleaning the refrigerator, Weeding the garden, Mowing the lawn, Washing the car

Sports or leisure: Brisk walking (12-13 mins per Km), Bowling, Volleyball, Ping pong, Shooting baskets, Bicycling moderately on level ground, Weightlifting (small weights), Calisthenic exercises, Playing catch, Baseball

LIGHT ACTIVITIES (3)

Occupational tasks: Photocopying, Going for coffee, Looking for books in the library

Household activities: Getting dressed, Tidying up, Washing dishes, Cooking, Shopping

Sports or leisure activities: Strolling

VERY LIGHT ACTIVITIES (2)

Occupational tasks: Writing, Reading, Typing at computer, Talking on phone, Sitting in class

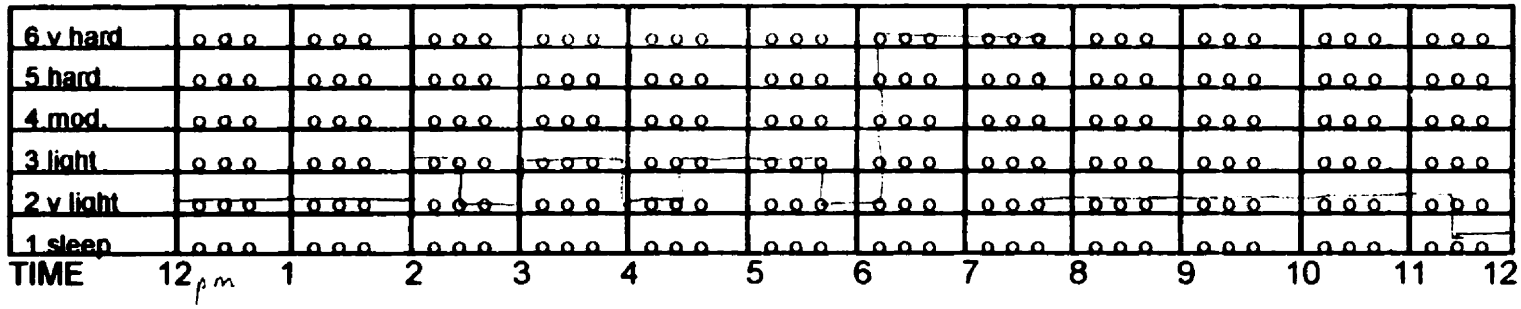
Household activities: Eating, Knitting, Driving a car

Sports or leisure activities: Chess, Playing cards, Painting pictures, Listening to music, TV

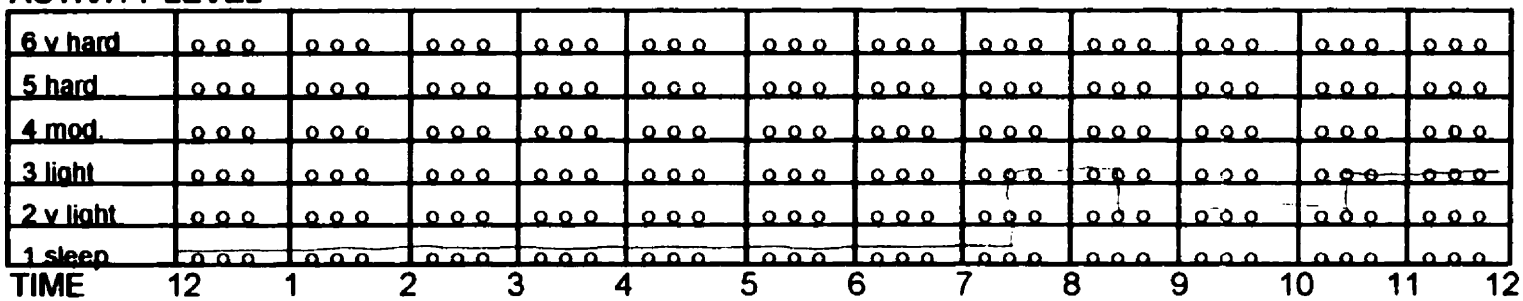
ID ____ Activity Diary Example Date _____

1 SLEEP	2 VERY LIGHT	3 LIGHT	4 MODERATE	5 HARD	6 VERY HARD

ACTIVITY LEVEL



ACTIVITY LEVEL



Each column of the table represents one hour of time. Each of the small circles within a square represents 15 minutes. To the best of your ability, indicate your level of activity for each quarter hour of the day by *drawing a line to join each successive circle at the appropriate level of activity*. To estimate the correct activity level, use as guidelines the examples supplied. If you are not sure, make a note of the activity, and we can discuss it when you return for your second visit.

In the above example, I started my diary at 12 pm on the first day. I went to the library to read for 2 hours, walked to my car, drove home, made dinner, watched TV for an hour, drove to the gym for a workout. I then drove home, got ready for bed and read. I slept from 11.30 pm to 7:15 am. The next morning, I got dressed, made a lunch, gathered my books together, drove to school, sat in class for 2 hours, went to lunch, and walked to my lab. At 12 pm noon, I finished keeping the diary.

Affect Intensity Measure (AIM)

The following statements refer to the emotional reactions to typical life-events. Please indicate how YOU react to these events by circling the appropriate number for each statement from the following scale. Please base your answers on how YOU react, not on how you think others react or how a person should react.

