EFFECTS OF TWO FREQUENCIES OF HORIZONTAL ROCKING ON INFANT RESPIRATION

by

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Effects of two frequencies of horizontal rocking on infant respiration

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ABSTRACT

Investigators, as well as mothers throughout the world, agree that rocking is one of the most effective methods for soothing distressed infants. Rocking has been shown to reduce crying and increase visual alertness. The larger the amplitude and the faster the rate of rocking, the more effective it is.

The question of why rocking is soothing to infants has not been well studied. Studies of heart rate change in response to rocking have yielded different results depending on age and motor activity. A pilot study preceding the present research found that respiration was more immediately responsive to rocking than was heart rate. The purpose of the present study was to explore this relationship more fully. It was hypothesized that rocking increases the frequency and regularity of respiration and influences behavioural state.

Twenty-six 6- to 8-week-old infants were rocked at two frequencies of horizontal rocking (27 or 50 rocks per minute). The experimental session consisted of a 2-minute no rocking baseline, followed by a 6-minute period of rocking at one speed, a 6-minute period of no rocking, a 6-minute period of rocking at the other speed, and a 10-minute post-rocking period. Respiration was measured by a unilateral nasal thermister, and state was continuously rated by two independent observers on a 7-point scale.

Analyses of variance revealed that the infants breathed faster during rocking than no rocking, and they breathed faster and more regularly during fast rocking (R50) than the infants who merely heard the sound of fast rocking. Results are discussed in terms of rocking having an effect on the organization of biological rhythms. No effects of rocking on state were found. It is argued that this was due to the fact that infants in the study were not crying during the baseline period, and that one of the control groups was probably not representive of the population.

Implications of these results for future research on rocking and other soothing methods are examined.

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DEDICATION

To the parents and their infants who made this research possible

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A. INTRODUCTION

Although mothers throughout the world have probably employed rocking as a soothing device for thousands of years, research attempting to understand this phenomenon only dates back about two decades. The research undertaken has focused on three areas: (1) the behavioural and physiological effects of rocking on infants, (2) the physical parameters of rocking that optimally produce these effects, and (3) hypotheses attempting to explain why certain types of rocking produce such effects. To date there are no adequate hypotheses that account for the effects rocking has on infants.

The purpose of the present research was to determine the effects of different frequencies of horizontal rocking on infants' rate and regularity of respiration. To begin, a brief discussion of the soothing literature is necessary.

Soothing

In a review of the soothing literature (Ames & MacKinnon, 1983) four major categories of soothers were described: auditory stimulation, swaddling, non-nutritive sucking, and rocking. Such soothing techniques generally reduce arousal level in crying infants (Birns, Blank & Bridger, 1966; Korner & Thoman, 1970). There have only been a few studies that have examined the various soothing techniques to determine if there are differences in efficacy among them, and if the soothing effects are cumulative.

One of the earliest studies was by Birns, Blank and Bridger (1966). They were interested in determining the efficacy of four soothing methods on highly aroused neonates. The soothing techniques were: continuous auditory stimulation, sucking on a sweetened pacifier, gentle rocking, and immersing the neonate's foot in warm water. Each infant received the four stimuli and one no-stimulus condition three times in an identical predetermined but random order. Each of the 15 trials lasted for 60 seconds with a 20-second intertrial period during which the infant received three foot flicks to ensure a high state of arousal. The authors found that no one soothing technique was any better than the others, but that they were all more effective than no intervention.

Along a similar line, Korner & Thoman (1972) questioned whether common caregiver interventions had an equal effect in soothing distressed neonates. There were five interventions involving singly or in combination, contact and movement/rocking with or without the upright position. A sixth condition involved a high-pitched female voice simulating "mother talk". Each infant received a random presentation of the six 30-second interventions. A minimum of two minutes was required to elapse between conditions. To ensure that all infants were highly aroused, interventions were only presented after an infant spontaneously fussed for at least one minute and cried vigorously for 10 seconds.

The authors found that interventions had differential effects in reducing or stopping crying in infants. Interventions involving lifting the infant and maintaining the upright position had the most powerful soothing effect during the intervention, while the rocking motion had the most powerful calming effect 30 seconds after the intervention.

