Infant Motor Activity: Temperament and Wake-Sleep Behaviour

by

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INFANT MOTOR ACTIVITY: TEMPERAMENT AND WAKE-SLEEP BEHAVIOUR

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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ABSTRACT

As a sign of well-being and normal development, motor activity has always been of central interest to the parents of young children. In recent years developmental psychologists have been examining the meaning of motor activity in the behavioural repertoire of the young as it has related to individual differences. In general terms, this study has focused on the issue of whether infants can be meaningfully differentiated in terms of their customary level of motor activity. Several more specific questions have been addressed. What kinds of behavioural states are related to infant motor activity? How does motor activity fit into the parents' perceptions of temperament? How do infants' daily patterns of behaviour influence parents' perceptions of their infant's temperament?

Two approaches to the study of infant activity were particularly pertinent to this study. Rothbart (1981), for example, has incorporated activity as a central dimension of infant temperament. She has defined activity level as the level of the child's gross motor activity, including movement of arms and legs, squirming and locomotor activity, and She has assumed that there is an

underlying constitutional tendency of the infant to react in a typical manner across a variety of situations. Eaton (Eaton & Enns, 1986) has defined activity level simply as the individual's customary level of energy expenditure through movement. Energy used to maintain bodily functions is excluded from the notion of activity level, by restricting consideration to movement-based calorie costs.

In the empirical literature activity has been accepted as a central component of child temperament because it appears as a relatively stable orthogonal dimension that provides good discriminative power to detect individual differences. Individual differences in activity level typically have been investigated within the temperament research tradition, including studies that relate temperament to 'crying' and 'wake-sleep' behaviours.

One paradoxical finding in the temperament research literature has been that motor activity in the young has been associated with both positive and negative characteristics. Using parent ratings, Matheny, Wilson, Dolan and Krantz (1981) clustered 'activity' with negative characteristics such as, 'temper,' 'crying' and 'irritability.' Likewise, Carey and McDevitt's (1978) study associated activity with 'difficult,' 'unresponsive'

and 'withdrawing' temperaments. However, Eaton and Dureski (1986) and Crockenberg and Acredolo (1983) also used parent ratings of temperament and found that activity was related to positive characteristics such as 'smiling and laughter' in three-month olds. One goal of this study was to address this paradox.

Validity of parent ratings has been a problem in infant temperament studies. Several researchers have found discrepancies between objective activity measures and parent ratings of their childrens' activity. The present study has examined both parent ratings and objective measures of activity to evaluate convergent validity for a parent rating scale, Rothbart's (1981) Infant Behavior Questionnaire (IBQ).

Subjects in the study numbered 46 infants (16 males and 30 females), having a mean age of 24.2 weeks. Parents of the infants were asked to complete the IBQ, a measure of infant temperament, at the beginning of the study. The IBQ included an 'activity' subscale as well as subscales for 'smiling and laughter,' 'fear of novelty,' 'distress to limitations,' 'soothability' and 'duration of orienting.' At an initial home visit, the IBQ was collected, and further assessments were carried out. The infants wore motion recorders (actometers), one per limb,

for a 48-hour period at home, as an objective measure of activity (Eaton & Dureski, 1986). The actometers were modified wristwatches responsive to movement. Infants were also weighed, measured and assessed on their physical development with the motor component of The Bayley Scales of Infant Development (Bayley, 1969). Over the same period of time that the infants were wearing the actometers, parents were asked to keep a structured diary (Barr, Kramer, Boisjoly, McVey-White, & Pless, 1986) of their infants' behaviours. The behaviours reported included sleep, contentedness, fussing, crying, and feeding. Parents were asked to carry out normal patterns of care during the entire data-collection period.

The main hypotheses of the study were as follows:

1. Convergent validity was predicted between the actometer measure of activity (AL) and the IBQ parent rating of activity.
2. Sex differences were predicted to be present with males more active than females.
3. 'Extreme' infants with either highly positive or highly negative affective states were predicted to be most active. That is, actometer measures of activity (AL) were expected to relate to both positive and negative aspects of temperament, as

expressed by both parent diary and the IBQ parent rating scale. Similarily, overall IBQ reactivity scores were predicted to relate to diary reports of contentedness and fussing and crying.

Both the IBQ parent-rated Activity subscale and the composite actometer score (the mean of the transformed raw scores from each of the limbs) were used as measures of motor activity. Diary-reported behaviours were based on durations of time awake for each diary category except 'sleeping.' Scores were transformed using the arcsine transformation to approximate a normal distribution.

Results confirmed that actometer-measured activity (AL) was significantly related to parent-rated activity. The convergent validity between the two instruments provides evidence that the IBQ (Rothbart, 1981) is a valid parent-rated measure of infant activity for infants at six months of age. Although Eaton and Dureski (1986) did not find validity at three months of age, it may be that by six months parents have had a chance to compare their infant with others and have a more accurate idea of their own infant's activity level.

Results did not confirm that sex differences were significant. Males were found to more active than females only at the trend level. However, results were similar to

those found by Eaton and Enns (1986) in their meta-analysis of sex differences in activity level. In the present study the effect size was 0.6 standard deviations for actometer measures of activity. That is, males were objectively about one-half standard deviation more active than females. However, parents did not rate their male babies as more active than their female babies. Because there were almost twice as many females as males in the study, the power to detect a sex difference was low, and results might have been clearer if the numbers had been balanced.

Results of the hypotheses dealing with the curvilinear relationships expected between activity and both positive and negative temperaments were partially confirmed. AL was significantly related to diary reports of crying and fussiness but was not related to reports of infant contentedness. Contentedness, in fact, was related to low levels of activity. It may be the case that the category 'content' covered too broad a range of behaviour to offer meaningful results. More likely, contentedness at six months of age was expressed as quiet, self-absorbed activity rather than as more physical active social interaction.

AL was related to overall IBQ positive reactivity but not negative reactivity. Although these results look puzzling at first glance, the relationship of AL with positive reactivity is mostly due to the relationship of AL with one of the components of the positive reactivity scale, parent-rated activity level.

Results of the predicted relationship for the IBQ positive reactivity score were not confirmed in that positive reactivity did not relate to diary contentedness. This lack of a relationship is, however, consistent with the finding that parent-rated activity level was not associated with diary contentedness. Activity level, it will be recalled, is a component of positive reactivity. The IBQ negative reactivity score was related to diary reports of crying and fussing as expected.

In sum, AL was most strongly correlated with crying and fussing behaviour. Moreover, the diary behaviour most pertinent to parental perceptions of activity was fussing. Fussing behaviour was significantly related to all of the parent-rated IBQ subscales. In contrast, 'crying' behaviour was related only to parent perceptions of activity. Actometer-measured activity (AL) was related to parental ratings of activity, but not to other parent-rated temperamental characteristics. It is concluded that

though it has links to other constructs such as fussiness, activity level is a distinct and useful dimension of individual difference in infancy.

INTRODUCTION

Background and History

Motor activity has been examined in the past mainly as an end-product or result of some prior cause. Only in recent years has interest been expressed in the role that activity itself has in explaining human behaviour. The meaningfulness of activity as an integral and universal component of behaviour has been considered a particularily salient feature in the behavioural repertoire of infants and children. Investigators are now focusing their attention on activity in the young to examine its relation to normal development in general and to the study of individual differences in particular.

According to Gordon and Bell (1961), the original psychological studies in infant activity developed in the 1930's out of the behaviourists' interests in learned and unlearned responses to stimulation. For example, Watson (1925) maintained that each unlearned act of the newborn (such as body movement and birth cry in addition to excretory and feeding responses) becomes conditioned shortly after birth. Those unlearned movements of the

body become organized and integrated into habits to maintain an "activity stream" which becomes more complex with age. Individual differences were seen simply as a result of different conditioning due to environmental differences. Irwin (1930) was impressed by what he termed the "mass activity" of an infant which described unorganized rapid body movements apparently lacking any specific external stimulus or response. He maintained that this type of movement was endogenous in origin.

Later, in the 1940's and 1950's infant activity was discussed in terms of psychoanalytic theory. Manifest activity in the newborn, for example, was seen as an indicator of the ego-less state in which the id functions dominated. Activity acted as a safety valve mechanism whereby tension was discharged in order to restore the infant's homeostatic equilibrium (Fries & Woolf, 1953). Escalona (1962) speculated that behavioural differences in neonatal activity level may foreshadow the development of other ego functions. High activity for example, might be associated with low frustration tolerance, difficulty in abstract thinking and ambivalence or turbulence in early object relations. She also noted individual differences in activity in sleep and awake states, and the need to assess consistencies and discrepancies in a baby's responsiveness in various states.

Still later perspectives in the 1960's drew attention to a possible convergence of aspects of neo-Pavlovian temperament theory, developed mainly in the Soviet Union, and individual difference constructs such as extraversion, developed in the West (Mangan & Paisey, 1983). The readiness, strength or speed of the nervous system to form conditioned responses, or the capacity of the nervous system to react quickly to changes in the environment was conceived as the physiological basis of temperament. Neo-Pavlovian tradition postulated the existence of a number of orthogonal hypothetical neurophysiological processes thought to underlie observable differences. For example, in 1972, Nebylitsyn (in Mangan & Paisey, 1983) distinguished on the basis of electroencephalograph (EEG) studies, two orthogonal parameters of temperament - general level of activity and emotionality. Nebylitsyn postulated that there is a cortical substrate for activity level which effects the individual's level of inner drive, or the tendency of the individual to interact with the environment. This tendency produces distinct, relatively stable individual personality traits or observable individual differences. In 1964, Gray (in Mangan & Paisey, 1983) proposed that the neo-Pavlovian construct of strength of the nervous system in human beings might be functionally equivalent to Western theories of arousal.

Current Perspectives on Activity

A current perspective, the natural history approach, shares an interest in particular motor behaviours with behaviourists and Pavlovians, but emphasizes observational over experimental techniques. Like the neo-Pavlovian approach, the natural history approach has drawn widely from concepts of evolutionary biology, neurology, clinical paediatrics and psychology. For example, Hopkins and Prechtl (1984) have looked at a qualitative approach to the study of movement and motor development in infants. Their aim was to provide a description of general movements during wakefulness, in order to classify movement patterns and to trace the developmental course of the types of movement.

In contrast to the predominately European-flavoured natural history approach, North American researchers have been focusing on normal social development or on psychobiological behaviours of infants and children. For example, recent research has related motor activity to crying (Korner, Hutchinson, Koperski, Kraemer, & Schneider, 1981), differences between full-term and premature infants (Woodson, Drinkwin, & Hamilton, 1985; Scafidi et al., 1986; Michaelis, Parmelee, Stern & Haber, 1973), arousal, attention and affect during early social

interactions (Field, 1981), and individual differences in temperament (Rothbart, 1986; Peters-Martin & Wachs, 1984; Lambert, 1982).

In addition to the study of what 'normal' activity means, researchers have also been investigating abnormal behavioural activity. Extremes of activity type, whether hypoactive or hyperactive, have been felt to be predictive of later psychopathology. For example, abnormal activity from birth (or before) can indicate neurological or physical handicaps and other clinical or developmental problems (Barkley, 1981). Mentally retarded Down's syndrome infants are typically hypoactive (Field, 1981). Crying activity has been studied in relation to its clinical implications, for example, in sudden death syndrome, in infants 'at risk', in those with genetic anomalies (Colton & Steinschneider, 1980), and in relation to social and developmental functions (Frodi & Lamb, 1980).

Defining Activity

It is evident from the preceeding historical overview of activity research that underlying theoretical hypotheses concerning activity have varied widely, as have the reasons for studying activity and the methods employed

for its study. Because of differing hypotheses concerning activity and because of the scope of the concept, there is no clear consensus on the definition of activity as a unitary phenomenon. Conceptually, activity has been difficult to classify because it does not necessarily involve interpersonal interaction, nor does it necessarily have adaptive implications, nor relate to cognitive abilities. Yet activity has the potential to involve all of these dimensions. Every response that an organism is capable of making, purposeful or random, internally or externally stimulated, conceivably could be defined as activity, but would not be useful as a definition. Nevertheless, Stratton (1982) suggests that for both parents and researchers alike, the perception of infant activity is a compelling individual characteristic. It is therefore important that a definition of activity be able to distinguish individual differences. Specific definitions of activity have evolved out of the theoretical behaviouristic, neo-Pavlovian and natural history approaches to the concept of activity.

A Behaviouristic Definition of Activity

Behaviourists were interested in newborn movement which they termed 'newborn mass activity' (Irwin, 1930 in Hopkins & Prechtl, 1984). They defined activity as either

unorganized rapid movements involving the whole infant, or as segmented activity occurring slowly enough for small movements to be discriminated by an observer. They found that mass activity, as measured in the laboratory by a stabilimeter, was greater during wakefulness than during sleep (Irwin, 1932 in Hopkins & Prechtl, 1984) but they were looking for a repertoire of specific reactions to specific stimuli. Irwin (1930) felt that internal influences producing mass activity probably were located in the alimentary canal rather than in the brain, which was perceived as being passive in the very young.

Neo-Pavlovian Definition of Activity

For the neo-Pavlovians, activity tends to be defined as a measure of individual difference in reflex response time. The level of inner drive or tendency of individuals to interact with their environment may manifest itself as intellectual, motor or social activity. The emphasis on activity concerns its significance as a regulator of stimulation, which characterizes the dynamics of individual behaviour. Strelau (1983) discusses activity as the way in which an individual typically controls and maintains a personal 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. Strelau also maintains that both reactivity and activity are basic dimensions of biologically-based temperament responsible for individual differences in the energy level of behaviour. Intensity or magnitude of reaction, as a trait, provides a measurement of reactivity that is treated as a relatively stable individual tendency to react to stimuli or situations.

Activity itself 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.

In discussing the concept of activity, the point of departure for the neo-Pavlovians is that of goal-directed behaviour. In infants however, activity begins as non-specific and becomes goal-directed later. Other than suggesting that the infant must learn from its social environment how to regulate its own arousal level, the Pavlovian tradition says little about the development of activity or reactivity in early childhood.