NEVER 1	ALMOST NEVER 2	OCCASIONALLY 3	USUALLY 4	ALMOST ALWAYS 5	ALWAYS 6

1.	When I accomplish something difficult I feel delighted or elated.	1 2 3 4 5 6
2.	When I feel happy it is a strong type of exuberance.	1 2 3 4 5 6
3.	I enjoy being with other people very much.	1 2 3 4 5 6
4.	I feel pretty bad when I tell a lie.	1 2 3 4 5 6
5.	When I solve a small personal problem, I feel euphoric.	1 2 3 4 5 6
6.	My emotions tend to be more intense than those of most people.	1 2 3 4 5 6
7.	My happy moods are so strong that I feel like I'm "in heaven."	1 2 3 4 5 6
8.	I get overly enthusiastic.	1 2 3 4 5 6
9.	If I complete a task I thought was impossible, I am ecstatic.	1 2 3 4 5 6
10.	My heart races at the anticipation of some exciting event.	1 2 3 4 5 6
11.	Sad movies deeply touch me.	1 2 3 4 5 6
12.	When I'm happy it's a feeling of being untroubled and content rather than being zestful and aroused.	1 2 3 4 5 6
13.	When I talk in front of a group for the first time my voice gets shaky and my heart races.	1 2 3 4 5 6
14.	When something good happens, I am usually much more jubilant than others.	1 2 3 4 5 6
15.	My friends might say I'm emotional.	1 2 3 4 5 6
16.	The memories I like the most are of those of times when I felt content and peaceful rather than zestful and enthusiastic.	1 2 3 4 5 6
17.	The sight of someone who is hurt badly affects me strongly.	1 2 3 4 5 6
18.	When I'm feeling well it's easy for me to go from being in a good mood to being really joyful.	1 2 3 4 5 6

NEVER 1	ALMOST NEVER 2	OCCASIONALLY 3	USUALLY 4	ALMOST ALWAYS 5	ALWAYS 6

19.	"Calm and cool" could easily describe me.	1 2 3 4 5 6
20.	When I'm happy I feel like I'm bursting with joy.	1 2 3 4 5 6
21.	Seeing a picture of some violent car accident in a newspaper makes me feel sick to my stomach.	1 2 3 4 5 6
22.	When "I'm happy I feel very energetic.	1 2 3 4 5 6
23.	When I receive an award I become overjoyed.	1 2 3 4 5 6
24.	When I succeed at something, my reaction is calm contentment.	1 2 3 4 5 6
25.	When I do something wrong I have strong feelings of shame and guilt.	1 2 3 4 5 6
26.	I can remain calm even on the most trying days.	1 2 3 4 5 6
27.	When things are going good I feel "on top of the world."	1 2 3 4 5 6
28.	When I get angry it's easy for me to still be rational and not overreact.	1 2 3 4 5 6
29.	When I know I have done something very well, I feel relaxed and content rather than excited and elated.	1 2 3 4 5 6
30.	When I do feel anxiety it is normally very strong.	1 2 3 4 5 6
31.	My negative moods are mild in intensity.	1 2 3 4 5 6
32.	When I am excited over something I want to share my feelings with everyone.	1 2 3 4 5 6
33.	When I feel happiness, it is a quiet type of contentment.	1 2 3 4 5 6
34.	My friends would probably say I'm a tense or "high-strung" person.	1 2 3 4 5 6
35.	When I'm happy I bubble over with energy.	1 2 3 4 5 6
36.	When I feel guilty, this emotion is quite strong.	1 2 3 4 5 6
37.	I would characterize my happy moods as closer to contentment than to joy.	1 2 3 4 5 6
38.	When someone compliments me, I get so happy I could "burst."	1 2 3 4 5 6
39.	When I am nervous I get shaky all over.	1 2 3 4 5 6
40.	When I am happy the feeling is more like contentment and inner calm than one of exhilaration and excitement.	1 2 3 4 5 6

ref: Weinfurt, K. P., Bryant, F. B., & Yarnold, P. R. (1994). The factor structure of the Affect Intensity Measure: In search of a measurement model. *Journal of Research in Personality*, *28*, 314-31.

Larsen, R. J., and Diener, E. (1987). Affect intensity as an individual difference characteristic: A review. *Journal of Research in Personality*, *21*, 1-39.

*Affect Intensity Measure - AIM Scoring

40 items, score 1-6
from never, almost never, occasionally, usually, almost always, always

• = items reflected for Weinfurt's factors

Positive Affectivity 4factor Weinfurt':
AIM1-AIM3 AIM5 AIM7-AIM10 AIM14 AIM18
AIM20 AIM22 AIM23 AIM27 AIM32 AIM35 AIM38

Negative Intensity 4factor Weinfurt':
AIM6 AIM13 AIM15 AIM19* AIM26* AIM28* AIM30 AIM31• AIM34 AIM39

Serenity Weinfurt':
VAR AIM12 AIM16 AIM24 AIM29 AIM33 AIM37 AIM40

Negative Reactivity 4factor Weinfurt':
AIM4 AIM11 AIM17 AIM21 AIM25 AIM36

Overall AIM score': AIM1-AIM40

The Lateral Preference Inventory

Simply read each of the questions below. Decide which hand, foot, etc. you use for each activity and then circle the answer that describes you the best. If you are unsure of any answer, try to act out the action.