Brackbill (1971) was interested in determining whether arousal level in infants decreased as an inverse function of the number of sensory modalities continuously stimulated. One-month-old infants serving as their own controls received five different randomly ordered interventions. The conditions were no intervention, one, two, three, or four types of stimulation. The types of stimulation presented were: auditory stimulation (heart beat sounds); visual stimulation (increased illumination); proprioceptive-tactile stimulation (swaddling); and temperature stimulation (higher room temperature). Brackbill found that no one technique was more effective than the others, but that there was a cumulative effect in the efficacy of soothing techniques in reducing arousal across modalities. Similarly, Korner & Thoman (1970) found that infants were more visually alert when they simultaneously received several different types of stimulation.

The experimental literature indicates that any soothing method is a more effective soother than no intervention, and that there is a cumulative effect. It is not possible, however, to draw any definite conclusions regarding the relative efficacy of soothing methods because of the lack of a common measuring scale across modalities. For example, it is not possible to equate a certain frequency and amplitude of rocking with a particular intensity of sound, or with a particular degree of tightness of swaddling.

One possible solution to this problem would be to find the optimal conditions for each of the methods and by comparing the optimal levels of each method determine which, if any, was the most effective soother. With the present knowledge such a study is far from possible. An option that is currently available, however, is to ask mothers what they believe to be the most effective soother for their child. Such a pragmatic method also tells us what soothing methods are actually being employed outside of the psychology laboratory. Ames, Gavel, Khazaie & Farrell (1984) conducted such a study by asking 337 mothers of 2- to 18-week old infants to rate the effectiveness of different soothers they commonly used to stop their infant from crying when he or she was not hungry. Other than feeding, the most highly rated techniques were walking, rocking, and car and buggy ride, all of which involve moving the infant through space. This indicates that mothers perceive movement/rocking to be the most effective soothing technique for their infants.

Definition of State

Infants' behaviour and responses to external stimuli not only vary depending on the modality and intensity of the stimulus, but also depending upon the infants' behavioural state. It has only been during the past two decades, however, that researchers have begun to realize the importance of considering infant state in their research. Since infant behavioural states are so variable, they have often been considered a nuisance to be controlled for (Escalona, 1962). In contrast, Korner (1972) and Ashton (1973) have argued that taking state into account helps to organize confusing data, rather than adding to the confusion. Both have also emphasized the importance of studying state as a variable in its own right.

Wolff's (1966) classification system for infant behavioural state was one of the earliest and most influential works in this area. Since Wolff's system was published, several investigators have developed new classification schemes or made modifications to Wolff's. Since many of these classification schemes are based on different underlying assumptions and advocate different methods and criteria to rate state, many investigators (e.g., Ashton, 1973; Prechtl, 1974) feel that there is little or no agreement within the literature, especially among the different classification schemes. Others such as Korner (1972), however, believe that there are more similarities than differences among the various schemes. Although there appears to be much diversity, the present author believes that all classifications of state share a fundamental orientation and that their differences are mainly the degree of specification of infant state. For example, some researchers describe two types of sleep, whereas others make further subdivisions.

In general there are two methods available to assess state. They are (1) direct behavioural observation, and (2) polygraphic recordings. Within each of these methods different investigators employ different criteria. For example, behavioural criteria may include eye movement, crying, gross and fine body movements; polygraphic criteria may include skin conduction, respiration, electroencephalogram, electromyogram, and heart rate. Prechtl (1976) explained that the diversity of criteria in polygraphic recording need not be a source of worry since many of the physiological variables are related during the different states and change their properties together at the same time, when state changes.

Many investigators (Bell, 1963; Brackbill, 1971) have conceptualized infant state as referring to a quantitative continuum of overall arousal or excitability of the nervous system, with deep sleep representing the lowest level and crying the highest on the arousal continuum. Others (Graham & Jackson, 1970; Korner, 1972; Prechtl, 1976; Wolff, 1966) have strongly rejected such a unidimensional approach, arguing that it is outdated in light of more recent neurophysiological theories of arousal and what is known about the reticular formation (Graham

& Jackson, 1970; Prechtl, 1974). Korner (1972) further explained that EEG research has demonstrated that during irregular REM sleep the brain is at least as activated or aroused as during irregular waking. Such theorists conceptualize infant behavioural states as representing distinct and qualitatively different modes of neurophysiological activity. In support for such an hypothesis Prechtl (1974) reported that discriminant analysis has separated clusters of physiological variables that correspond to independently assessed behavioural states. Furthermore, Prechtl reports that infants' responsiveness to a variety of stimuli was clearly shown to be dependent upon the infants' state. For example, certain reflexes (e.g., tendon reflexes) are almost impossible to elicit during certain states. Prechtl interprets these data as evidence for mutually exclusive and qualitative differences between states.