A Natural History Definition of Activity

In their discussion of a natural history approach or qualitative approach to the development of infant activity, Hopkins and Prechtl (1984) define spontaneous motor behaviour as the activity of muscles that results in recognizable patterns of movement, ordered and sequential, and even highly stereotypical. One example is the rooting reflex in human infants, which develops from rhythmical side-to-side movements of the newborn, into gradual directed spatially-oriented head-turning movements, which, in turn result in the location of the nipple for feeding.

Hopkins and Prechtl (1984) describe the development of the newborn's repertoire of motor behaviours as a systematic sequence of changes in terms of general movements and more differentiated movement patterns during wakefulness. They classified infant activity by form and quality of general movements (such as 'writhing', 'fidgety', or 'jerky'). In addition, they classified movements by consequence and orientation, describing goal-directed, voluntary fine and gross movements (such as 'mutual manipulation of the fingers at the midline', 'reaching and touching' and 'trunk rotation').

Recent Approaches

In attempting to integrate Pavlovian concepts of activity with psychobiological views on temperament, as well as with social and emotional views of development, recent research has focused on the study of activity in infancy. It has also focused on the development of more specific operational definitions of activity. Methodology has essentially followed the natural history approach rather than the experimental approach.

Thomas, Chess and Birch (1968) for example, defined activity level as the amount of spontaneous movement in the child's behaviour and the daily proportion of active to inactive periods. Rather than focus on the strongly environmental or strongly psychoanalytic theories, they formulated dimensions of temperament based on the underlying acceptance of the notion of individual differences. Specifically, Thomas, Chess, Birch, Hertzig and Korn (1963) defined activity as the extent to which a motor component exists during bathing, eating, playing, dressing and handling.

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 questionnaire asks the 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.

Rothbart (1986) has incorporated activity as a central dimension of infant temperament. She defines activity level as the level of the child's gross motor activity, including movement of arms and legs, squirming and locomotor activity. She assumes that motor activity is an underlying constitutional tendency of the infant to react in a typical manner or style across a variety of situations and to regulate its own responses.

Eaton (Eaton & Enns, 1986) defines activity level simply as the individual's customary level of energy expenditure through movement. This definition avoids the more theoretical approaches and links 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, that is, calories burned, to maintain body temperature and to grow, but these sources of energy

expenditure are excluded by restricting consideration to movement-based calorie costs. Such an approach allows for practical measurement but is broad enough to encompass some of the theoretically-based definitions discussed above.

Conceptual Issues in the Study of Activity

Conceptual issues of importance when trying to define, measure or develop hypotheses about infant activity, revolve around the individual style of behaviour or the way the infants typically act or interact with their environment. Arousal (Buss & Plomin, 1984; Field, 1981), state (Anders, 1979; Stratton, 1982; Prechtl & O'Brien, 1982; Wolff, 1984), and reactivity of the nervous system (Rothbart & Derryberry, 1981) all describe individual differences in susceptibility to stimuli and initiation of behaviour.

Arousal

Buss and Plomin (1984) maintain that arousal involves unfocused diffuse behaviour that usually involves the whole organism. Cyclic variations in sleep-wakefulness, for example, are linked to the biological substrate on which behaviour rests. Arousal is seen as a

multidimensional concept or process which may take different forms of activity and which will result in individual differences. Behavioural arousal varies along a continuum from deep sleep to great excitement. The higher the level of arousal, the greater the motor activity. Activity (i.e., the energy or vigour of behaviour) is regarded as the output of arousal and sensitivity to stimuli (i.e., the alertness or attentiveness of the infant) as the input of arousal. Both the autonomic nervous system (sympathetic) and the central nervous system (reticular formation) mediate the level of arousal. For example, the 'fight-or-flight' reaction to sympathetic nervous system arousal helps the individual deal with emergencies. Homeostatic mechanisms of the parasympathetic system predominate in the low-arousal routine vegetative functions necessary to maintain life.

Field (1981) links arousal to attention and affect during interactions and sees arousal as a foundation for infant social development and later cognitive development. She proposes a model which can explain the multivariate relationship among arousal, attention and affect. More specifically, Field suggests that there is an intrinsic curvilinear relationship between stimulation and the arousal/attention/affect processes. The threshold of

attention is at the lower limit of an optimal 'band of activation' and at its upper limit is the aversion threshold. These thresholds shift and the width of the band varies as a function of the infant's rest and activity or arousal cycles, and of his or her development and individual differences. For example, in infants experiencing developmental delays or deficits (such as Down's syndrome infants or preterms), the activation band may be narrower and arousal cycles shorter. The attention threshold is higher than normal and the aversion threshold is lower. Social interactions may be more fragile for such infants. As the upper limit of the activation band is approached the infant manifests an inattentive or gaze-averting response. If the limit is exceeded, an aversive reaction or negative affect (fussing or crying) will occur.

State

The arousal concept leads to the 'state' notion in infancy research. In his discussion of infant state and rhythmic processes, Anders (1978) notes that attention to the 'state' variable has assumed prominence in developmental research. However, there is disagreement over how state should be described. One view holds that state refers to a convenient classification of neonatal

behaviours that occur together. Escalona (1962) for example, considered state to include conditions such as the infant's position, the baseline level of its behavioural activities, its maturational level of competence and such variables as time since last feeding. However, this all-embracing connotation of state, restricts its usefulness because it becomes a minute listing of all possible physiological and behavioural conditions.

Another view regards state as a physiological or behavioural manifestation of central nervous system arousal, which effects the capacity of the infant to respond to stimulation. Prechtl and O'Brien (1982) and Anders (1978) for example, suggest that it is more fruitful to restrict the connotation of state to various classes of wakefulness and sleep. They feel that the essential characteristics of state include the stability of the condition over time and the cyclic and rhythmic patterns of change over time.

Anders (1978) notes developmental changes of state in the infant's sleep cycle. The basic rest-activity cycle of 50 to 60 minutes in infants (compared to 90 to 100 minutes in adults) underlies a cyclical four-hour (approximately) sleep-wake rhythm. This rhythm gradually

develops into a more mature pattern of nocturnal sleep and daytime wakefulness called the circadian rhythm. Individual differences reflect varying proportions of time in different states, or different patterns of state sequence.

Wolff (1984) maintains that a waking state of alert activity can be defined as that condition in which newly acquired coordinated movements are initiated spontaneously by the infant. In other words, the infant develops an ability to stimulate its own alertness by choosing to initiate goal-directed activity and inventing new combinations of actions or coordinated movements. The study of this activity might then provide clues about the physiological and behavioural mechanisms involved in state organization that determines infant wakefulness and self-equilibration. He suggests that coordinated movements and the dynamic interaction among motor patterns are the primary mechanisms by which wakefulness becomes a stable behavioural state in the infant. He notes that changes in various state variables appear to induce spontaneous state transitions. For example, monotonous or rhythmic movements produced by the infant, appear to promote the induction of sleep. Increased variability of motor rhythms has been observed in high risk infants and may be related to unstable behavioural states and increased

variability in patterns of state transitions for the high risk infant.

Reactivity of the Nervous System

Two of the key concepts in Rothbart and Derryberry's (1981) theory of infant temperament are reactivity of the nervous system and self-regulation of reactivity which they assume have a constitutional origin. By constitutional origin they mean the relatively enduring biological make-up of the individual, which, over time is influenced by heredity, maturation and experience. Reactivity is defined as the excitability, responsivity or arousability of the physiological and behavioural systems of the individual. It depends upon the infant's sensitivity to stimuli (threshold), upon the strength of the stimulus reaction (intensity) and upon the cyclical and temporal aspects of response. Self-regulation modulates the reactivity by controlling reactivity at underlying neural and behavioural levels. The pattern of reactivity is managed through the processes of approach or avoidance (behaviour), attention (cognition) or by self-stimulation or self-soothing. The concepts are similar to Nebylitsyn's (1972, in Mangan & Paisey, 1983) 'strength of the nervous system' and to Strelau's (1983) activity and reactivity mentioned earlier, except that Rothbart has

extended the concepts to refer to individual differences in infant temperament. According to Rothbart and Derryberry (1981), motor activity, facial expressions, vocal activity and emotional reactions reflect the infant's reactivity and self-regulatory mechanisms. The characteristic reactivity and self-regulation (temperament) is important for the infant's social development. For example, in terms of infant-caregiver interaction, infants who cry a large part of their waking hours, will probably develop different relationships with their parents, than those who are content much of the time they are awake.

Rothbart has attempted to integrate psychobiological views of temperament with views on social-emotional development in infancy. The implication is that a great number of different variables - emotional, cognitive and social - must be examined in order to predict behaviour at a molar level. Rothbart and Derryberry (1981) emphasize that both constructs, reactivity and self-regulation, can be used to describe temperament at the neural level, the physiological level of interacting systems, and at the behavioural level. However, at the present state of knowledge about causal relations between neurophysiology and behaviour, it is difficult to determine exactly how a behaviour, such as fearfulness or general activity level,

is related to individual differences at the neural or physiological level.

Implications. The conceptual issues of arousal, state and reactivity of the nervous system are important to the study of activity because they provide a possible environmental and physiological structure or background underlying individual differences in activity level. All infants do not start off at the same level of arousal. Varying degrees or types of stimulation will have differential effects in terms of behavioural reaction. Different patterns of sleep, wakefulness and irritability may influence activity level to a great degree.

The focus in this study is on individual differences and on the general issue of whether infants can be meaningfully differentiated, in terms of their customary levels of motor activity in their home environments. From this perspective, momentary shifts in arousal or state are not of central importance. However, if one infant is consistently sleepier, less reactive or less aroused than another, these differences will matter for activity level. The relationship between individual differences in activity level and related individual differences has been investigated empirically within the temperament research tradition, which will be considered next.

Activity and Temperament Research

Motor activity does not exist independently of many other behavioural characteristics, as the earlier discussion of arousal and state should make clear. However, in the study of individual differences in infants and children, activity has been found to be a relatively stable, consistent characteristic. Many argue that individual differences must be heritable to some degree in order to classify them as temperamental (Buss & Plomin, 1984). Research on the heritable characteristics of temperament has found that behaviours pertaining to temper, activity level, attention span or task persistence, are particularly salient for detecting individual differences, because they typically provide sharp and relatively stable contrasts between identical and fraternal twins (Matheny, Wilson, Dolan, & Krantz, 1981). Theoretical notions of state, arousal and reactivity, imply that behavioural activity is only the 'tip of the iceberg'. Motor activity, as overt evidence of an underlying biological or genetic substrate, is an intriguing one. So is the idea that activity is a reflection of the social, emotional or physical environment.

Empirical temperament research includes a wide variety of infant behaviours related to arousal, state and reactivity of the nervous system, such as crying and wake-sleep behaviour. Activity has been related to temperament reactivity (Rothbart, 1981, 1986; Zeanah, Korner, Berkowitz, & Linden, 1985), wake and sleep behaviour (Snow, Jacklin, & Maccoby, 1980; Woolf, 1984; Dittrichova, Brichacek, Paul, & Tautermannova, 1982; Sostek & Anders, 1981) and crying (Korner, Kraemer, Haffner, & Thoman, 1974; Korner, Hutchinson, Koperski, Kraemer, & Schneider, 1981; Korner, Zeanah, Linden, Berkowitz, Kraemer, & Agras, 1985), as well as to sex differences (Eaton & Enns, 1986), birth order and size (Eaton & Dureski, 1986).

Temperamental Correlates of Activity

Activity has been accepted as a central component of child temperament because it appears as a relatively stable, orthogonal dimension that provides good discriminative power to detect individual differences. What temperamental features of infant behaviour are associated with activity level differences? For infants, activity has been associated with both negative and positive temperamental characteristics. Matheny et al. (1981) for example, clustered activity level with the

negative temperamental characteristics such as 'temper', 'crying', and 'irritability'. Carey and McDevitt's (1978) study associated activity with 'difficult' temperament, particularly when the infant was unresponsive to or withdrawing from environmental stimuli (even mothers' soothing behaviours). Other studies that assess temperamental or behavioural style have found other results.

Eaton and Dureski (1986), using the IBQ activity scale at three months of age, found that IBQ-measured activity was positively related to 'smiling and laughter'. However, activity measured by actometers was related only to 'soothability' of the infant. Crockenberg and Acredolo (1983) also found that activity was positively related to 'smiling and laughter' at three months using the IBQ. Activity in their study was also related to 'fuss/cry' episodes at one-month of age. McGrade (1968), using an early version of the Bayley Infant Behavior Profile, found that happiness at eight months of age showed a positive correlation with activity and negative correlations with tension and fearfulness. Bates, Olson, Pettit, and Bayles (1982), in a factor analysis of home observations of 168 six-month-old infants, also found a happy-active factor in which the infant's smiling, positive vocalization and motor activity were interrelated. Thus, it seems that

activity has been related both to negative characteristics, such as crying and fussing, and to more positive characteristics, such as smiling.

One study found that there was a relationship between activity and both positive and negative behaviours on a parent questionnaire, which raises the problem of the validity of parent ratings. Zeanah et al. (1985) found that activity was related to both intensity of affective expression (including negative mood) and to extraversion (including the tendency to approach, rather than avoid, novel stimuli) on a parental rating questionnaire. Their study involved 24 boys and 26 girls whose mean age was six and one-half years. The activity monitor used was a solid state ambulatory microcomputer worn in a small backpack for a 24-hour period on a non-school day. A sensor was taped to the child's thigh on the dominant leg. It transmitted counts of movement, which reflected both frequency and amplitude.

In the Zeanah et al. (1985) study there was some discrepancy between the objective measures of activity and what parents perceived as activity. 'Easy' children were rated by parents as being significantly less active than 'other' children. However, the activity monitor showed no significant differences between the two groups. In fact,

parental perception of the child's behavioural style on the activity dimension was unrelated to the objective measurement of the child's activity.

The preceeding results suggest that high levels of activity can be related to both positive and negative aspects of infant and child behaviour, and raise questions about the validity of the widely used parent-rating measures. It may be that what makes activity level noticed by parents or teachers as a salient temperamental characteristic is its social appropriateness or context rather than the amount of motor activity per se (Mintz & Collins, 1985). The proposed research will evaluate the possibility that both positive and negative features of infant behaviour are associated with high levels of activity. The validity of parent perceptions of infant activity will also be addressed.