1. With which hand do you draw?	Left	Right	Either
2. Which hand would you use to throw a ball to hit a target?	Left	Right	Either
3. In which hand would you use an eraser on paper?	Left	Right	Either
4. Which hand removes the top card when you are dealing from a deck?	Left	Right	Either
5. With which foot would you kick a ball to hit a target?	Left	Right	Either
6. If you wanted to pick up a pebble with your toes, which foot would you use?	Left	Right	Either
7. Which foot would you use to step on a bug?	Left	Right	Either
8. If you had to step up onto a chair, which foot would you place on the chair first?	Left	Right	Either
9. Which eye would you use to look through a telescope?	Left	Right	Either
10. If you had to look into a dark bottle to see how full it was, which eye would you use?	Left	Right	Either
11. Which eye would you use to peep through a keyhole?	Left	Right	Either
12. Which eye would you use to sight down a rifle?	Left	Right	Either
13. If you wanted to listen in on a conversation going on behind a closed door, which ear would you place against the door?	Left	Right	Either
14. Into which ear would you place the earphone of a transistor radio?	Left	Right	Either
15. If you wanted to hear someone's heartbeat which ear would you place against their chest?	Left	Right	Either
16. Imagine a small box resting on a table. This box contains a small clock. Which ear would you press against the box to find out if the clock was ticking?	Left	Right	Either

Reference for Coren's lateral preference inventory:

Coren, S. (1993). The lateral preference inventory for measurement of handedness, footedness, eyedness, and earedness: Norms for young adults. *Bulletin of the Psychonomic Society, 31*, 1-3.

Scoring Instructions:

Items 1-4 are handedness, 5-8 are footedness, 9-12 are eyedness, and 13-16 are earedness. For each 4-item subscale, compute (R-L), where R is the number of "right" responses and L is the number of "left" responses.

Feedback on the Activity Study

This study is an example of both correlational and quasi-experimental studies. I will correlate the movement data from the two different instruments, expecting that there is a high positive correlation between the two types of instruments. The correlational study is important because, in addition to carrying out experiments, it is important to collect ecologically valid data in every-day situations.

I need reliability data for my activity measures to understand how accurately and consistently each of the instruments measures activity. If my instruments are inconsistent or inaccurate, the data that I collect also will be inconsistent and inaccurate, making it difficult for me to understand and interpret my results or confirm my hypotheses. (Garbage in equals garbage out!)

The diary should provide external validity for the instruments. The diary will help me to determine if the instruments measure what I think they are measuring.

In analyzing the participants' data, I can determine the variance in activity that can be accounted for by the instruments themselves, by the individual who is wearing the instrument, and by measurement error. This information informs me about how much power I have to detect individual differences, and so helps to give me an idea about how many participants I will need for my dissertation activity study.

Appendix B

Study 2: Instruments and forms:

Consent form

Activity monitors and demographic information form

Pavlovian Temperament Survey (PTS)

PTS scoring key

Behavioral Inhibition/Behavioral Activation (BISBAS):

subscales and reference

BISBAS scale

BISBAS scoring

PANAS - current

PANAS - since the last time

PANAS scoring and reference

Dichotic Listening Task (DL) instructions and reference

DL correct stimulus trials at right- and left- ears, as recorded on tape

CONSENT FORM

ACTIVITY STUDY, NANCY McKEEN, University of Manitoba

This study is being conducted by Nancy McKeen from the Department of Psychology at the University of Manitoba. The goal of the project is to examine motor activity and its emotional correlates. Each participating person's motor activity level will be measured with two small watch-like motion recorders worn on each wrist for 24 hours. I will measure other characteristics, such as temperament traits, personality, and mood. I will also measure language, emotional perception, and dexterity. I want to see if such characteristics are related to activity level. This study has been approved by the Human Ethical Review Committee of the Psychology Department.

In signing this consent form, I understand that:

- my participation in the project is entirely voluntary;
- I can withdraw from the study at any time and for any reason;
- my participation involves completing some questionnaires about my personality and characteristic behaviour;
- my participation involves wearing motion recorders, answering demographic questions, being measured for physical size (e.g., height and weight), completing a test of motor dexterity and ear perception; and being asked for my hand, eye, foot, and ear preferences;
- information about me will be kept confidential and the data will be kept in locked locations;
- scientific reports about the results of the research may be prepared if findings warrant, but my name (or specific details that might identify me) will not be used in such reports without my permission;
- I have been given a copy of this form; and
- I can contact the Chair, Human Ethical Review Committee, Department of Psychology (474-9338), with any complaints about this research. If you have any other questions, call Nancy McKeen or Dr. Warren O. Eaton at 474-6955.

Thank you for your time and valuable participation.