Although the current trend is to view infant states as being physiologically distinct it has not been demonstrated that behavioural states are either distinct or continuous. Therefore it is unclear whether one should treat behavioural state as being an ordinal or nominal scale. Confounding this is the fact that there is practically no discussion on how to represent or analyze state in a meaningful way. Most researchers using behavioural state represent and analyze state as an ordinal scale. The present author believes that such an assumption is unwarranted since there are no experimental data on this issue. The most conservative method will be employed in the present study, in that the data will be treated as a nominal scale. The present study will employ behavioural criteria for state. The rationale is that we are interested in why rocking is an effective soothing method and the most pragmatic way to define soothing is behaviourally as parents do.

Throughout the introduction the term arousal will be employed to describe studies thus described by the original authors. The present author, however, does not adhere to the view that state is the manifestation of the level of arousal or excitation in the brain.

Effects of Rocking

Arousal

It is well established in the literature that rocking decreases arousal level in infants. Several studies have demonstrated that rocking reduces and stops crying (Ambrose, 1969; DeLucia, 1969; Gordon & Foss, 1966; Knowles,1959; Korner & Thoman, 1970; Pederson, 1975; Pederson & Ter Vrugt, 1973; Van den Daele, 1970), delays its onset (Gordon & Foss, 1966), reduces motor activity (Van den Daele, 1970), and increases sleep in infants (Knowles, 1959; Ter Vrugt & Pederson, 1973). Such results have been found both in studies that employ rocking as the only method of intervention (Ambrose, 1969; DeLucia, 1969) and in those that combine rocking with several other soothing methods in one session (Birns, Blank, & Bridger, 1966; Korner & Thoman, 1972) or over a period of several days (Ourth & Brown, 1961; Nehrke, Hardesty, Brill & Ourth, 1968).

Early studies generally recorded reduction of crying as a function of rocking; however, few actually recorded or controlled for the infants' state of arousal. It was not until the 1970s that researchers began to measure infants' state at intervals before, during and/or after the rocking/movement intervention. As more studies began to measure state prior to rocking it became evident that there is a relationship between the infants' prestimulus state and the magnitude of arousal reduction as a function of rocking. The consensus in the literature is that the more highly aroused the infant, the greater the reduction in arousal (Byrne & Horowitz, 1979; Korner, 1970; Pederson & Ter Vrugt, 1973; Ter Vrugt & Pederson, 1973).

Since the decrease in an infant's arousal level during rocking is related to the infant's initial state it is important for researchers to control for prestimulus state. In the rocking/movement literature three approaches have been taken to this methodological problem:

1. Induce all subjects to a comparable state. For example, Birns, Blank and Bridger (1966) employed foot flicks to ensure that all infants would be highly aroused. This method does not seem natural since infants are being aroused by external stimuli rather than responding to internal stimuli, or spontaneous

arousal. Furthermore, since there may be individual differences in infants' responses to foot flicks or other stimuli the desired state may not be attained (Korner & Thoman, 1972).

2. Make the introduction of the intervention dependent upon the infant being in the desired state. For example, Korner and Thoman (1972) waited for infants to fuss spontaneously before the intervention took place. Such an approach is time-consuming and costly.

3. The easiest, most natural and cost-efficient approach is to group infants according to their prestimulus state, as has been done, e.g., by Pomerleau & Malcuit (1981) and by Ter Vrugt (1970).

Visual Alertness

Several studies have demonstrated an increase in visual alertness in neonates during and shortly after a period of rocking/movement.

The earliest study demonstrating a relationship between rocking and visual behaviour was conducted by White and Castle in 1966. They provided institutional neonates with two supplementary 10 minute handling sessions daily for 30 days (age 6 to 36 days). Handling referred to a nurse holding a blindfolded infant in an upright position against her breast while rocking in a rocking chair. After the 30 days of supplementary rocking, the handled group of neonates differed from the control group only in that they were more visually attentive. This difference tended to diminish with time.

Ottinger, Blatchley and Dennenberg (1968) attempted to determine whether supplementary stimulation would increase neonates' visual alertness and fixation time. An experimental group of infants received supplementary stimulation (auditory, tactile, visual and rocking) for 140 minutes a day for their first three days of life. Rocking was of the longest duration, comprising 100 of the 140 minutes of daily stimulation. It was found that all infants spent more time with eyes open during the post-test as compared to the pre-test. Furthermore, on the post-test, experimental neonates spent a greater proportion of time fixated on the visual targets than did control neonates. Although visual alertness was enhanced, it was not certain which variables of stimulation produced the demonstrable effect.