Activity and Crying

Past research by Korner et al. (1974, 1981) aimed to capture reliable individual differences in characteristic levels of energy expenditure before the impact of postnatal experiences became an influential factor. One of their main areas of focus has been the examination of the effects of crying on activity level and individual differences in activity level among neonates.

Korner et al. (1974), with a sample of 31 fullterm healthy neonates (17 females and 14 males), found generally, that the highest rates of activity occurred during crying time and the lowest rates of activity occurred during noncrying time. Noncrying and crying activity were highly correlated, $r = .62$, $p < .001$, suggesting that the infants tended to be either active or inactive, whether they were crying or not. Overall, this early study showed that crying activity essentially measured the same activity factor as noncrying activity, but they distinguished the two in their data analysis.

Korner et al.'s 1981 study replicated their 1974 study, measuring the activity and crying patterns of 72 normal neonates during the first three days of life. One of their best overall measures of total activity was the amplitude of the infant's movement, as measured by an activity sensitive transducer mattress. Amplitude (rather than frequency of movement) was stable for both crying and noncrying activity. They suggest that the vigour of the infant's movements may be a more enduring index of characteristic energy expenditure than activity level as measured by frequency of movement, in that vigour is apparently unconfounded by the infant's irritability level. More work on the links between infant crying and irritability on the one hand and activity level on the

other is needed because the Korner findings are based only on the first days of life.

It is interesting to note that neonatal differences may relate to later behaviour. Korner, Zeanah, Linden, Berkowitz, Kraemer, and Agras' (1985) found that neonatal activity measures would predict, to some degree, later activity and behavioural style. Vigorous neonates (as measured by the transducer mattress) tended to become highly active children of four to eight years (as measured by the activity monitor) and inactive neonates whose median amplitude of movements were low tended to become inactive as children, $r = .29$, $p < .05$. Though the longitudinal correlation is not strong, the possibility of temperamental continuity from infancy to childhood is of central interest to many investigators. The proposed study will not look at the continuity question, but will, it is hoped, establish some reliable measurement procedures for the early infancy period.

Developmental changes in crying behaviour are relevant to activity level. Crying increases in frequency to six weeks of age (Rebelsky & Black, 1972) but by three months of age crying episodes start to decrease. For example, Snow, Jacklin, Nagy, and Maccoby (1980) found that the mean number of 15-minute intervals during which crying

occurred dropped from three months to 26 months, with no sex differences evident. Although crying frequency seems to be stable over time within individual infants, if the total amount of crying at six months of age is limited to less than one-half hour, crying by itself should not affect activity measures as much as at earlier ages, and Korner et al.'s (1974, 1981) concerns about infant irritability confounding activity measurements in the neonates should be of less concern by six months of age. At this age, the infant has an expanding repertoire of behaviours with which to communicate. The activity that the infant displays in crying should be offset by the activity involved in social behaviour, so that crying in the 'average' infant will not necessarily be associated with higher levels of activity.

Activity and Wake-Sleep Behaviour

To discover what they termed the 'structure' of infant behaviour, Czechoslovakian researchers (Dittrichova, Brichacek, Paul, & Tautermannova, 1982) have carried out an intensive analysis of sleep and waking behaviour of 21 healthy infants between birth and six months of age. The infants were living with their mothers in a residential unit where the research took place. Using EEG apparatus and observation, the researchers studied the EEG

recordings, rapid eye movements and body movements during sleep. The waking behaviour studied included smiling, vocalization and crying, finger sucking and body movements.

In a correlational 'linkage' analysis of interrelations among parameters of waking, 'maintenance of waking state' was found to be a central factor. Infants who were able to maintain a waking state for long periods of time were more active, yet length of uninterrupted waking was negatively correlated with length of crying. Length of crying was negatively related to length of time spent smiling. The infant's characteristic structures of behaviour during waking time (for example, length of waking, maintenance of waking state, duration of body movements, smiling and crying) remained relatively stable during the first six months of age.

It would appear then that 'wake-sleep' state behaviour is an important correlate of individual differences in activity level. Several studies have found the diary method a feasible way to study the wake-sleep behaviour of infants. Bernal (1973), for example, investigated the night waking habits of 77 infants in a longitudinal study. Data was obtained from mothers by interview and by 48-hour diary recordings when the infants were 8-, 14-, 20- and

30-weeks of age. The babies who were perceived by their mothers as having a sleep problem at 14 months of age were found to have slept in significantly shorter bouts of time at the earlier ages, resulting in significantly less total sleep time in a 24-hour period.

In a related study on infant irritability, Snow, Jacklin, and Maccoby (1980) examined infants at ages 3-, 6-, 9-, 12-, 18- and 26-months of age and focused on the frequency of crying episodes in relation to the number of wake-sleep transitions at each age. Their data was obtained through diary records kept by the parents. Each 15-minute interval during the 24-hour period was scored to indicate if and when sleep occurred, if and when the infant was awake, and if and when the infant cried. Snow et al. (1980) found that both crying frequency and wake-sleep transitions showed some stability over time. The child who cries more often than other age-mates at nine months is more likely to cry more often at 12-, 18- and 26-months. Frequency of crying at six months significantly predicted crying at nine months ($r = .26$, $p < .05$). Frequency of transitions at six months significantly predicted transitions at 9-, 12- and 18-months. The relationship between frequency of crying episodes and wake-sleep transitions suggested that children who are frequent criers are also likely to

develop sleep patterns in which they fall asleep and wake up quite frequently. In the age range from 3 to 18 months the child who cries more than others during the wake-sleep transitions also cries more at other times of the day. This study suggests either that irritable infants will have frequent wake-sleep transitions or that infants with frequent wake-sleep transitions may have a difficult time coping with the transitions and have frequent periods of crying. Whatever the cause, these infants may be more active than infants who cry very little and who have regular and longer sleep cycles. This study will obtain a measure of infant wake-sleep and crying behaviour by means of a parent diary.

Accuracy of Parent Diaries

The natural history approach emphasizes *in vivo* observation of behaviour with extensive sampling, an expensive research strategy when observers go to the home. One alternative is to have the parent collect data using a diary method. While parent diaries have had limited use in the study of normal infant motor activity, and do have some shortcomings, they would seem to be an appropriate instrument to obtain wake-sleep state data on infants.

To assess the validity of parental diaries for infant cry and fuss behaviour, Barr et al. (1986) compared diary records with audio-taped recordings. Over a 24-hour period the negative vocalizations of 10 six-week-old infants wearing voice-activated recorders were compared with diaries kept by parents over the same period of time. The researchers combined clusters or episodes of cry/fuss behaviour that occurred within five minutes of each other into a single episode, and excluded vocalizations that were less than 30 seconds in length. They found an overall correlation of .64 ($p < .03$) between diary frequency of cry/fuss and recorded episodes of negative vocalization. Parents missed an average of 20% of the total duration of negative vocalizations and 14% of the total frequency of episodes. Missed vocalizations were no more frequent at night than at other times. However, there was considerable variability between subjects, suggesting a wide range of individual recording styles, particularly with regard to what was recorded as "crying" and what was recorded as "fussing". In previous pilot work the diary format used with 409 subjects provided a reponse rate of 92% with usable diaries obtained from 91% of the sample.

In addition to the problem of comparing the 'fine grained' data from the recordings to the parent diary

data, the researchers found that parental concepts of 'fussing' did not necessarily involve vocalizations on the part of the infant. For some, the concept of 'fussing' connoted a description of the infant's agitated or distressed behavioural state rather than a vocal act. So, for example, the diary might indicate periods of fussing when the corresponding tape transcript indicated almost no negative vocalizations. To parents, 'fussing' tends to involve motoric as well as vocal behaviour. For the purpose of describing fussing behaviour, the authors concluded that parent diaries might be more useful than audio-taped recordings.

In one other study, Anders (1978) recorded the wake-sleep behaviour of two- and nine-month-old infants. In the infants' homes he used time-lapse video recording along with audio-recordings, to derive 'sleep profiles' of the infants. A comparison of parent diaries with time-tape video recordings of childrens' sleep patterns, showed that parent diaries were in agreement with the video recordings over 90% of the time (Snow et al., 1980). Thus, diary records have been used for measuring state-relevant behaviours, such as crying and sleeping, and are reasonably valid.

Activity and Other Findings

Finally, empirical research on activity among infants has found that activity is positively related to age (Dittrichova et al., 1982; Campbell, Kuyek, Lang, & Partington, 1971; Rothbart, 1986), and size (Eaton & Dureski, 1986), and negatively related to birth order (Eaton, Chipperfield, & Dureski, 1986; Eaton & Dureski, 1986). Regarding sex differences in infancy, Eaton and Enns (1986) in a review article, examined 14 studies where mean age was from 0 to 11 months of age, and concluded that activity level sex differences are likely present in infancy. Many of the 14 studies in Eaton and Enns (1986) weren't significant, but nearly every one went in the same direction, i.e., males > females. However, Rothbart (1986) and Korner et al. (1985) did not find significant sex differences in their respective studies.

Activity and Temperament Research Summary

In summary, the correlates of activity have typically been studied empirically in terms of temperament, wake-sleep and crying behaviour. Researchers have found that activity is a salient feature of temperament throughout childhood, but that both positive and negative aspects of temperament are related to activity. For example, Carey

and McDevitt's (1978) 'difficult' infants are more active than the 'easy' infants, but Rothbart's (1986) active infants 'laugh and smile' more than the inactive ones. In neonates, crying has been closely related to activity, but as the infant grows older, crying diminishes and social activity and coordinated physical activity tend to become pertinent correlates. Infants who are 'crybabies' at six months of age however, tend to remain so through infancy. In general, activity appears to be related to the frequency of wake-sleep transitions (which may involve crying), rather than to the total duration of wake or sleep time. Sex differences in activity have not been 'clear-cut.' They appear to be present in some studies and absent in others. Finally, the diary method may be useful as a means to study changes in infant wake-sleep transitions and crying behaviour.

Issues in the Measurement of Activity

From the discussion on empirical findings related to activity, it is evident that there are a variety of techniques by which to measure activity. Both Rothbart and Goldsmith (1985) and Tryon (1985) have reviewed human activity measurement and discuss three main orientations or approaches that researchers have used. The first is the rating scale, whereby parents, teachers or therapists

are asked to rate subjectively how active they think the individual is. The second is the behavioural observation, whereby activity is directly observed and recorded by the investigator. The third is behavioural measurement which uses objective electronic or mechanical devices to determine, quantify and record physical forces associated with the activity. Both the parent rating scale and the objective behavioural measure of motor activity are discussed in detail, because a measure of each is used in the present study.

The Rating Scale

Activity level ratings are typically embedded in a parent report questionnaire which ia a multiscaled paper and pencil instrument, usually containing between five and twenty items per subscale. Instructions to the parents usually specify some context for responding to the items, and provide an explanation for the rating scale. The rating is typically based on a five- to seven-point scale requiring judgments as to frequency or intensity of the behaviour. Most items refer to specific behaviours, e.g., " ... when in the bath, how often did the baby splash or kick?". The questionnaire usually takes about 30 minutes to complete and is often done at the parent's home.

The main difficulty with the parent report is the possibility of bias due to parent cognition, personality, attitudes, and past experience. The parents' interpretation of their infant's behaviour will reflect such factors as their own comprehension of the instructions, knowledge of their infant's behaviour, accuracy of their memory, response sets and knowledge of what other infants of the same age are like. In addition, intrinsic biases related to the questionnaire method itself may cause difficulty. For example, the questionnaire may inquire about rarely observed situations or behaviours, or may not provide an adequate selection of response options or item selection.

Several empirical studies have, however, found that parent reports of their childrens' activity have been valid. Eaton (1983) found a significant correlation (r = .75, $p < .01$) between parent ratings of activity and mechanical (actometer) measures in preschoolers. Stevens, Kupst, Suran, and Schulman (1978) found that mothers were better than clinicians in judging the overall activity level of their school-age sons using mechanical (actometer) devices to assess activity. Barkley and Ullman (1975) also found that parental opinion on their childrens' activity level was significantly related (F = 12.97, $p < .01$) to clinically defined hyperactivity.

However, in this last study parent ratings of activity were not significantly related to actometer measures. It seems then that parents' judgments of motor activity have some validity, even though such judgments may be influenced by other factors. In spite of their difficulties, rating questionnaires have been widely used. One of the most commonly employed is Rothbart's (1981) Infant Behavior Questionnaire (IBQ), which will be described in some detail because of its use in the study.

The Infant Behaviour Questionnaire. Rothbart's (1981) Infant Behaviour Questionnaire (IBQ) assesses infant temperament on six dimensions, one of which is 'activity level.' The other temperament dimensions include 'smiling and laughter,' 'fear,' 'distress to limitations,' 'soothability' and 'duration of orienting.' All of the dimensions have been identified as conceptually independent measures of individual differences. Rothbart defines activity level as the child's gross motor activity, including movement of arms and legs, squirming and locomotor activity. The activity subscale consists of 17 items based on a broad range of activities, from feeding to sleeping to playing to daily routines. Composite measures are derived from five of the six temperamental dimensions to represent a dimension of reactivity. Positive reactivity includes unit-weighted

summed standard scores for 'smiling and laughter,' and 'activity level.' Negative reactivity includes scores for 'fear' and 'distress to limitations'. Overall reactivity is derived from subtracting the standardized positive composite score from the negative composite score (Rothbart, 1986).

In an attempt to negotiate the biases inherent in parent reporting (when for example, judgments made are either retrospective or global in nature, or involve the parents comparing their own child with other children), the IBQ asks parents about the relative occurrence of concrete behaviours in specifically defined situations within a specific time period. Each of the 94 items is based on a seven-point rating scale of frequency of occurrence. For example, rather than asking parents to make the comparative judgment, "My child is extremely active", the IBQ asks parents, "During the past week, when being undressed, how often did your baby wave his/her arms and kick?" Responses range from 1 (never) to 4 (about half the time) to 7 (always). If the parent has not seen the activity during the time the parent may respond with an 'X' (does not apply).

IBQ standardization. The IBQ was standardized on a sample of 463 infants (ages 3-, 6-, 9-, and 12-months)

whose parents were administered the questionnaire. The mean item-scale correlations for the temperamental scales ranged from .41 to .77. Coefficient alphas ranged from .67 to .84 with a median of .79 (Rothbart, 1981).