Name: _____ Date: _____

Telephone: Home:_____ Work:_____

Name of a Contact Person: _____

(a person who might get a message to you)

Activity Monitors & Demographic Information

Name:_____ ID____

Actometers: Acto Set: ____ Left Acto # _____ Right Acto # _____

ACTO START DATE: (DDMMMYY:hh:mm) _ _ _ _ _ _ _ _ : _ _ : _ _

ACTO START READING: (hh:mm:ss)

Left arm: _ _ : _ _ : _ _ Right arm: _ _ : _ _ : _ _

ACTO END DATE: (DDMMMYY:hh:mm) _ _ _ _ _ _ _ _ : _ _ : _ _

ACTO FINAL READING: (hh:mm:ss)

Left arm: _ _ : _ _ : _ _ Right arm: _ _ : _ _ : _ _

Accelerometers: Epoch (hh:mm:ss) _ _ : _ _ : _ _

CSA Right #: _____ CSA Left #: _____

CSA BEGIN TIME: (DDMMMYY:hh:mm)

Left: _ _ _ _ _ _ _ _ : _ _ : _ _ Right: _ _ _ _ _ _ _ _ : _ _ : _ _

CSA END TIME: (DDMMMYY:hh:mm)

Left: _ _ _ _ _ _ _ _ : _ _ : _ _ Right: _ _ _ _ _ _ _ _ : _ _ : _ _

How typical a day was this for you? For activity? (1=Not, 2=Fairly, 3=Very): _____

For frequency of interacting with others? _____

For quality of interactions with others? _____

Did you participate in any athletic activities while you were wearing the monitors? ____

In **which sports** did you participate? _____

Gender: (1=M, 2=F): _____

Birthdate: (DDMMMYY) _ _ _ _ _ _ _ _

Height (cm): Height: _____

Weight (lbs): Weight1: _____ Weight2:_____

Shoulder bag? (L= 1 Both=2 R=3): ____

'Morning' or 'Evening' Person? (in energy level, easiness in rising) _____

(am=1 ?=2 pm=3)

ID _____ Pavlovian Temperament Survey

The items in this inventory refer to various aspects of temperament - the ways people react to everyday events. There are no right or wrong answers; every type of temperament has its advantages.

Your answers to these questions will be used only for research purposes. It is very important that you answer the questions truthfully.

Please respond to the items without looking back at your answers to earlier items. Try to describe yourself honestly: in terms of **what you have been like in the past year**, not what or how you would like to be. You may find it easier to respond to the items if you compare yourself with other people of the same sex and roughly the same age.

Naturally, your behaviour and views change from situation to situation, but please try to describe yourself as you usually are - in general on the average.

Please respond to the items below by circling the number following the statement that best describes your view of each statement.

STRONGLY DISAGREE 1	DISAGREE 2	AGREE 3	STRONGLY AGREE 4

1.	Sudden danger would prevent me from carrying on with something I am doing.	1 2 3 4
2.	When someone hurts me, I try to get back at them, "tit for tat."	1 2 3 4
3.	I don't mind if I suddenly have to work with people I don't know.	1 2 3 4
4.	I find it unpleasant when I've made up my mind to do something, and for some reason I can't begin on it.	1 2 3 4

STRONGLY DISAGREE 1	DISAGREE 2	AGREE 3	STRONGLY AGREE 4

5.	I can feel at home very quickly in strange places.	1 2 3 4
6.	I avoid noise when I am reading.	1 2 3 4
7.	I can switch quickly from one job to another.	1 2 3 4
8.	I gladly accept the challenges of risky projects.	1 2 3 4
9.	When it becomes necessary, it is easy for me to stop watching TV or listening to the radio.	1 2 3 4
10.	I get flustered easily when I am under a lot of pressure.	1 2 3 4
11.	When I am angry and I meet friends who are in high spirits, I can easily forget my anger and enjoy their company.	1 2 3 4
12.	During a conversation, I sometimes have trouble waiting for my turn to speak.	1 2 3 4
13.	I like it when I can do several things at the same time.	1 2 3 4
14.	It is hard for me to suppress my annoyance, even when it is necessary.	1 2 3 4
15.	My efficiency declines when there is a lot going on around me.	1 2 3 4
16.	It is hard for me to give up something that I am enjoying (eg., watching TV) even when others ask me to.	1 2 3 4
17.	Even when I am working very hard, I feel fresh.	1 2 3 4
18.	Unexpected events are stressful for me.	1 2 3 4
19.	I don't have to open a present right away just to see what it is.	1 2 3 4
20.	It takes me quite a while to get used to a new place.	1 2 3 4
21.	I would be unable to function if I learned about the death of someone very close to me.	1 2 3 4
22.	I can easily do many different things one after another.	1 2 3 4
23.	My performance suffers in an environment with a lot of distractions.	1 2 3 4

STRONGLY DISAGREE 1	DISAGREE 2	AGREE 3	STRONGLY AGREE 4

24.	It is difficult for me to interrupt something I am doing, even if someone asks me to.	1 2 3 4
25.	If carrying out a plan becomes dangerous, that is a good reason for me to stop.	1 2 3 4
26.	If I am in a bad mood, even things that I usually enjoy can't get me out of it.	1 2 3 4
27.	It is difficult for me to let other people finish what they are saying.	1 2 3 4
28.	I don't care if my hobby inconveniences other people.	1 2 3 4
29.	I can control myself when a nasty comment is on the tip of my tongue.	1 2 3 4
30.	I like working when there is a lot going on around me.	1 2 3 4
31.	When my job changes, I am quick to adust.	1 2 3 4
32.	I am reluctant to take major risks.	1 2 3 4
33.	I adapt quickly to changes in the way my work is organized.	1 2 3 4
34.	I keep cool if I am under a lot of time pressure.	1 2 3 4
35.	At festive occasions I can hardly wait for the formalities to be over.	1 2 3 4
36.	It is easy for me to shift back and forth between very different activities.	1 2 3 4
37.	I can't work if I am surrounded by hustle and bustle.	1 2 3 4
38.	When someone has hurt my feelings, I can regain my composure if I have to.	1 2 3 4
39.	I usually answer questions immediately, even when it is advisable to wait.	1 2 3 4
40.	I can easily adapt to sudden changes in my work schedule.	1 2 3 4