Korner and Grobstein (1966) found that neonates stopped crying and became visually alert when picked up and brought to the examiner's shoulder, whereas handling and the upright position (sitting up) alone elicited no more visual alertness than no intervention. It was postulated that bringing an infant to the shoulder lowers the infant's level of arousal in addition to imposing motor restraints on the infant which result in the state of alert inactivity. It was further suggested that handling or the upright position alone may not be sufficient to reduce the infant's state to one of alertness.

Korner and Thoman (1970) extended earlier research in order to determine which type of stimulation elicits visual alertness and scanning behavior in neonates. They randomly presented to 40 crying and 24 sleeping neonates six interventions that are common caregiver activities. These involved, singly or in combination, contact and movement/rocking with or without the upright position. Each intervention lasted 30 seconds, with a minimum of two minutes elapsing between interventions. The six interventions were:

1. Lifting the infant to the shoulder (upright, vestibular, and contact)
2. Lifting the infant horizontally and cradled in the nursing position (vestibular and contact)
3. Nurse bent over supine infant and held close (contact only)
4. Infant who was previously placed in an infant seat was raised to the upright position (upright and vestibular)
5. Infant was moved to and fro horizontally in an infant seat 14 times with a total displacement of 18 inches (vestibular only)
6.Infant lying supine was talked to in a high pitched female voice simulating "mother talk".

The authors demonstrated that the rocking motion (#5) was more effective in eliciting visual alertness than contact alone (#3). The effects of the upright position alone could not be determined since it always occurred together with movement.

Gregg, Haffner, and Korner (1976) attempted to clarify the roles of what they called vestibular-proprioceptive stimulation and the upright position in evoking visual attentiveness in neonates. Forty-eight wakeful noncrying newborns were placed 10 inches away from a moving stimulus in either the horizontal or upright position, with or without rocking/movement, and with or without a pacifier. What the authors called vestibular-proprioceptive stimulation consisted of moving the infant seat to and fro six inches eight times. Results indicated that the rocking motion and the pacifier significantly enhanced initial and average visual tracking scores, and that body position was not significant.

Overall, the research on the relationship between stimulation and visual behaviour in infants indicates that it is movement/rocking that increases visual alertness and not body contact or the upright position. Furthermore, the results generalize across two prestimulus states, since Korner & Thoman (1970) employed crying infants whereas Gregg et. al. (1976) used wakeful noncrying subjects. Gregg, Korner, and colleagues explained that rocking/movement probably affects neonates' visual behaviour because the infant responds by orienting to the changing stimulation. For the crying infant, rocking may reduce the arousal level, making it possible for him or her to become visually alert. For the noncrying infant, rocking may cause the infant to orient to the changing conditions, thereby facilitating the focus of his or her attention on the only stimulus in the visual field.

Heart Rate

Pomerleau and Malcuit (1981) conducted a study examining the effects of rocking on heart rate and behaviour. Neonates received 20 10-second rocking stimulations at an interval of 35 to 120 seconds for a total of 19 to 25 minutes. Rocking consisted of four 25.5 cm lateral displacements of a motorized cradle in a 10° arc (60 cm radius). Neonatal state, movement and activity were assessed before, during, and after stimulation. Neonates were grouped according to their dominant state in the session. The four groups were: NREM with movement, transitional sleep, alert, and crying.

Averaging across neonates, the authors found an accelerative heart rate response to the onset of rocking which peaked between three to six seconds after onset, and returned to baseline around six seconds after stimulus offset. Individual analyses for each state confirmed the accelerative heart rate response in sleeping neonates. For the two awake groups (alert and crying) there was an absence of an overall HR response to the rocking. When the awake neonates were categorized according to change in activity level it was found that with the onset of rocking, infants who increased motor activity showed HR acceleration, those who decreased motor activity showed HR deceleration, and when there was no change in motor activity, HR remained at baselevel. Therefore, cardiac acceleration was related to motor activation and cardiac deceleration to motor quieting at stimulus onset. These results indicate that rocking elicited a differential HR depending upon the infants' behavioural state and/or motor response. The authors could not explain the differential motor reaction and HR response to the onset of rocking in alert and crying infants.

Malcuit, Pomerleau, and Brosseau (1984) demonstrated that like newborns, awake one-month-old infants' heart rate during rocking varies according to their level of motor activity. Such results were found for two speeds of lateral rocking (.4 cps and .1 cps). Three-month-old infants, however, showed heart rate deceleration to rocking for both enhanced and reduced motor activity.