IBQ reliability. Moderate correlations (.45 to .69, $p < .05$) were found between scale scores of 24 pairs of adults (mothers and fathers), who each completed a questionnaire. The activity level scale was correlated .69, $p < .05$, between parents. Eaton and Dureski (1986) had the primary caregivers complete the IBQ based on the previous one-week period and on a subsequent 24-hour period. As assessed by the alpha coefficient, reliability was .73 for the one-week IBQ activity subscale and .75 for the 24-hour activity subscale. The 1-week and 24-hour versions of the scale also correlated highly with each other, $r = .79$, $p < .0001$.

IBQ stability. Thirty-six mothers participated in a longitudinal study on their infants, starting when their infants were three months of age. Their mothers completed an IBQ when the infant was 3-, 6-, 9- and 12-months of age. Stability correlations for activity level were significant between the ages of three and six months and between the ages of six and 12 months. The composite positive and negative reactivity measures showed similar

patterns across ages. Stability of the correlations were significant from three to six months and from six to nine months. Positive reactivity was stable from the three to nine month period.

IBQ validity. Rothbart (1986) found that the correlation found between the parent IBQ report and the trained home observer for activity level and for the reactivity dimensions were statistically significant at six and nine months ($p < .01$, one-tailed), but not at three months. Eaton and Dureski (1986) found the correlation of actometer score with the IBQ activity subscale for four-month-olds was non-significant. In fact, in their study, no IBQ activity item appears in a "10 best" list of ranked IBQ items correlated with actometer scores. Therefore, the IBQ activity subscale remains unvalidated for three-month-olds. Overall, moderate convergence was found by Rothbart (1986) between the home observation and the IBQ with five out of eight dimensions (including 'activity level' and the three composite measures of reactivity) significant at six months of age and seven of the eight at nine months. Thus, there is some question about the validity of the IBQ activity subscale before six months of age, and one purpose of the proposed research will be to address this question in a sample of six-month olds.

Behavioural Observations

A typical behavioural observation involves a one- to three-hour home visit by a trained observer, usually scheduled at a time when normal activities are expected. The observer records the particular behaviours of interest while maintaining an unobtrusive presence. Several visits may be scheduled to obtain a more complete record before inferences are drawn. Home observations are typically utilized to establish convergent validity with parent rating questionnaires when more objective measures are not available. Carey (1983) suggests however, that expert observation measures may not be measuring the same characteristic as either the parent or as other experts. He warns against too much reliance on brief professional ratings over maternal ratings.

For both rating scales and behavioural observations in particular, the study of infants poses a special difficulty. Infants change so rapidly that what seems like an appropriate characteristic to study at one age, may not seem appropriate at another. For example, irritability might be reflected in crying at two months, but at a later age in sleep difficulties or in discipline problems. However, when the variables that are being measured change at each age, it is difficult to say for

certain that one is equivalent to another. Therefore, it is important to develop valid instruments by which to measure activity and relate it to predictable characteristics of the infant.

One such characteristic is the development of the infant's motor skills. The well-known Bayley (Bayley, 1969) scale of physical development was used in this study to assess the motor skills of the infants. It was thought that the infant's relative level of physical development might influence level of motor activity.

The Bayley Scales of Infant Development. The Bayley Scales of Infant Development (BSID) (Bayley, 1969) is, at present, considered to be the best measure of infant development available (Sattler, 1982). It is designed to evaluate an infant's developmental standing relative to other infants of his/her age. The age range for the scales is from 2- to 30-months.

The Motor Scale component of the BSID is designed to provide a measure of the infant's degree of body control, co-ordination of large muscle groups and fine manipulative skills. The 81 items included in the scale are specifically directed towards behaviors reflecting fine and gross motor abilities such as sitting, crawling, standing, walking and grasping. From the Motor Scale a

standard score, the Psychomotor Developmental Index (PDI) is derived. The PDI is a normalized score with a mean of 100 and a standard deviation of 16.

BSID Motor Scale standardization. According to Sattler (1982), the BSID is a well standardized test. Both the Mental Scale and Motor Scale were standardized on a sample of 1,262 normal, North American infants in fourteen age groups ranging from 2- to 30-months. Attempts to control for sex, race, residence and education of the head of the household were included in the standardization process. Generally, the sample is considered representative of the population; however, Bayley (1969) reports that there may be an under-representation of the rural population. The effects of this under-representation are deemed 'negligible' by Bayley.

BSID Motor Scale reliability. Split-half reliability coefficients for the fourteen age groups range from .68 to .92 with a median of .84. The reliabilities for the first four age groups tend to be lower; however, at six months of age, the reliability coefficient is at a very acceptable level of .89.

Objective Measurements

Objective behavioural measurement can be carried out by means of electronic or mechanical devices associated with some overt behaviour. Actometers or motion recorders which measure activity acceleration, pedometers which measure vertical movements associated with walking, stabilimeters which measure activity in a sitting or lying position, ultrasound which measures frequency, distance and direction of movement, and load transducers which measure pressure changes associated with walking, are all used to objectively measure some type of activity.

Tryon (1985) favours the behavioural measurement approach for several reasons. Firstly, he feels that it achieves a higher level of accuracy than do other more subjective methods. Secondly, the use of an electronic or mechanical instrument allows behaviour to be monitored over protracted periods of time in order to obtain naturalistic samples of activity. Thirdly, the instrument can remain more accurate than a human observer over time and is often less expensive in the long run. Finally, instruments tend not to invade the individual's privacy in the same way as an observer might. One type of instrument, the actometer, has been used successfully with young infants in the home setting (Eaton & Dureski, 1986),

and is considered in some detail because it was used in the present study.

Actometers

The Kaulins and Willis actometer is a modified wrist watch responsive to movement in the north-south and east-west planes, where 12 o'clock is North. It also responds to 'tipping'. Thus, if worn on the wrist or side of the ankle, it will respond to typical movements of the limb.

Actometer standardization. One actometer unit (AU) is defined as the energy required to advance the 'minute hand' by a one minute interval marking on the face of the dial. Typically, the number of minutes of wearing-time is recorded so that AU per minute calculations can be made and measurements compared across unequal wearing intervals.

Actometer reliability. Tryon's (1985) evaluation of actometers found a mean correlational coefficient (*r* squared) of .95. Four actometers were taken, strapped at various distances to a metre stick attached to a motorized pendulum. The actometers oscillated for ten minutes on ten occasions at each of eight intensity levels. Eaton (1983) found that actometer reliability was substantial when actometers were used on 27 preschoolers during a free

play period of about 20 minutes in length over a period of 13 days. The reliability of each single actometer score was .33 increasing to .88 when a total of 13 actometer sessions were included. In one study by Eaton and Dureski (1986), four-month-old infants wore four actometers (one each limb) for a 24-hour period of time at home. A single limb actometer reading had an estimated reliability of .51 and the composite of all four limbs had a reliability of .81. In another study (Eaton, McKeen & Lam, 1988), 43 6-week-old infants wore 4 actometers in the home for 48 hours. The estimated reliability of the 4 aggregated limb scores was .82.

Actometer validity. 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 interrelations 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.

Actometer stability. Three independent actometer samples of approximately two hours length each, were taken in the Buss et al. (1980) study approximately one week apart on all of the children at ages three and four. Reliability for age three was .86 and at age four it was .62.

Hypotheses

In summary, this correlational study on infant motor activity made use of a parent rating scale (the IBQ) to obtain estimates of infant temperament and activity by parents, an objective measurement of activity (the actometers), and a new method (the parent diary) to obtain data on state transitions in relation to activity. The hypotheses are discussed in terms of the bivariate relationships expected among each of the three instruments.

Given previous empirical findings, the relationship between activity level as measured by actometer and the parent diary of infant activities, is hypothesized as follows:

1. Although Dittrichova et al. (1982) found that length of time in waking state was associated with activity (that is, those who sleep more are less active), the more interesting hypothesis is that the frequency of state transitions will be positively related to activity. Because Snow et al. (1980) found that infants tend to cry at sleep-wake transitions and Korner et al. (1974, 1981) found that crying was related to activity, those infants who have frequent changes of state (to or from sleep to awake as measured by parent diary), will tend to be more active (as measured by actometers) than those infants with fewer state changes.

2. A second hypothesis is that 'extreme' infants with either highly positive affective states or highly negative affective states will tend to be the most active. That is, infants with a longer total duration of 'awake and content' states and those

with frequent and/or longer total duration of 'crying' and 'fussy' episodes (as measured by the diary) will tend to show high activity levels (as measured by actometer).

In the investigation of a relationship between activity level, as measured objectively by actometer and temperament, as measured by the IBQ parent rating, several hypotheses are advanced:

3. Although Eaton and Dureski (1986) did not find a relationship between parent ratings on the activity subscale of the IBQ and actometer measures of activity at three-months of age, there should be convergent evidence by six months. A positive relationship between parent perceptions of activity and AL is predicted.

4. Because parent perceptions of motor activity may be influenced by the overall behavioural style of their infants, the IBQ temperament scale should reflect that influence. The actometer measure of activity (AL) should be positively related to the extremes in infant temperament as rated by parents. Specifically, AL should be related to both negative and positive reactivity composites on the IBQ.

5. In keeping with the sex differences in activity level found by Eaton and Enns (1986), motor activity, as measured by actometers, is expected to be significant, with males more active than females.

Hypotheses regarding the relationship between infant temperament as measured by the IBQ and the parent diary of infant sleep-wake behaviour include:

6. Convergent validity should be evident between the unpleasant or stressful diary behaviours and the overall reactivity scores on the IBQ. That is, diary reports of 'crying' and 'fussing' and frequency of 'state transitions' will be positively related to the IBQ negative reactivity scales ('distress to limitations' and 'fear') and negatively related to the positive reactivity scales ('smiling and laughter' and 'activity level').

7. Because parent perceptions may be influenced more by the frequency of the infant's shift from one state to another than by motor activity per se, diary reports of frequency of 'state transitions' will be positively related to parent perceptions of activity on the IBQ scale.

METHOD

Participants

The participants were recruited from among the names published in the classified birth announcement section of the Winnipeg Free Press. Parents of infants named were contacted by letter when the infants were approximately five months of age. Addresses were obtained and confirmed through the telephone directory and Hendersen's City Directory. Postal codes were obtained through post office code books. A total of 141 letters were sent out and 47 parents agreed to participate, for an acceptance rate of 33%. It was felt that the participation rate might have been higher if the study had not been carried out during the month of July, when many families were away on holidays. The sample included both male and female infants whose mothers were not considered high risk during their pregnancies and whose births were not premature (before 37 weeks gestation).

Procedure

An initial letter to the parents (Appendix A) briefly explained the purpose and requirements of the study, and requested participation. Approximately one week after the letter was sent, parents were contacted by telephone to request their participation in the study (Appendix A) and to answer any questions. Formal consent was obtained on the first home visit (Appendix A).

Following initial contact and informal consent to participate, instructions were given to complete the Rothbart Infant Behavior Questionnaire (IBQ) which had been mailed out along with the introductory letter. Parents were instructed to complete the IBQ just prior to an arranged home visit. This initial home visit took place when the infant was approximately six months of age. A telephone call was given the day before the visit as a reminder to the parent and to ensure that the infant was in good health.

At the initial home visit, the IBQ was collected, the parent interviewed and instructions given for further data collection procedures. Specifically, the parent was given instructions on how to complete the parent diary of infant behaviour (Appendix A) over the following 48-hour period and then actometers were demonstrated and attached to the

infant's limbs. The parent was provided with both verbal and written instructions regarding the use and care of the instruments (Appendix A). The infant was also weighed and measured at this first visit, and a measure of physical development taken (Bayley, 1969). Interview information included information on the mother's pregnancy, birth, lifestyle habits and demographics (Appendix A). Throughout the two-day data collection period, parents were encouraged to maintain normal activities with their infant.

The second and final home visit took place two days after the first visit. At this second visit the parent diary was collected and the actometers read and collected.

Finally, parents were thanked for their participation, presented with a 'Baby of Science' certificate as a souvenir and sent a brief summary of results when the investigation was completed.

Instruments

Parent questionnaire. As described earlier, the IBQ is a caregiver report instrument in which parents are asked to rate a variety of specific concrete infant behaviours observed over the previous week during particular situations. The parents were asked to complete the

questionnaire just prior to the initial home visit. Data from the questionnaire then was based on the one-week period of time prior to the actometer activity measure and the infant diary completion. Parental responses to the 94-item questionnaire were scored to provide the six temperamental dimension scales ('activity level,' 'smiling and laughter,' 'distress to limitations,' 'distress to novelty,' 'soothability' and 'duration of orienting').

Reliabilities for the six subscales were carried out using SPSSX software (SPSS Inc., 1983) to obtain a measure of Chronbach's alpha, which measures the internal consistency of each of the appropriate subscale items. The activity subscale consisted of 17 items and its alpha was .81. The smiling and laughter subscale consisted of 15 items and its alpha was .86. The distress to novelty subscale consisted of 13 items and its alpha was .69. The distress to limits subscale consisted of 20 items and its alpha was .78. The duration of orienting subscale consisted of 11 items and its alpha was .89. Finally, the soothability subscale consisted of 11 items and its alpha was .66.

The composite scores for positive reactivity ('smiling and laughter' and 'activity level') and for negative reactivity ('fear' and 'distress to limitations') were

obtained by standardizing each of the IBQ subscales and summing the appropriate ones. Two 'overall composite' scores were obtained, one by subtracting the positive reactivity score from the negative reactivity score (Rothbart, 1986), and one by summing the positive and negative reactivity scores.

Activity measure. At the initial home visit a 48-hour objective measure of infant activity was initiated with 4 Kaulins and Willis model 101 motion recorders, or actometers. These instruments are similar in appearance to a child's wristwatch, and each weigh 13 grams. Motions of the watch cause the hands to advance so that each elapsed second on the actometer represents an activity unit (AU).