STRONGLY DISAGREE 1	DISAGREE 2	AGREE 3	STRONGLY AGREE 4

41.	It is easy for people to notice my disappointment, even if I would like to hide it.	1 2 3 4
42.	Fatigue often causes me to make mistakes.	1 2 3 4
43.	If need be, I can refrain from expressing my opinion, even if I know I am right.	1 2 3 4
44.	If I am staying in a new place, I get used to it quickly.	1 2 3 4
45.	I can't defend myself very well when I am attacked in public.	1 2 3 4
46.	I don't have any trouble changing quickly from one activity to another.	1 2 3 4
47.	Sudden danger does not discourage me.	1 2 3 4
48.	I don't like it all when I cannot begin something I have planned to do.	1 2 3 4
49.	I don't like to speak in public.	1 2 3 4
50.	I get impatient when I can't begin a meal because I'm waiting for others.	1 2 3 4
51.	I need a lot of time before I can go from being sad to being happy.	1 2 3 4
52.	My face is like an open book which everyone can read.	1 2 3 4
53.	I don't like to make decisions that can have wide-ranging consequences.	1 2 3 4
54.	I get unsettled by unexpected changes in my daily routine.	1 2 3 4
55.	I get rattled when I work under noisy conditions.	1 2 3 4
56.	It is hard for me to control my curiosity when I have the chance to look at someone else's things or notes.	1 2 3 4
57.	I quickly get used to new working conditions.	1 2 3 4
58.	I get impatient easily when I am explaining something.	1 2 3 4

STRONGLY DISAGREE 1	DISAGREE 2	AGREE 3	STRONGLY AGREE 4

59.	I need a while to "warm up" when I'm starting something new.	1 2 3 4
60.	Loud conversations nearby do not affect how well I get things done.	1 2 3 4
61.	I can't change from one emotion to another.	1 2 3 4
62.	When I really feel like enjoying myself, I am too impatient to wait for others who want to come.	1 2 3 4
63.	I get tired quickly when I have to work longer than usual.	1 2 3 4
64.	When I have asked someone to do a job, it is hard for me to wait until it is finished.	1 2 3 4
65.	I love talking to several people at the same time.	1 2 3 4
66.	I would panic if I were the victim of a theft.	1 2 3 4

SCORING KEY: PTS-AmE (66-item)

This key allows scoring of Strength of Excitation (SE), Strength of Inhibition (SI), and Mobility of Nervous Processes (MO). For each scale, some of items are reverse-worded.

The key is based upon assigning a numerical score of 1 to "strongly agree," through 4 for "strongly disagree," so that coding can proceed in a natural direction — that is with higher numbers representing respondents' marks further to the right in the set of response boxes for each item. Because "strongly agree" is then represented by the lowest number, scores in which higher numerical values represent greater amounts of the trait must be obtained by *reverse coding of positively worded items—items whose wording reflects the trait in question.* Such items are indicated by a (-) in the key.

Strength of Excitation (SE)	**Strength of Inhibition (SI)**	**Mobility (MO)**
1	2	3 (-)
6	4	5 (-)
8 (-)	9 (-)	7 (-)
10	12	11 (-)
15	14	13 (-)
17 (-)	16	18
21	19 (-)	20
23	24	22 (-)
25	27	26
30 (-)	28	31 (-)
32	29 (-)	33 (-)
34 (-)	35	36 (-)
37	39	38 (-)
42	41	40 (-)
45	43 (-)	44 (-)
47 (-)	48	46 (-)
49	50	51
53	52	54
55	56	57 (-)
60 (-)	58	59
63	62	61
66	64	65 (-)

BIS/BAS Scale Items

Ref: Carver, C. S, & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology, 67*, 319-333.

1. BIS
   a. If I think something unpleasant is going to happen, I usually get pretty "worked up."
   b. I worry about making mistakes.
   c. Criticism or scolding hurts me quite a bit.
   d. I feel pretty worried or upset when I think or know somebody is angry at me.
   e. *Even if something bad is about to happen to me, I rarely experience fear or nervousness.*(reverse code)
   f. I feel worried when I think I have done poorly at something.
   g. *I have few fears compared to my friends.* (Reverse code)

2. BAS Reward Responsiveness
   a. When I get something I want, I feel excited and energized.
   b. When I'm doing well at something, I love to keep at it.
   c. When good things happen to me, it affects me strongly.
   d. It would excite me to win a contest.
   e. When I see an opportunity for something I like, I get excited right away.

3. BAS Drive
   a. When I want something, I usually go all-out to get it.
   b. I go out of my way to get things I want.
   c. If I see a chance to get something I want, I move on it right away.
   d. When I go after something, I use a "no holds barred" approach.

4. BAS Fun Seeking
   a. I will often do things for no other reason than that they might be fun.
   b. I crave excitement and new sensations.
   c. I'm always willing to try something new if I think it will be fun.
   d. I often act on the spur of the moment.

Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4

1.	If I think something unpleasant is going to happen, I usually get pretty "worked up."	1	2	3	4
2.	When I get something I want, I feel excited and energized.	1	2	3	4
3.	When I want something, I usually go all-out to get it.	1	2	3	4
4.	I will often do things for no other reason than that they might be fun.	1	2	3	4
5.	I worry about making mistakes.	1	2	3	4
6.	When I'm doing well at something, I love to keep at it.	1	2	3	4
7.	I go out of my way to get things I want.	1	2	3	4
8.	I crave excitement and new sensations.	1	2	3	4
9.	Criticism or scolding hurts me quite a bit.	1	2	3	4
10.	When good things happen to me, it affects me strongly.	1	2	3	4
11.	If I see a chance to get something I want, I move on it right away.	1	2	3	4
12.	I feel pretty worried or upset when I think or know somebody is angry at me.	1	2	3	4
13.	Even if something bad is about to happen to me, I rarely experience fear or nervousness.	1	2	3	4
14.	It would excite me to win a contest.	1	2	3	4
15.	I'm always willing to try something new if I think it will be fun.	1	2	3	4
16.	I feel worried when I think I have done poorly at something.	1	2	3	4
17.	I have few fears compared to my friends.	1	2	3	4
18.	When I see an opportunity for something I like, I get excited right away.	1	2	3	4
19.	When I go after something, I use a "no holds barred" approach.	1	2	3	4
20.	I often act on the spur of the moment.	1	2	3	4

BISBAS Scoring

BIS: Mean of items: 1 5 9 12 13* 16 17*

BAS Drive: Mean of items: 3 7 11 19

BAS Reward: Mean of items: 2 6 10 14 18

BAS Fun: Mean of items: 4 8 15 20

Mean BAS: Mean of Drive, Reward, and Fun subscales

* = reverse score item

Likert type scale: 1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree

PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way **right now, that is, at the present moment**. Use the following scale to record your answers:

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

____interested	____guilty	____irritable	____determined
____distressed	____scared	____alert	____attentive
____excited	____hostile	____ashamed	____jittery
____upset	____enthusiastic	____inspired	____active
____strong	____proud	____nervous	____afraid

PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way **since the last time you completed the checklist**. Use the following scale to record your answers:

Very slightly or Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
1	**2**	**3**	**4**	**5**

____interested	____guilty	____irritable	____determined
____distressed	____scared	____alert	____attentive
____excited	____hostile	____ashamed	____jittery
____upset	____enthusiastic	____inspired	____active
____strong	____proud	____nervous	____afraid

PANAS Scoring

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063-1070.
20 items, 2 subscales - PA (10items), NA (10 items);

* No reflections on the PANAS scores need reverse scoring.;

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P_PA = MEAN (OF P1 P3 P5 P9 P10 P12 P14 P16 P17 P19);
P_NA = MEAN (OF P2 P4 P6 P7 P8  P11 P13 P15 P18 P20);

   P_PA  = 'PANAS Positive Affect'
   P_NA  = 'PANAS Negative Affect'

;
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ID#: _____ Date (ddMONyy): _____

DICHOTIC EMOTIONAL WORDS TASK (WATERLOO TAPE)

Instructions:

1. Check that both channels are equal in volume using the calibration tone. "The tone should sound like it is coming from the centre of your head."
2. Explain the dichotic procedure
   a. i.e., hear two different words at same time - one in each ear.
3. Demonstrate the dichotic procedure:
   a. one male voice & one female voice
   b. CV's: PA, DA, GA, KA, PA, TA
   c. ask participant to repeat what male or female voice says
   d. 8 trials
4. Explain the experiment.
   a. one male voice
   b. 4 words: BOWER, DOWER, POWER, TOWER
   c. 4 tones of voice: HAPPY, SAD, ANGRY, NEUTRAL
   d. 16 stimuli in total
   e. Listen for target 'X' (eg, "the word, BOWER" or "a Happy tone of voice"
   f. Play all 16 stimuli binaurally - subject should identify one example of target 'X." If not, play the stimuli again.
5. Repeat:
   a. Listen for 'X'
   b. "If you hear 'X' in either ear - tell me (circle) 'YES' "
   c. "If you do not hear 'X' in either ear - tell me (circle) 'NO' "
6. There are 144 trials, divided into 8 sets of 18 trials. After each set of 18, there is a 10 second break. A tone will indicate when the next set is about to begin.
7. Ask participant if there are any questions.
8. Play Block One.
9. Response sheet (2 pages) should be photocopied single sheet, double-sided.
10. Tape & Instructions distributed for M. P. Bryden by Dr. B. Bulman-Fleming, Department of Psychology, University of Waterloo, Waterloo, ON N2L 3G1 phone: 519-888-4567 x3043; FAX: 519-746-8631 email: bfleming@watarts.uwaterloo.ca

DICHOTIC EMOTIONAL WORDS TAPE

Tokens are 500 milliseconds, presented with a 4500 millisecond SOA.
There is a 10 second break every 18 trials.
A tone marks the start of another set of 18 trials.

Dichotic Demonstration Trials (3 second ISI)
- Presented once at beginning of tape.
- Ask subject to repeat what the male (or female) voice says.

1. "Ready" signal
2. f_BA - m_KA
3. f_PA - m_GA
4. m_BA - f_KA
5. m_GA - f_PA
6. m_PA - f_GA
7. f_KA - m_BA
8. m_KA - f_BA
9. f_GA - m_PA

Binaural Demonstration of Stimuli (3 second SOA)
- Presented twice; once before BLOCK 1 and once before BLOCK 2.
- Ask subject to report the occurence of their target word and/or emotion.
- If subject does not report at least once, rewind and repeat demo trials.