After demonstrating an actometer to the parent, the start time of each of four actometers was recorded. Then they were attached to the infant by means of elastic fabric bands and Velcro fasteners, one per infant limb, for the duration of the data collection period. Specifically, at the wrists, the actometers were attached to the dorsal aspect of each forearm proximal to the radialcarpal joint. At the ankles, the actometers were attached superior to the lateral malleoli. The parent recorded those times when the actometers were off the baby

(for example, during baths). Actometers were colour coded and keyed to the parent's recording sheet to prevent confusion about matching limb to instrument. At the end of the 48-hour period, the actometers were removed and the final reading taken.

Raw actometer scores were converted to a rate measure by calculating the number of activity units per 30 minutes real time. As found by Eaton and Dureski (1986), this measure was positively skewed, so the rate measure was logarithmically transformed, to produce an actometer score for each limb. The composite actometer score for each infant then was calculated by taking the mean of the four limb scores.

Actometer reliability. Reliability was estimated first by correlating right-sided motor activity with left-sided motor activity, $r = .81$, $p < .0001$. Using a length factor of two, the Spearman-Brown prophecy formula was then used to estimate the reliability of the AL score for all 4 limbs. This estimate of reliability was .90.

Parent diary of infant behaviour. During the same initial home visit, parents also were provided with a time-structured diary of infant behaviour (Barr et al., 1986) completed for the 48-hour period of time over which the actometer activity measure was being obtained.

Symbols, representing six mutually exclusive infant behaviours were used to simplify and standardize recording procedures. These six behaviours include: 'sleeping,' 'awake and content,' 'fussing,' 'crying,' 'feeding' and 'forgetting.' Instructions to parents stressed that all behaviour was to be coded by one, and only one, of the available symbols (see Figure 1). The smallest time unit for recording was five minutes. Although Snow et al. (1980) used a 15-minute unit, it was considered that a five-minute unit would provide a finer representation of individual differences. For each child, a reported shift into or out of the sleep category was scored as a state transition. These were summed to create the variable, 'wake-sleep transitions'. The total number of behavioural changes were also calculated and correlations among 'sleep' and 'awake and content' and 'fussing' and 'crying' durations were examined.

Diary reliability. The stability of diary behaviours from day 1 to day 2 were examined for 26 diaries, as a measure of diary reliability. The inter-day correlation for 'sleep' was .62, $p < .0008$, for 'contentedness,' .50, $p < .009$, for 'crying,' .21, $p < .30$, for 'fussing,' .50, $p < .01$, and for 'feeding,' .68, $p < .0001$.

Physical measures. At the first home visit, the infant was weighed with portable infant scales wearing a diaper and light indoor clothing. The infant's length was measured using an anthropometer. Parental assistance was requested for this procedure to aid speed and accuracy. Two measures of both length and weight were taken. Inter-measure correlations were .99 and 1.0 respectively, indicating good reliability. The mean values were used as the true measures. A measure of physical development was taken at this first visit according to the protocol for the Bayley Scales of Infant Development (Bayley, 1969).

Bayley physical development test reliability. Two testers simultaneously scored the Bayley test of physical development for 8 subjects. The inter-tester correlation was .93, indicating good reliability.

RESULTS

Preliminary Data Assessment

Statistical analyses throughout were conducted with the SAS software system (SAS Institute, 1985). All major variables were examined for possible outliers and skewed values using the SAS Univariate and Frequency procedures. During this assessment of the variables from the initial summary of data, it became apparent that the values from one infant, who was ill during the data collection period, created a problem. This infant wore the actometers for a shorter period of time than did the other infants, and his mother felt that he was becoming distressed. Data from the final night was missing. In addition, diary returns were quite atypical. For example, this infant's mother recorded 14 bowel movements in an 18-hour period. It was therefore decided to drop this one subject from the sample to produce a final sample of 46 infants.

Initial Data Manipulation

Initial manipulation of the data set involved the calculation of new variables, such as mean weight and length of the infant, chronological age of the infant in weeks, ponderal index of the infant and socioeconomic status (Appendix B). Distributions of the new variables were examined for skewness and transformed when necessary by applying the appropriate log or arcsine transformations. The effect of the transformations was to normalize the distibution, while maintaining the rank order of the subjects. For example, the actometer-measured activity level variable was taken as the mean rate per 30 minutes of the four actometers for each infant. Due to a positively skewed distribution of this mean rate, a log transformation was applied to the rate measure of activity, to form the final activity level measure (AL). AL is used as the actometer measure of activity throughout the study.

Differences in weight and overall ponderal index between the males and females were not significant. The mean infant weight was 8.1 Kg and the mean ponderal index was 2.7. However, the boys were significantly longer, $r = -.42$, $p < .004$. The mean length for the girls was 65.8 cm and for the boys it was 67.9 cm. The boys in the sample

were also older than the girls, $r = -.30$, $p < .05$. The mean chronological age for the males was 24.5 weeks and for the females, 24.1 weeks. However, there was no significant sex difference in gestational age, the difference between the assessment date and the mother's original due date.

Actometer - Diary Hypotheses

Table 1 is a summary of infant behaviour as recorded by parents on the infant diary. Throughout the study, the total duration for a diary category, i.e., the number of five-minute intervals recorded, was used in the analyses. The alternative index, the frequency of distinct behavioural episodes of a diary category, produced generally poorer results (see Appendix C). To accomodate possible differences in parental recording style with regard to what was recorded as 'fussing' and what was recorded as 'crying,' the two were combined to form a new variable, 'crying and fussing.'

The first and second hypotheses dealt with the relationships expected to emerge between the actometer measure of activity (AL) and the diary behaviours. To

Table 1

Mean Diary Values - How the 6- Month Old Spends Its Time

Diary Category	Mean % of Total Time	Range %
Crying	2	0 - 6
Fussing	4	0 - 10
Feeding	8	4 - 14
Awake & Content	31	20 - 45
Sleeping	56	45 - 67

Note. All Tables are based on a sample size of 46 infants.

test the first hypothesis, the frequency of wake-sleep transitions and the frequency of diary changes were examined in correlations with activity level (AL), as shown on Table 2. It was expected that infants who had frequent changes of state to and from sleep and awake or who frequently changed from one behaviour to another would be the more active. However, the data did not support the first hypothesis; the correlation between AL and both the number of wake-sleep transitions and the frequency of diary changes was found to be non-significant. When effects due to the age of the infant were partialled, results were similarly non-significant, with correlations of .00 and .18 for frequency of wake-sleep transitions and of diary changes respectively.

Table 2

Correlations of Actometer AL With Diary Behaviours Based on Total Time

Diary Category	Correlation with Activity (AL)
Wake-Sleep Transitions	-.01
Frequency of Diary Changes	.23
Sleeping	-.38 ***
Content	.07
Crying	.34 **
Fussing	.39 ***
Feeding	.18
Crying & Fussing	.45 ***

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

In the second hypothesis it was expected that there would be evidence of a curvilinear relationship between infant activity (AL) and both highly positive and highly negative diary behaviours. To test this hypothesis, diary reports of time spent awake and content and time spent crying and fussing were correlated with AL. The variables related to the second hypothesis are also found in Table

2. Preliminary results showed partial support for the second hypothesis in that time spent crying and fussing was correlated with activity, while time in the content category was not.

Because the focus was on activity and because sleeping behaviour was negatively related to activity, new diary-behaviour variables were created based on the percentage of time spent awake. Table 3 shows the percentage of the various diary behaviours which occurred while the infants were awake. Total awake behaviours accounted for 44% of the infants' time.

Table 3

Non-Sleeping Diary Behaviours

Diary Category	Mean % of Time Awake	Range %
Content	71	55 - 89
Crying	4	0 - 18
Fussing	8	0 - 12
Feeding	17	7 - 32

Because these raw percentage values showed skewed distributions, new variables were created by normalizing with the arcsine transformation (Appendix B). Table 4 shows the correlation between AL and the transformed variables based on per cent of time awake. The second hypothesis was examined again using the transformed diary variables based on the infants' awake time.

Table 4

Correlations of Actometer AL With Diary Categories Based on Duration of Time Awake

Diary Category	Correlation with Activity (AL)
Content	-.27 *
Feeding	.02
Crying	.31 **
Fussing	.33 **
Crying & Fussing	.39 ***

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

In keeping with the prior results, crying and fussing and the combined time of crying and fussing were positively related to AL. However, there was a trend

toward a negative relationship between AL and behavioural contentedness. This trend was in the opposite direction predicted in the second hypothesis.

Because crying, fussing and contentedness might be age-related, age was held constant in partial correlations, and the same results emerged. The correlation between AL and combined crying and fussing was $r = .36$, $p < .01$ and for contentedness, $r = -.23$, ns. Thus, the time awake that the infant spent in a contented state was not related to activity level (AL). The diary categories most strongly related to individual differences in AL during time spent awake, were the unpleasant or negative ones of crying and fussing.

Actometer - IBQ Hypotheses

The third and fourth hypotheses dealt with the relationship expected between the Rothbart IBQ parent questionnaire of infant temperament and actometer-measured activity level (AL). Data manipulation carried out prior to testing of these hypotheses involved the calculation of the six IBQ subscale scores from Rothbart's 94-item questionnaire. The correlational matrix for the six subscales can be seen in Appendix D. Reversal items were

reflected and items inappropriate for the 6-month test were omitted (Appendix E).

In hypothesis 3, it was expected that parent perceptions of infant activity would be positively related to actometer measures of activity (AL). This hypothesis was strongly supported by the data. The IBQ had been completed by parents the day before the actometers were attached and was based on infant behaviour for the week prior to actometer assessment. Table 5 shows the correlational relationships between AL and the six IBQ subscale scores.

Table 5

Actometer - IBQ Subscale Correlations

IBQ Subscale	r With Actometer AL
Activity Level	.48 ****
Laughter & Smiling	.09
Distress to Limitations	.17
Distress to Novelty	.04
Duration of Orientation	-.12
Soothability	-.07

**** $p < .001$.

In hypotheses 4, it was expected that the IBQ composite reactivity scores, created from the individual IBQ subscales, would be related to AL. That is, the more extreme the scores in how parents rated their infants' temperament, either negatively or positively, the more active the infant would prove to be. To create the IBQ composite reactivity scores and the additional overall reactivity scores, the individual subscale scores were first standardized. Then the positive reactivity score variable was created by summing the standardized subscale scores of 'activity level' and 'smiling and laughter', while the negative reactivity score variable was created by summing the standardized subscale scores of 'distress to novelty' and 'distress to limitations'. As one measure of overall reactivity the positive reactivity score was subtracted from the negative score following Rothbart (1986). In addition, because it seemed intuitively valid to sum the positive and negative reactivity scores to obtain a measure of overall parent-rated reactivity, the 'negative plus positive' variable was created. Table 6 examined the relationship between overall reactivity levels and positive and negative composite scores with activity level (AL).

Table 6

Correlations of Actometer AL With Composite & Overall IBQ Scores

IBQ Scores	r With Actometer AL
IBQ Composites:	
Positive Reactivity	.36 ***
Negative Reactivity	.13
Overall Reactivity:	
Sum of Negative + Positive	.34 ***
Negative - Positive (Rothbart)	-.16

*** $p < .01$.

The data support the fourth hypothesis in part. In keeping with the expected results, positive reactivity showed a significant positive correlation with AL. Negative reactivity however, was not related to activity (AL), a result not in keeping with expectation.

IBQ - Diary Hypotheses

The sixth and seventh hypotheses dealt with the expected relationships between the IBQ parent questionnaire and the recorded diary behaviours. In the sixth hypothesis, it was expected that there would be

evidence of convergent validity between the diary behaviours and the IBQ reactivity scores. Unpleasant or stressful diary behaviours, such as crying, fussing, frequency of changes and wake-sleep transitions, should be related to the negative reactivity score, which was composed of the individual subscales, 'distress to limitations' and 'distress to novelty'. Positive diary behaviours, such as contentedness, should be related to the positive reactivity score, composed of 'smiling and laughter' and 'activity level'. Initially, the sixth hypothesis was tested by examining the correlations between the individual IBQ subscales and the diary behaviours as shown in Table 7. 'Soothability' was dropped from the Table because it had no significant diary behaviour correlates.

With two exceptions, frequency of behavioural changes and of wake-sleep transitions did not relate to parent ratings as expected. The exceptions occurred in the negative relationship between frequency of diary changes and duration of orientation and between wake-sleep transitions and smiling and laughter.

Crying and fussing, as expected in the sixth hypothesis, was positively related to parent perceptions of activity level. Crying was also related to parent

Table 7

Correlations of IBQ Subscales With Diary Behaviours

Diary Behaviours	IBQ Subscale				
	Activity	Smiling	Limits	Fear	Orientation
Changes	.13	-.24	.12	.21	-.33 **
WS Trans	-.01	-.30 **	.14	.07	-.20
Sleeping	-.05	-.03	.01	.17	.18
Content	-.31 **	.29 **	-.34 **	-.26 *	.21
Crying	.40 ***	.05	.21	.10	-.00
Fussing	.30 **	-.38 ***	.38 ***	.32 **	-.30 **
Cry & Fuss	.42 ***	-.24	.37 ***	.29 **	-.22

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

perceptions of activity but not to any other IBQ subscale. Fussing behaviour, on the other hand, appeared to be more pertinent to parental perceptions. Fussing was related positively to activity, distress to imposed limits, and fear or distress to novelty. It also was related negatively to perceived smiling and laughter, and duration of orienting. Sleep time did not relate to any of the infant temperament parent ratings. Time awake spent

content also was related negatively to distress to limitations, and at the trend level to fear of novelty and positively to smiling and laughter.

To test the sixth hypothesis further, correlations between the diary behaviours and positive and negative reactivity composites were examined. The results are shown in Table 8.

Table 8

Correlations of IBQ Reactivity Composites With Diary Behaviours

Diary Behaviours	Correlations With: Positive Reactivity	Negative Reactivity
Frequency of Diary Changes	-.07	.20
Wake-Sleep Transitions	-.20	.12
Sleeping	-.05	.11
Content	-.02	-.37 ***
Crying	.29 **	.19
Fussing	-.05	.42 ***
Crying & Fussing	.12	.40 ***
All Waking Behaviours	.08	-.13

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

The sixth hypothesis found partial support in the relationship between the IBQ negative reactivity score and the stressful or unpleasant diary behaviours. The negative IBQ reactivity score was related, as expected, to the unpleasant diary behaviours, crying and combined crying and fussing. However, there was no inverse relationship between positive reactivity and any of the unpleasant or stressful diary behaviours (frequency of diary changes, wake-sleep transitions, crying and/or fussing). Unexpectedly, crying was directly related to the positive IBQ reactivity score. This result was in the opposite direction to that expected in the hypothesis, and is presumably due to the crying-activity relationship. It is recalled that the IBQ activity subscale is a component of the positive reactivity score.