1. Tone
2. Sad Power
3. Angry Power
4. Sad Tower
5. Neutral Bower
6. Sad Bower
7. Angry Dower
8. Sad Dower
9. Angry Bower
10. Happy Power
11. Happy Tower
12. Angry Tower
13. Neutral Dower
14. Neutral Power
15. Happy Dower
16. Neutral Tower
17. Happy Bower

Dichotic Experimental Trials
There are two blocks of 144 experimental trials, divided into sets of 18 trials as described below. Each of the 2 blocks is divided into Part A and Part B. In each Part, the 72 nonsimilar pairs of stimuli are presented once.

RESPONSE SHEET

HAND _____ TARGET _____ SUBJECT # _____
PROGRAM _____ SEX _____
ORDER _____ AGE _____

1.	YES	NO	19.	YES	NO	37.	YES	NO	55.	YES	NO
2.	YES	NO	20.	YES	NO	38.	YES	NO	56.	YES	NO
3.	YES	NO	21.	YES	NO	39.	YES	NO	57.	YES	NO
4.	YES	NO	22.	YES	NO	40.	YES	NO	58.	YES	NO
5.	YES	NO	23.	YES	NO	41.	YES	NO	59.	YES	NO
6.	YES	NO	24.	YES	NO	42.	YES	NO	60.	YES	NO
7.	YES	NO	25.	YES	NO	43.	YES	NO	61.	YES	NO
8.	YES	NO	26.	YES	NO	44.	YES	NO	62.	YES	NO
9.	YES	NO	27.	YES	NO	45.	YES	NO	63.	YES	NO
10.	YES	NO	28.	YES	NO	46.	YES	NO	64.	YES	NO
11.	YES	NO	29.	YES	NO	47.	YES	NO	65.	YES	NO
12.	YES	NO	30.	YES	NO	48.	YES	NO	66.	YES	NO
13.	YES	NO	31.	YES	NO	49.	YES	NO	67.	YES	NO
14.	YES	NO	32.	YES	NO	50.	YES	NO	68.	YES	NO
15.	YES	NO	33.	YES	NO	51.	YES	NO	69.	YES	NO
16.	YES	NO	34.	YES	NO	52.	YES	NO	70.	YES	NO
17.	YES	NO	35.	YES	NO	53.	YES	NO	71.	YES	NO
18.	YES	NO	36.	YES	NO	54.	YES	NO	72.	YES	NO

RESPONSE SHEET

TARGET _____ SUBJECT # _____

73. YES NO	91. YES NO	109. YES NO	127. YES NO
74. YES NO	92. YES NO	110. YES NO	128. YES NO
75. YES NO	93. YES NO	111. YES NO	129. YES NO
76. YES NO	94. YES NO	112. YES NO	130. YES NO
77. YES NO	95. YES NO	113. YES NO	131. YES NO
78. YES NO	96. YES NO	114. YES NO	132. YES NO
79. YES NO	97. YES NO	115. YES NO	133. YES NO
80. YES NO	98. YES NO	116. YES NO	134. YES NO
81. YES NO	99. YES NO	117. YES NO	135. YES NO
82. YES NO	100. YES NO	118. YES NO	136. YES NO
83. YES NO	101. YES NO	119. YES NO	137. YES NO
84. YES NO	102. YES NO	120. YES NO	138. YES NO
85. YES NO	103. YES NO	121. YES NO	139. YES NO
86. YES NO	104. YES NO	122. YES NO	140. YES NO
87. YES NO	105. YES NO	123. YES NO	141. YES NO
88. YES NO	106. YES NO	124. YES NO	142. YES NO
89. YES NO	107. YES NO	125. YES NO	143. YES NO
90. YES NO	108. YES NO	126. YES NO	144. YES NO

EXPERIMENTAL TRIALS - BLOCK 1

PART A

(Left ear - Right ear)

1.	NP-HT	19.	HP-ST	37.	AB-HT	55.	HT-AD
2.	NT-AP	20.	ST-AD	38.	ST-NP	56.	HB-SP
3.	HP-AD	21.	NB-AT	39.	ND-SB	57.	AB-SP
4.	AD-NB	22.	NB-HD	40.	AP-HT	58.	NP-HB
5.	SP-AD	23.	AT-HP	41.	HT-ND	59.	AT-SD
6.	AD-NP	24.	ST-ND	42.	AD-SB	60.	ND-SP
7.	SD-HP	25.	HB-AT	43.	SP-HT	61.	HP-ND
8.	AD-HB	26.	AP-ST	44.	NB-AP	62.	SD-AP
9.	SB-AT	27.	SB-NP	45.	HD-AP	63.	NB-SP
10.	HT-SB	28.	SB-HP	46.	HP-NB	64.	HD-SB
11.	NP-AB	29.	NT-SB	47.	SD-HT	65.	NT-HD
12.	SD-NB	30.	HD-SP	48.	SP-AT	66.	NP-SD
13.	SD-NT	31.	AP-ND	49.	HB-ND	67.	AB-ST
14.	AD-NT	32.	HD-NP	50.	AP-HB	68.	AT-NP
15.	HP-AB	33.	HB-SD	51.	AB-HD	69.	ST-HD
16.	HP-NT	34.	NB-ST	52.	ND-AT	70.	NT-HB
17.	NT-AB	35.	SB-AP	53.	SP-NT	71.	ND-AB
18.	ST-HB	36.	HT-NB	54.	AT-HD	72.	AB-SD