Table 9 examines the correlations between the diary behaviours and the overall reactivity scores. In general, the sum of the negative and positive reactivity scores was more strongly related to diary reports than the difference between the negative and positive components. Nevertheless, some of these relationships are puzzling. For example, one would expect crying and fussing to have a similar relationship to the sum score, but they do not.

Table 9

Correlations of Overall IBQ Reactivity With Diary Behaviours

	IBQ Overall Reactivity	
	Difference	Sum
Diary Behaviours	Neg - Pos	Neg + Pos
Frequency of Diary Changes	.19	.08
Wake-Sleep Transitions	.23	-.05
Sleeping	.12	.05
Content	-.26 *	-.27 *
Crying	-.06	.33 **
Fussing	.35 **	.27 *
Crying & Fussing	.21	.37 ***
All Waking Behaviours	-.15	-.04

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

In the seventh hypothesis it was expected that diary reports of frequency of diary changes or of wake-sleep transitions, would be positively related to the IBQ activity subscale. Results in Table 7 show that this hypothesis was not supported by the data.

Sex Differences

The fifth hypothesis dealt with the expectation of sex differences in activity level. Initial correlational analysis in testing for sex differences showed that there were no significant differences in parental perceptions of activity (IBQ Activity) between infant males and infant females, r = .04, ns. There was, however, a trend toward males being more active than females when actometer-measured activity (AL) was correlated with sex, r = -.25, p < .09.

In a further test of the fifth hypothesis, the two measures of activity were used in a multivariate analysis. Sex differences were not significant by Wilk's criterion, $F(2,43) = 2.22$, p < .12. Parental perception of infant activity by itself was not significant for sex, $F(1,44)$ = .06, p < .82. However, the actometer measure of activity (AL) showed a significant trend toward sex differences, with boys tending to be the more active, $F(1,44) = 2.93$, p < .09.

Supplementary Analyses

Physical and Demographic Variables. Table 10 identifies the significant physical measures and demographic variables from the three instruments used in the study. The ponderal index (PI) was a "fatness" ratio measure (Appendix B) taken at the time of assessment. The age variable used was gestational age (GA) based on the mothers' reported due dates. The physical measure of development was the raw score on the Bayley (1969) physical development index (PDI).

Predictability. An exploratory 11-item questionnaire (see Appendix B) was developed to provide a context with which to further examine the behavioural state changes, wake-sleep transitions and IBQ parent ratings. It was felt that infants who were more frequent "changers" or who had frequent wake-sleep transitions might be less predictable than other infants. Therefore, parents would have more difficulty rating these infants. Then again, even if infants went through many behavioural changes and transitions, parents whose infants were regular and predictable would be more "readable" to their parents. A principal components analysis was performed on the infant

Table 10

Significant Correlations of Physical & Demographic Variables With Other Variables

	Physical & Demographic Variables				
Other Variables	PI	GA	Sex	PDI	SES
Actometer					
AL			-.25 *		
Diary					
Changes	-.26 *	.28		.29 **	.41 ***
Sleep		-.34 **		-.27 *	
IBQ					
Limits	.36 ***		-.30 **		
Soothability			-.25 *		

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

predictability questions in order to summarize the data and reduce the number of variables from 11 to five. Table 11 shows the first five of the components along with the question item that correlates with them.

Each of the five components then was correlated with the diary wake-sleep transitions and frequency of changes as well as IBQ variables. Table 12 shows the significant correlations between the predictability components and other variables in the study.

Table 11

Correlation of Principal Components With Question Items

Question Item	Component One	Two	Three	Four	Five
Predictability in:					
1. Feeding time	.00	.11	**.49**	**.38**	.25
2. Amount of food	.19	.16	.12	.05	**.71**
3. Nap time	.24	-.09	**.42**	**-.40**	.01
4. Nap length	.22	-.26	**.46**	-.21	.14
5. Bed time	.10	**.47**	**.31**	.04	**-.30**
6. Sleeping all night	.11	.20	.30	**.50**	**-.41**
7. Night sleep length	**.30**	**.48**	-.20	-.16	.12
8. Daily fussiness	**.52**	-.18	-.22	.32	.04
9. Time of fussiness	**.54**	-.15	-.24	.24	-.02
10. Pattern of B.M.'s	**.32**	**-.39**	.15	-.21	**-.33**
11. Daily happy time	.28	**.43**	-.05	**-.40**	-.15

Note. Bold type signifies the four most highly weighted items for each component

The third component concerned with predictability on feedings, naps and bedtime, was negatively related to frequency of diary changes, as well as to parent perceptions of activity and distress to limits.

Table 12

Significant Correlations Between

Predictability Components and Other Variables

Other Variables	Predictability Component				
	One	Two	Three	Four	Five
Diary Categories:					
Wake-sleep transitions	.05	-.06	-.15	.00	.19
N changes	.21	-.18	-.42 ***	.13	-.03
IBQ Subscales:					
Activity			-.32 **		
Orientation			.29 *		
Limits			-.31 **		
Neg Reactivity			-.29 **	.28 *	

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

DISCUSSION

The goal of this study was to examine the meaning of motor activity in infants as a component of the child's overall behavioural repertoire and as it related to parent perceptions of individual differences in temperament. More specifically, the study attempted to address several questions. What kinds of behavioural states are related to infant motor activity? How does motor activity fit into the parent's perception of temperament? How do infants' daily patterns of behaviour influence parents' perceptions of their infant's temperament?

Activity and Behavioural State Transitions

For the first two hypotheses, which dealt with behavioural state transitions and actometer measures of activity (AL), the expected relationships did not emerge. Wake-sleep transitions and frequency of change from one behaviour category to another did not relate to AL. Frequency of behavioural change showed a negative trend with ponderal index, i.e., more frequent state changes for thinner babies, and a positive trend with gestational age. "Changers" tended to be thinner, older, and developmentally more physically mature.

However, Dittrichova et al.'s (1982) finding that infants who slept more were less active was confirmed. It was also found that relatively immature infants tended to sleep more and were less active. Given our knowledge of development, these outcomes are hardly surprising. They do raise an interesting question of cause and effect, however. Were these infants less developed than their peers of the same age because they slept more and therefore received less stimulation or did they sleep more simply because they were immature? Or does some underlying third process control both sleep and receptiveness to stimulation?

Neo-Pavlovians such as Strelau (1983) or natural historians such as Wolff (1984) might suggest underlying theoretical reasons for the maturity connection. Strelau (1983) maintains, for example, that motor activity acts as a self-regulator of individual optimum stimulation. Infants who sleep more have lower levels of motor activity. Therefore they would have lower levels of self-stimulation. Low levels of self-stimulation would in turn lead to low levels of arousal and increased sleep time. Similiarly, Wolff (1984) could suggest that newly acquired coordinated movements are used by infants to stimulate their own alertness. Perhaps those infants who are slower at physical development do not yet possess the

coordination of movements or actions that they need to initiate new combinations of activities and motor patterns by which wakefulness becomes a stable state.

There was a surprising lack of relationship between physical development and AL in the study. It was suggested that AL might be greater in infants who were more physically mature, or conversely that immature infants, having less coordination and control over their body movements, might be the more active. The failure to find any significant relationship does not clarify the issue. A broader range of physical development status may be necessary to resolve the issue in future work.

It was expected that both positive (awake and content) and negative (fussing and crying) diary behaviours would be related to activity (AL). The negative diary behaviours were related to AL as anticipated. However, contentedness tended to accompany lower, rather than higher levels of activity. In line with Strelau's argument, the infants spending more time in a quiet, content state may have had lower levels of activity because of adequate levels of stimulation.

The lack of a content-AL relationship might have also been due in part to the broad definition of 'awake and content.' 'Fussing,' and, particularly, 'crying'

behaviour is quite specific and easy to identify. Whereas, 'content' behaviour may range from extreme happiness to a state of non-reactiveness. As such, the "content" category may be too broad to be identified as a truly 'positive' behavioural state. It also might have been the case that contentedness at six months of age was expressed as quiet, self-absorbed activity rather than as more physically active social interaction.

The relationship of activity (AL) with the negative diary behaviours of crying and fussing was part of a consistent trend throughout the study. Crying and fussing together comprised only an average of 6% (about 24 minutes) of the infants' waking hours. Still, these two negative behaviours were significant predictors of objectively measured activity. Korner et al.'s (1974, 1981) concern about AL being confounded by infant irritability is a valid one.

Activity and Parent Perceptions

Convergent validity between parent ratings of activity and actometer measures (AL) was strongly confirmed. The relationship between the two instruments provided evidence that the IBQ (Rothbart, 1981) Activity scale is a valid measure for infants at six months of age. The motor

activity that the actometers were measuring corresponded to what the parents perceived as activity. Although Eaton and Dureski (1986) did not find convergent validity between IBQ parent-rated activity and actometer AL at three months of age, it may be that by six months infants are more understandable to the parents than they were at the younger age.

A curvilinear relationship was expected between overall parent perceptions of temperament and actometer measures of activity (AL). It was thought that highly positive or highly negative ratings of infants would be related to their AL. Results indicated, however, that AL was related to overall positive reactivity, but not to overall negative reactivity.

These results were puzzling at first glance because they appeared inconsistent with the AL-fussing relationship found earlier. However, by definition, overall positive reactivity on the IBQ included both 'smiling and laughter' and 'activity level' subscales. As already discussed, 'activity level' was strongly correlated to AL, the actometer measure of activity. However, contrary to the findings of Eaton and Dureski (1986) and Crockenberg and Acredolo (1983), 'smiling and laughter' was not related to AL. So the apparent

fulfillment of the hypothesis relating positive reactivity to AL was probably due almost entirely to the relationship of parental perception of activity with AL and not to that of 'smiling and laughter' with AL.

Unexpectedly, the results also showed that the negative parent perceptions, as expressed by the overall negative reactivity score, were not related to AL. It will be recalled that negative reactivity was made up of parental perceptions of infant 'distress to imposed limitations' and 'distress or fear in novel situations.' At this age, it seemed plausible that both of these two IBQ subscales, would result in increased motor activity due to crying and/or fussing behaviour. Results confirmed that 'distress to imposed limits' and 'distress to novelty' were both related to 'cry and fuss' behaviour. In addition, 'crying and fussing' was related to actometer AL. It would seem plausible then that 'distress to imposed limits' and 'fear of novelty' would also be related to AL, but they were not.

It may be the case that at six months of age 'distress to imposed limits' and 'fear of novelty' produce two different types of behaviour. For example, 'distress to imposed limits' shows a positive but non-significant relationship with AL, but 'fear of novelty' shows none.

It could be that at this age, distress as a result of imposed limits results in increased physical activity, but that fear of novel situations results in "freezing" behaviour. Combining the two subscales may have been inappropriate in such a case. The lack of a correlation between the two distress scales suggests that they may be addressing different behavioural domains.

Parents had quite accurate ideas of how active their infants were. The IBQ Activity subscale was the only parent-rated characteristic that was related to actometer-measured AL. Therefore, as a dimension of infant temperament, IBQ activity was orthogonal to other IBQ scales, and can be treated as a distinct construct. On the other hand, it appeared that Rothbart's (1986) overall positive and negative reactivity scales only served to confuse the relationship between parent perceptions and both actometer AL and diary behaviours.

Diary Behaviours and Parent Perceptions

Examination of the overall IBQ reactivity scores was not very helpful in clarifying the relationship that was expected between diary behaviours and parent perceptions on the IBQ overall reactivity scales. There was evidence of consistency, however, between the individual IBQ

subscales and diary categories of behaviour. Parental perception of activity was negatively related to 'contentedness' and positively related to 'crying and fussing.' Diary 'contentedness' was related to IBQ 'smiling and laughter.' Contentedness was also negatively related to 'fear or distress in novel situations.' 'Fussing' was negatively related to 'smiling and laughter' and positively related to 'distress to imposed limits.'

Overall, diary reports of 'fussing' behaviour appeared to be most pertinent to parental perceptions of infant temperament. Five of the six IBQ subscales were significantly related to 'fussing.' In contrast, 'crying' behaviour was related only to one, parent perception of activity. 'Soothability' was the only scale not related to diary behaviours. Parents appeared most influenced in the ratings of their infants' temperaments by the negative 'fussing' behaviour. To some lesser extent, however, 'awake and content' behaviour also influenced their opinions as expressed on the IBQ.

Sex Differences

Sex differences were hypothesized to be significant in the fifth hypothesis. Boys were found to be more active than girls only at the trend level. However, the effect

sizes were similar to those found by Eaton and Enns (1986) for AL. For actometer measures of activity the effect size is 0.6 standard deviations in the present study. That is, boys were about one-half standard deviation more active than girls at this age as measured with the actometers. Parents, however, did not rate their male babies as more active than their female babies. In this study, there were almost twice as many females as males, so the power to detect a sex difference was low, and results might have been clearer if the numbers had been balanced.

Predictability

The disappointing outcomes of the initial analyses involving the diary frequency of changes and wake-sleep transitions prompted te examination of the predictability questionnaire components. It was thought that infant predictability might provide a context for understanding the diary-IBQ relationships. Results indicated that infants who changed their behaviour relatively infrequently were seen as less active, calmer and perhaps more predictable than others. In general, however, unpredictability of the infant was not related to changes, transitions or IBQ parent ratings.

Conclusion

The parent diary, as a relatively untried method of obtaining behavioural data, was well-received by parents. All of the diaries were usable, and it was evident that some parents were surprised at how their infants spent the day. Several asked for souvenir diaries. From a practical standpoint, the in-home use of diaries and actometers worked well and provided ecologically valid data over a reasonably long interval.

What emerged from the study, was that the negative behaviours were more pertinent to parents' perceptions of temperament than were the positive ones. Time spent fussing, in particular, affected parents' perception of infant temperament. It would be interesting to reassess the same infants to see if the infant behaviour, activity and parent perceptions remain stable over time as Korner et al. (1985) found. It may also be a sad fact that parents tend to focus on the negative behaviours and take the "good" for granted.

Actometer-measured activity (AL) provided strong evidence of convergent validity with parent ratings of activity at six months of age, and provided support for Rothbart's (1981) Infant Behavior Questionnaire. Motor activity in infants appears as a meaningful and measurable

individual characteristic. Parents have indicated that motor activity is a salient component of their infant's temperament, and it can be distinguished from other temperamental dimensions. Activity level is a distinct and useful dimension of individual differences in infancy.

APPENDICES

Appendix A

Forms

Parent Recruitment Letter

We are involved in a research project on the motor activity of infants in their fifth month. Specifically, we are interested in investigating the relation between activity and the infant's daily patterns of behaviour. We have obtained the names of parents and infants from the 'birth announcements' section of the newspaper and we are recruiting parent-volunteers who would be interested in participating in the project.

The research would involve measuring the activity level of your infant in your own home. The infant would wear motion recorders, similar in size and appearance to a wristwatch, for two days. These recorders would help us to understand how active infants are in their homes, while carrying on with their normal daily routines.

If you agree to participate in our study, we will send you an infant behaviour questionnaire and arrange a convenient time for a home visit to bring the motion recorders. To get an idea of what the infant is actually doing while he or she is wearing the motion recorders, we will ask you to complete a diary of your baby's wake and sleep behaviours. All specific information will be provided at the time of the home visit. Later, we will return to collect the motion recorders and diary, and to weigh and measure your baby.

The project should provide interesting information on infant activity, sleep patterns and behaviour. Parents who volunteer to participate will receive a summary of the results when the research is completed.

If you agree to participate, you would be free to withdraw from the study at any time. We will telephone in the next few days to answer any questions you may have and to see if you are interested in participating. If you wish, you can contact us in the meantime, by calling and leaving a message.

Sincerely,

Warren O. Eaton, Ph.D. Nancy A. McKeen, B.A. (Hons.), R.N.

Consent Form

I, _____, along with my infant, _____, agree to participate in a research study of infant behaviour conducted by Nancy McKeen and Dr. Warren O. Eaton, Department of Psychology, University of Manitoba. I understand that we are under no obligation to participate and that we may withdraw from the study at any time. I understand that information we provide for the study will be kept confidential to protect our privacy.

Date: _____ Signature _____

Address to which results to be sent:

Parent Instructions for Actometers

A. Please leave the recorders on baby as much as possible. It may be necessary to remove one or more of the recorders for dressing and undressing baby. The recorders aren't waterproof, so be sure to remove them for baths. It is also very important for us to know of times when a recorder is off baby, so if you find it necessary to remove one or more of the recorders:

   1) On the attached sheet note the time of day (not the time on the recorder itself) when each recorder is removed and re-attached.

   2) Be sure to re-attach each recorder on the arm or leg from which it was removed. They are color-coded so you can check the attached sheet to see which recorder goes on which limb.

   3) Be sure the recorder is snugly fastened on the outside of the wrist or ankle just above the wrist joint or ankle bone.

B. The recorders aren't fragile so you can treat your baby as you normally do.

C. If we can not be present for the final recorder removal, we would like you to remove the recorders at the suggested time listed on the attached sheet (or as close to this time as practical). Record the actual time of removal and store the recorders in a place where they won't be disturbed until we can collect them.

If you are uncertain about what to do, please call:

Nancy McKeen

or
leave message at

Actometer Recording Sheet

ID _____

Interviewer _____

Begin (DDMMMYY:hh:mm) __ __ __ __ __ __ __: __ __: __ __

Set ____	Acto #	Acto Start (hh:mm:ss)	Acto Stop (hh:mm:ss)
Right arm	_____	__ __: __ __: __ __	__ __: __ __: __ __
Left arm	_____	__ __: __ __: __ __	__ __: __ __: __ __
Right leg	_____	__ __: __ __: __ __	__ __: __ __: __ __
Left leg	_____	__ __: __ __: __ __	__ __: __ __: __ __

data entered? ____ checked? ____

data entered? ____ checked? ____

Incidentally, have you noticed a preference for left- or righthandedness in your baby? (1 = left, 2 = unsure or no preference, 3 = right) ____

Do you bottle feed? (1 = yes, 2 = no) ____

Amt. of formula per day _____

Length 1: __ __. __ cm Length 2: __ __. cm.

Weight 1: __ __ lbs __ __ oz. Weight 2: __ __ lbs __ __ oz

Amount Formula __ __. __ ozs or __ __ __ ml

Data entered? _____

checked _____

Parent Record of Actometer Removals

Check the recorders which are removed				Time of day		
Right Arm	Left Arm	Right Leg	Left Leg	Removed (hh:mm)	Replaced (hh:mm)	Comments
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________

B. Final Recorder Removal

Best time to remove motion recorders: ___: ___ am/pm on ____________.

Time of removal ___: ___ am/pm Date ____ ______ ______
hh mm Day Month Year

Once the recorders are removed, they should be moved as little as possible.

Parent Recruitment Letter

We are involved in a research project on the motor activity of infants in their fifth month. Specifically, we are interested in investigating the relation between activity and the infant's daily patterns of behaviour. We have obtained the names of parents and infants from the 'birth announcements' section of the newspaper and we are recruiting parent-volunteers who would be interested in participating in the project.

The research would involve measuring the activity level of your infant in your own home. The infant would wear motion recorders, similar in size and appearance to a wristwatch, for two days. These recorders would help us to understand how active infants are in their homes, while carrying on with their normal daily routines.

If you agree to participate in our study, we will send you an infant behaviour questionnaire and arrange a convenient time for a home visit to bring the motion recorders. To get an idea of what the infant is actually doing while he or she is wearing the motion recorders, we will ask you to complete a diary of your baby's wake and sleep behaviours. All specific information will be provided at the time of the home visit. Later, we will return to collect the motion recorders and diary, and to weigh and measure your baby.

The project should provide interesting information on infant activity, sleep patterns and behaviour. Parents who volunteer to participate will receive a summary of the results when the research is completed.

If you agree to participate, you would be free to withdraw from the study at any time. We will telephone in the next few days to answer any questions you may have and to see if you are interested in participating. If you wish, you can contact us in the meantime, by calling and leaving a message.

Sincerely,

Warren O. Eaton, Ph.D. Nancy A. McKeen, B.A. (Hons.), R.N.

Consent Form

I, _____, along with my infant, _____, agree to participate in a research study of infant behaviour conducted by Nancy McKeen and Dr. Warren O. Eaton, Department of Psychology, University of Manitoba. I understand that we are under no obligation to participate and that we may withdraw from the study at any time. I understand that information we provide for the study will be kept confidential to protect our privacy.

Date: _____ Signature _____

Address to which results to be sent:

Parent Instructions for Actometers

A. Please leave the recorders on baby as much as possible. It may be necessary to remove one or more of the recorders for dressing and undressing baby. The recorders aren't waterproof, so be sure to remove them for baths. It is also very important for us to know of times when a recorder is off baby, so if you find it necessary to remove one or more of the recorders:

   1) On the attached sheet note the time of day (not the time on the recorder itself) when each recorder is removed and re-attached.

   2) Be sure to re-attach each recorder on the arm or leg from which it was removed. They are color-coded so you can check the attached sheet to see which recorder goes on which limb.

   3) Be sure the recorder is snugly fastened on the outside of the wrist or ankle just above the wrist joint or ankle bone.

B. The recorders aren't fragile so you can treat your baby as you normally do.

C. If we can not be present for the final recorder removal, we would like you to remove the recorders at the suggested time listed on the attached sheet (or as close to this time as practical). Record the actual time of removal and store the recorders in a place where they won't be disturbed until we can collect them.

If you are uncertain about what to do, please call:

Nancy McKeen

or
leave message at

Actometer Recording Sheet

ID _____

Interviewer _____

Begin (DDMMMYY:hh:mm) __ __ __ __ __ __ __: __ __: __ __

Set ____	Acto #	Acto Start (hh:mm:ss)	Acto Stop (hh:mm:ss)
Right arm	_____	__ __: __ __: __ __	__ __: __ __: __ __
Left arm	_____	__ __: __ __: __ __	__ __: __ __: __ __
Right leg	_____	__ __: __ __: __ __	__ __: __ __: __ __
Left leg	_____	__ __: __ __: __ __	__ __: __ __: __ __

data entered? ____ checked? ____

data entered? ____ checked? ____

Incidentally, have you noticed a preference for left- or righthandedness in your baby? (1 = left, 2 = unsure or no preference, 3 = right) ____

Do you bottle feed? (1 = yes, 2 = no) ____

Amt. of formula per day _____

Length 1: __ __. __ cm Length 2: __ __. cm.

Weight 1: __ __ lbs __ __ oz. Weight 2: __ __ lbs __ __ oz

Amount Formula __ __. __ ozs or __ __ __ ml

Data entered? _____

checked _____

Parent Record of Actometer Removals

Check the recorders which are removed				Time of day		
Right Arm	Left Arm	Right Leg	Left Leg	Removed (hh:mm)	Replaced (hh:mm)	Comments
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________
___	___	___	___	__ __ : __ __	__ __ : __ __	________

B. Final Recorder Removal

Best time to remove motion recorders: ___: ___ am/pm on ___________.

Time of removal ___: ___ am/pm Date ____ ______ ______
hh mm Day Month Year

Once the recorders are removed, they should be moved as little as possible.

Parent Questionnaire

General Information

ID ____ Date (YY/MM/DD) _____ Interviewer _____

Baby's name _____ Sex _____

Baby's birth date _____ Baby's age now _____

Baby's original due date _____

Were there any birth complications for the baby or you? ____

Specify _____

_____

Has your baby had any health problems since birth? _____

Specify _____

_____

Was this your first (or second etc.) birth? _____

How many children now live in your home? _____

For each child:	Sex (M,F)	Birthdate (YY/MM/DD)	Relation to baby (Full or Half sib,Unrelated)
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____

Mother's birthdate (YY/MM/DD)_____

Mother's height (ft/in) _____

Father's birthdate (YY/MM/DD) _____

Father's height (ft/in) _____

Occupation and Education

We would like to ask some questions about you and your partner's occupational and educational backgrounds.

What is the highest grade or year (1 to 13) of secondary or elementary school ever attended?
mother _____ father _____

How many years of education have been completed at university?
mother _____ father _____

How many years of schooling have been completed at an institution other than a university, high school or elementary school? Include years of schooling at community colleges, institutes of technology, CEGEPS (general or professional), private trade schools or private business colleges, diploma schools of nursing etc.
mother _____ father _____

mother education classification ___
father education classification ___

Are you working now? Hours per week _____
If yes, what work do you do? _____
If no, did you work before your baby was born? _____
If yes, what work did you do? _____

Is your partner working now? (Y or N) _____
If yes, what work does he do? _____
If no, did he work before? (Y or N) _____
If yes, what work did he do? _____

mother occupation classification __
father occupation classification __

Predictability Questions

1. Is your baby usually predictable in when he or she wants to be fed (ie. hungry times not varying by more than 1 hour from day to day)?

yes no don't know/not sure

2. Is it easy to anticipate how much she will eat each day (ie. does she usually take about the same amount of milk or food from day to day)?

yes no don't know/not sure

3. Does your baby take a nap at about the same time each day (not varying by more than half an hour from one day to the next)?

yes no don't know/not sure

4. Do naps usually last about the same length of time from day to day (ie. not varying by more than half an hour)?

yes no don't know/not sure

5. Does your baby usually fall asleep at night at about the same time from day to day (ie. not varying by more than half an hour)?

yes no don't know/not sure

6. Does your baby usually sleep through the night?

yes no don't know/not sure

7. Does your baby usually sleep at night for about the same length of time (ie. the number of hours doesn't vary by more than half an hour from day to day)?

yes no don't know/not sure

8. Does your baby usually have a fussy period each day?

yes no don't know/not sure

9. Does the fussy period occur at about the same time every day? When does it occur? _____

yes no don't know/not sure

10. Do bowel movements show any particular patterns of occurrence from one day to the next?

yes no don't know/not sure

11. Does your baby have a period each day when he or she is happy and requires almost no attention?

yes no don't know/not sure

IBQ Scoring and Dimension Definitions

Scale scores for the Infant Behavior Questionnaire represent the mean score of all scale items applicable to the child during the last week or two weeks, as judged by the caretaker. Scales scores are to be computed by the following method

1. Sum all numerical item responses for a given scale. Note that:
   a) If caretaker omitted an item, that item receives no numerical score;
   b) If caretaker checked the "does not apply" response option for an item, that item receives no numerical score;
   c) Items indicated with an R are reverse items and must be scored in the following way:

7 becomes 1	3 becomes 5
6 becomes 2	2 becomes 6
5 becomes 3	1 becomes 7
4 remains 4	

2. Divide the total by the number of items receiving a numerical response. Do not include items marked "does not apply" or items receiving no response in determining the number of items. For example, given a sum of 40 for a scale of 17 items, with one item receiving no response, two items marked "does not apply", and 14 items receiving a numerical response, the sum of 40 would be divided by 14 to yield a mean of 2.85 for the scale score.

TEMPERAMENT DIMENSION DEFINITIONS
8/25/78

Activity Level. Child's gross motor activity, including movement of arms and legs squirming and locomotor activity.

Smiling and Laughter. Smiling or laughter from the child in any situation.

Distress and Latency to Approach Sudden or Novel Stimuli. The child's distress to sudden changes in stimulation and the child's distress and latency of movement toward a novel social or physical object.

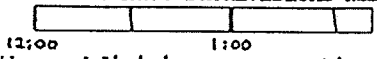
Distress to Limitations. Child's fussing, crying or showing distress while a) waiting for food, b) refusing a food, c) being in a confining place or position, d) being dressed or undressed, 4) being prevented access to an object toward which the child is directing her/his attention.

Soothability. Child's reduction of fussing, crying, or distress when soothing techniques are used by the caretaker of child.

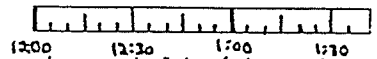
Duration of Orienting. The child's vocalization, looking at and/or interaction with a single object for extended periods of time when there has been no sudden change in stimulation.