PART B

(Left ear - Right ear)

73.	HT-SP	91.	HP-SB	109.	HT-AP	127.	SB-ND
74.	HP-SD	92.	HB-NT	110.	SP-ND	128.	ST-AP
75.	AB-NP	93.	AT-HB	111.	NB-HT	129.	HB-NP
76.	NB-HP	94.	NT-AD	112.	AP-SB	130.	AP-NT
77.	NP-HD	95.	NP-SB	113.	SD-NP	131.	SB-HD
78.	AD-HT	96.	NT-HP	114.	AP-SD	132.	NT-SP
79.	AT-SB	97.	HT-AB	115.	HD-NB	133.	AD-HP
80.	NP-ST	98.	ST-NB	116.	NT-SD	134.	AT-NB
81.	ND-AP	99.	HP-AT	117.	AP-HD	135.	SP-HD
82.	HD-ST	100.	AB-NT	118.	NB-SD	136.	SB-AD
83.	NB-AD	101.	HB-ST	119.	SP-AB	137.	ND-HB
84.	ST-HP	102.	ND-HT	120.	SB-NT	138.	SD-AT
85.	HB-AP	103.	HT-SD	121.	NP-AD	139.	ND-ST
86.	AT-ND	104.	HT-NP	122.	SP-NB	140.	AT-SP
87.	SD-HB	105.	SD-AB	123.	ST-AB	141.	AB-ND
88.	AB-HP	106.	NP-AT	124.	ND-HP	142.	HD-AB
89.	HB-AD	107.	HD-NT	125.	HD-AT	143.	SB-HT
90.	AP-NB	108.	AD-SP	126.	AD-ST	144.	SP-HB

EXPERIMENTAL TRIALS - BLOCK 2

PART A

(Left ear - Right ear)

1.	HT-AP	19.	NB-HD	37.	AD-NP	55.	SP-AD
2.	ND-AP	20.	HB-SD	38.	ST-HD	56.	AP-HB
3.	AD-HB	21.	SP-NT	39.	HP-ST	57.	HP-ND
4.	HT-ND	22.	SP-NB	40.	ST-NP	58.	AD-HT
5.	SD-AP	23.	ND-AB	41.	HP-NT	59.	SP-HT
6.	AT-NP	24.	HB-ST	42.	NP-SB	60.	AT-HB
7.	SD-NP	25.	HP-SD	43.	AB-HP	61.	NB-AP
8.	AP-ST	26.	HD-NT	44.	NP-HD	62.	SD-NT
9.	ND-SP	27.	AP-NT	45.	AT-SB	63.	NB-HP
10.	NB-HT	28.	AB-SD	46.	SB-HP	64.	SB-HD
11.	HD-AP	29.	SB-ND	47.	NP-AB	65.	HT-SB
12.	ND-AT	30.	AT-SP	48.	AB-ST	66.	AT-NB
13.	AD-HP	31.	NT-AB	49.	NP-HB	67.	HT-AB
14.	HT-SD	32.	NB-ST	50.	AT-HD	68.	ST-ND
15.	NT-AD	33.	AD-NB	51.	SB-NT	69.	HD-SP
16.	NP-HT	34.	SD-AT	52.	HP-AT	70.	HB-ND
17.	SB-AP	35.	NB-SD	53.	SP-AB	71.	HB-SP
18.	HD-AB	36.	AD-SB	54.	NT-HB	72.	ST-AD

PART B

(Left ear - Right ear)

73.	AP-HT	91.	NB-AD	109.	HB-NT	127.	NP-AT
74.	HB-AD	92.	HD-SB	110.	SD-HT	128.	ST-HB
75.	NT-HD	93.	HB-NP	111.	SB-AD	129.	NB-SP
76.	SB-AT	94.	HP-AD	112.	AB-HT	130.	HD-ST
77.	HT-NB	95.	HT-NP	113.	ND-HP	131.	ND-HT
78.	AB-NP	96.	HB-AT	114.	SD-NB	132.	AB-ND
79.	SP-ND	97.	ND-SB	115.	HT-AD	133.	HD-NP
80.	AT-HP	98.	SD-AB	116.	NP-AD	134.	AB-HD
81.	ST-NB	99.	AD-NT	117.	NT-SP	135.	SD-HB
82.	SB-NP	100.	ST-HP	118.	AP-NB	136.	NP-ST
83.	AP-ND	101.	NT-HP	119.	AP-SB	137.	HB-AP
84.	SP-AT	102.	AB-SP	120.	HD-NB	138.	NB-AT
85.	NT-SD	103.	HD-AT	121.	AT-ND	139.	NT-SB
86.	AP-HD	104.	SD-HP	122.	AT-SD	140.	AD-ST
87.	ST-AB	105.	AP-SD	123.	ND-ST	141.	SP-HB
88.	HP-SB	106.	HP-NB	124.	NP-SD	142.	AB-NT
89.	ND-HB	107.	AD-SP	125.	HP-AB	143.	ST-AP
90.	NT-AP	108.	SB-HT	126.	HT-SP	144.	SP-HD