Parent Instructions for Completing the Diary

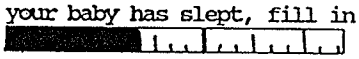
This record of the baby's day is designed to permit you to record your baby's behaviour easily over a continuous twenty-four hour period. As you can see, one whole day is represented by four bars which look very much like 'rulers'. These have subdivisions marked representing 1-hour intervals

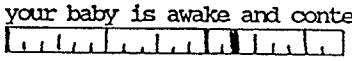


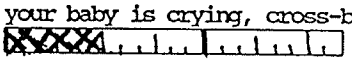
and further subdivisions representing 5-minute intervals

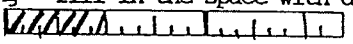


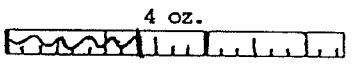
You are not expected to interrupt work every five minutes to fill in one unit. Rather, the record should be filled in periodically. As a rule of thumb, it should be filled in often enough to permit you to accurately remember what happened since the previous recording time. Some people find that it is easiest to record every 1 or 2 hours, others every 3 to 4 hours during the day. You can determine the frequency of recording which is best for you. The behaviours are each represented by a different type of shading or symbol. Only one type of shading is represented at a time, and can be filled in as follows:

(1) When your baby has slept, fill in the space with solid shading like this:

= 40 minutes sleeping;

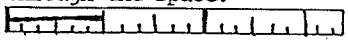
(2) When your baby is awake and content, just leave the space blank;

= 70 minutes awake and happy;

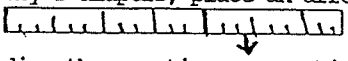
(3) When your baby is crying, cross-bar and space.

= 30 minutes of crying;

(4) When your baby is awake and fussy - making unhappy sounds but not actually crying - fill in the space with diagonal lines like this.

= 30 minutes of fussing;

(5) When your baby is feeding, draw a squiggled line through the space and fill in above the line the approximate amount of formula that you think the baby drank at that feed.


= 40 minutes of feeding, and about 4 oz. of formula taken);

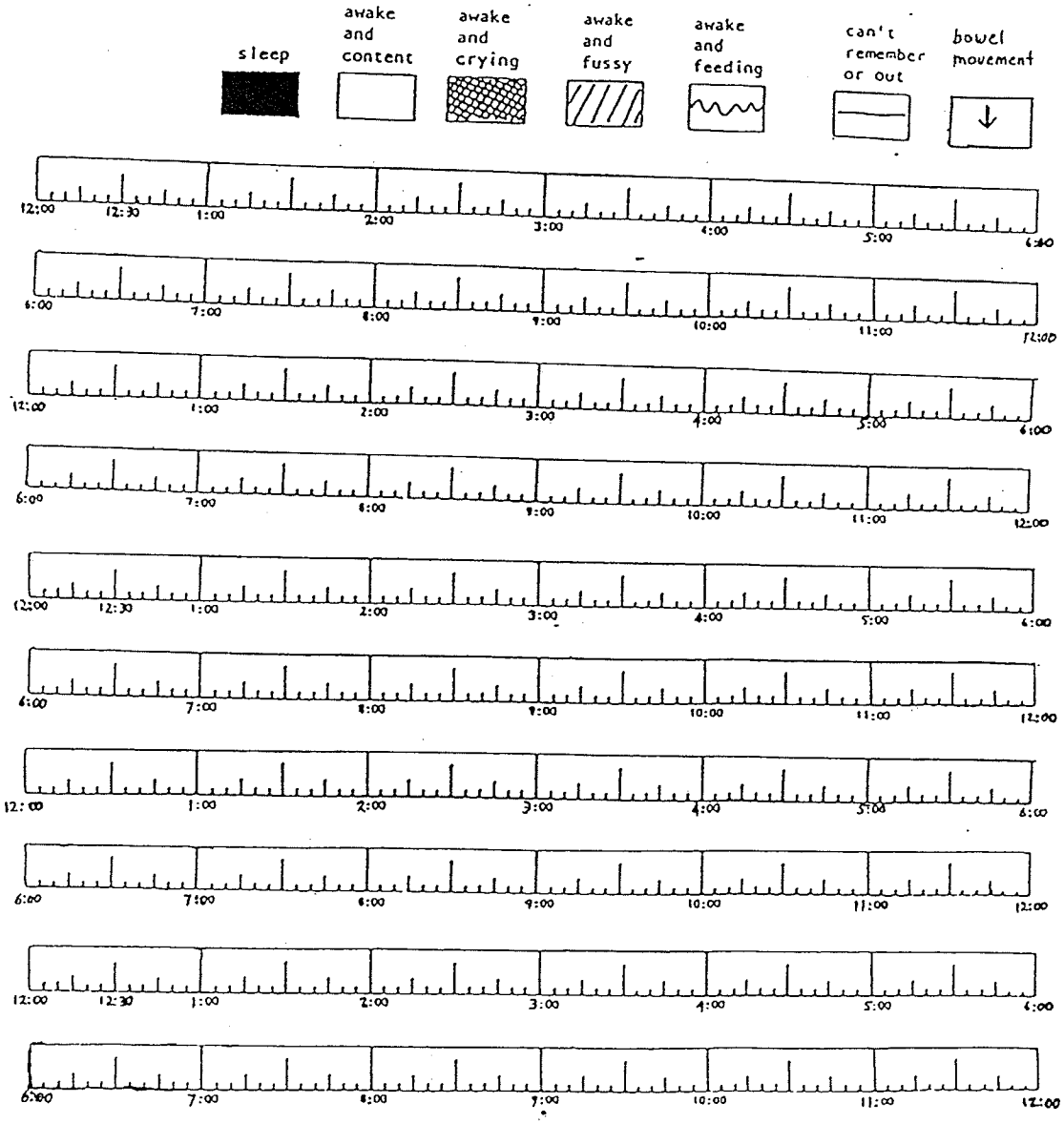
(6) When you go out and you don't remember the baby's behaviour, draw a straight line through the space:


(7) When the baby has a bowel movement or when you discover a bowel movement in the baby's diapers, place an arrow below the line:


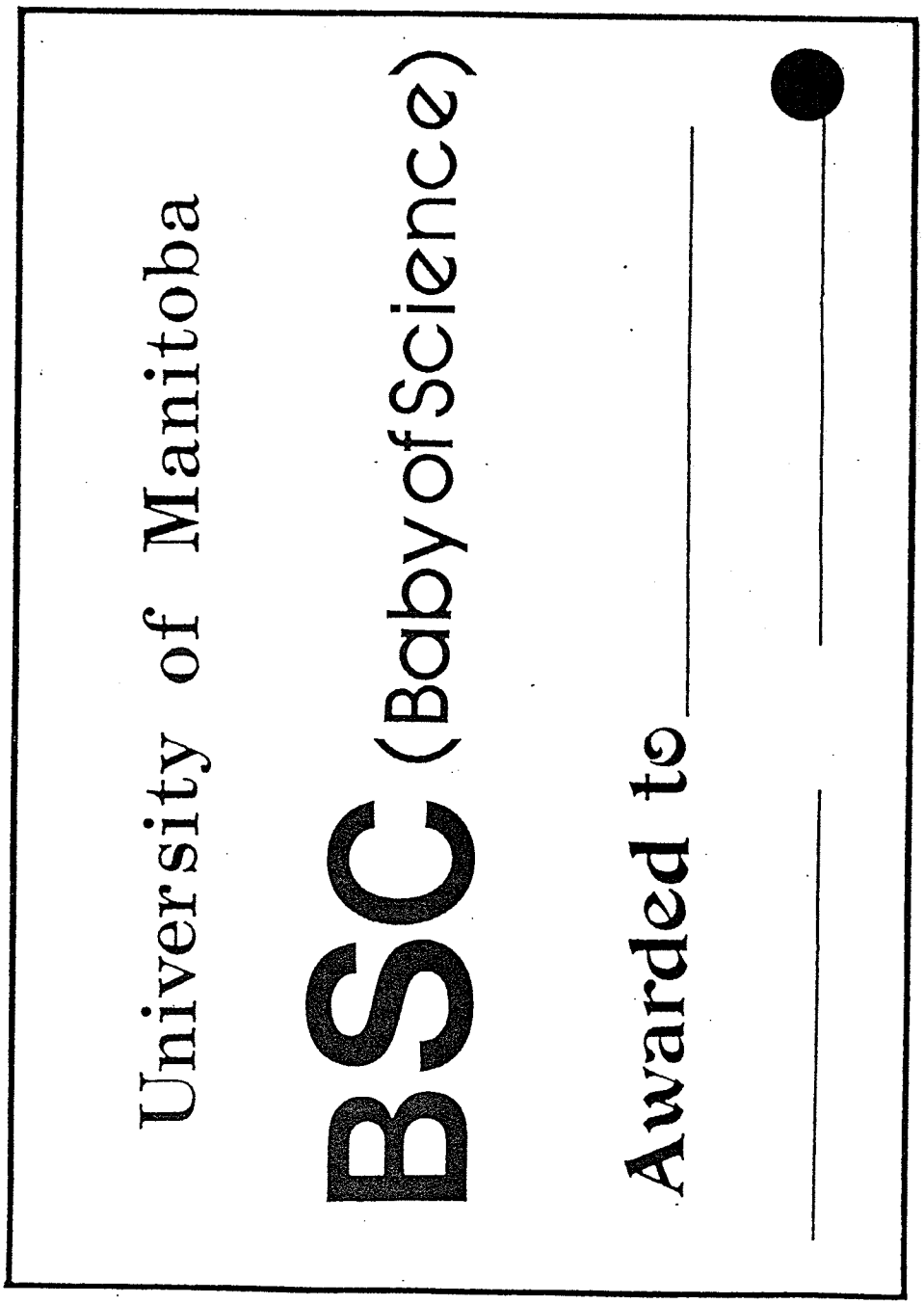
(8) Regarding the question: Was this a typical day?, please tell us whether unusual circumstances occurred (such as a cold, fever, presence of many visitors, a long car ride, etc.) which may have affected the baby's behaviour.

Thank you very much for your help. The record will be picked up at the next home visit.

The Baby's Day Diary



Baby of Science Diploma



Appendix B - Summary of Created Variables

Mean Weight: Mean of two measures in Kg. Reliability: 1.0

Mean Length: Mean of two measures in cm. Reliability: .99

Chronological age in weeks: Days between test date and birth date divided by 7.

Gestational age in weeks: Days between test date and mother-reported due date divided by 7.

Ponderal Index: Mean weight in gm multiplied by 100000 all divided by mean length in cm cubed

From Scanlon, CD '84, pp 669

SES: 5 * Mean of mother's and father's occupations
+ 3 * Mean of mother's and father's educations

From Hollingshead, Yale University, 1975

Actometer Transformations:

AU = Stop time - Start time

MIN = Total min. actos worn

AU_RATE = (AU/MIN) * 30

AU_LOG = LOG10(AU_RATE)

Diary Transformations:

Transformed value:

2 * (Arcsine of the square root of the pertinent diary behaviour)

(Diary behaviour in % of total time or % of time awake)

Mean Weight: Mean of two measures in Kg. Reliability: 1.0

Mean Length: Mean of two measures in cm. Reliability: .99

Chronological age in weeks: Days between test date and birth date divided by 7.

Gestational age in weeks: Days between test date and mother-reported due date divided by 7.

Ponderal Index: Mean weight in gm multiplied by 100000 all divided by mean length in cm cubed

From Scanlon, CD '84, pp 669

SES: 5 * Mean of mother's and father's occupations
+ 3 * Mean of mother's and father's educations

From Hollingshead, Yale University, 1975

Actometer Transformations:

AU = Stop time - Start time

MIN = Total min. actos worn

AU_RATE = (AU/MIN) * 30

AU_LOG = LOG10(AU_RATE)

Diary Transformations:

Transformed value:

2 * (Arcsine of the square root of the pertinent diary behaviour)

(Diary behaviour in % of total time or % of time awake)

Appendix C - Diary Duration vs Frequency

It was possible to calculate both total duration for a diary category and the total frequency, or episodes for that category. These two related variables are compared in the following table for each diary behaviour as it correlates with activity level as measured by the actometers. The durations of diary activities rather than their frequencies of occurrence provide the more interesting correlational information.

	Actometer AL With:	
Diary Behaviour	Duration	Frequency
Sleeping	-.38 ***	.16
Content	.07	.02
Crying	.34 **	.31 **
Fussing	.39 ***	.19
Feeding	.17	.20
Crying & Fussing	.43 ***	.29 **
All Waking Behaviours	.37 ***	.23

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

Appendix D - Correlational Matrix of IBQ Subscales

	Activity	Smiling	Novelty	Limits	Orientation
Smiling	.23				
Novelty	.16	-.32 **			
Limits	.43 ***	-.24	.36 **		
Orient.	.18	.56 ****	-.21	-.17	
Sooth.	.12	.31 **	.08	-.01	.26

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

Appendix E - Calculation of IBQ Subscales

Conversion of 'not applicable' codes from 8 to missing:

DO N=1 TO 94; IF I>7 THEN I =.; END.

REVERSAL ITEMS REFLECTED: 1,4,9,12,15,17,21
49,65,72,79,83.

OMIT ITEMS INAPPROPRIATE FOR 6-MONTH TEST: 45,55,81.

CALCULATION OF ACTIVITY SUBSCALE:

MEAN OF ITEMS 4 5 6 13-15 23 24 30 31 62 65-67 70-72.

CALCULATION OF DISTRESS TO NOVELTY SUBSCALE:

MEAN OF ITEMS 9-11 33 35 45 54 55 61 75-79 81 83.

CALCULATION OF DURATION OF ORIENTING SUBSCALE:

MEAN OF ITEMS 18 36-42 46 56 57.

CALCULATION OF SMILING & LAUGHTER SUBSCALE:

MEAN OF ITEMS 25 28 27 32 34 43 44 50-53 64 74 80 82.

CALCULATION OF DISTRESS TO LIMITATIONS:

MEAN OF ITEMS 1-3 7 8 12 16 17 19-22 47-49 58 63 68-69 73.

CALCULATION OF SOOTHABILITY SUBSCALE:

MEAN OF ITEMS 84-94.

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