Thus, these studies indicate that during rocking the heart rate of awake infants up to one month of age varies with their level of activity.

Respiration

Little is known concerning the effects of soothing on infant respiration rate and regularity. Brackbill (1971) remarked that infants' respiration became more regular during the implementation of various soothing techniques. There was, however, no description of how respiration was measured or analyzed, nor were any data provided. In examining the physiologic effects of motor restraint, Lipton, Steinschneider & Richmond (1960) found that swaddling decreased neonates' respiration rate.

More specifically, even less is known concerning the effects of rocking on respiratory activity. Ambrose (1969) claimed that rocking decreased irregular respiration in neonates; however, like Brackbill, he failed to provide data or a description of the methods of monitoring and analysing respiration. The only other studies that examined the effects of rocking on respiration involved premature infants (Korner, 1979; Korner, Guilleminault, Van den Hoed & Baldwin, 1978; Korner, Kraemer, Haffner & Cosper, 1975). Korner and her colleagues intermittently rocked premature infants in a head-to-toe direction on waterbeds at a rate of 12 to 13 oscillations per minute. These polygraphic studies found a significant reduction of apnea when premature infants were placed on oscillating waterbeds. Some of the most dramatic reductions in apnea were in infants with severe apnea associated with bradycardia.

Not only is there practically nothing known about infants' respiration during rocking, little is known concerning infant respiration rate and regularity in general. In the past decade, however, research has begun to examine infant respiration. It is fairly well documented that respiration rate and regularity are both influenced by state, vocalization, age, and feeding schedule of the infant (Adamson, Cranage, Maloney, Wilkinson, & Wilson, 1981; Ashton & Connolly, 1971; Curzi-Dascalova, Lebrun, & Korn, 1983; Hoppenbrouwer, Harper, Hodgman, Sterman, & McGinty, 1978; Langlois, Baken, & Wilder, 1980; Parmelee, Stern,

& Harris, 1972; Prechtl, 1968; Read & Henderson-Smith, 1984). Respiration rate and regularity are lower when an infant is in quiet sleep than active sleep, and greatest when the infant is awake (Adamson, et al., 1981; Hoppenbrouwer, et al., 1978). During the first year respiration rate decreases dramatically during crying (Langlois, Baken, & Wilder, 1980). Furthermore, in each state, respiration rate decreases with postnatal age (Adamson, et al., 1981), with respiration rate being the highest during the first week of life and sharply declining during the next months. During the third to six months, however, respiration rate stablizes. Regularity demonstrates a similar trend in that respiration becomes more regular with age, stabilizing at approximately three months of age (Hoppenbrouwer, et al., 1978). In addition, infants' respiration rates are higher immediately after feeding, decreasing as time since last feeding increases (Adamson, et al., 1981; Ashton & Connolly, 1971).

In summary, it is now known that in infants a) respiration rate decreases and b) regularity increases during the first three months, c) respiration is slower and more regular during sleeping than during non-crying waking states, d) respiration is slow during crying, and e) respiration rate increases after feeding. It has been claimed that rocking makes breathing more regular, but the only relevant data have come from Korner's studies showing the reduction of apnea in premature neonates on very gently and slowly oscillating waterbeds.

Physical Parameters of Rocking

Other research has studied the physical parameters that elicit the soothing effects of rocking in neonates and young infants. The parameters examined have been frequency, amplitude,and direction. To date no research has been done to systematically investigate the effects of the duration of rocking.

Frequency

Knowles (1959) stated that a frequency of 90 oscillations per minute at a four inch amplitude was effective in soothing infants. Ambrose (1969), DeLucia (1969), and Van den Daele (1970), however, were the first researchers to examine the effects of varying the rate of rocking on neonatal behaviour. They demonstrated that their fastest rates of rocking (60 to 70 rocks per minute) were optimal in decreasing and stopping crying and reducing activity (Van den Daele, 1970) in newborns.

Ter Vrugt and Pederson (1973) investigated the effects of four rates of vertical rocking on low and medium aroused two-month-old infants. The experimental design involved a one minute baseline, 15 minutes of rocking (at 30, 60, or 90 rock/min) or nonrocking, and a 10 minute post-observation period. In line with previous research Ter Vrugt and Pederson found that the faster rates of vertical rocking produced the greatest reduction in arousal during and immediately after rocking.

In the same year, Pederson and Ter Vrugt (1973) published an experiment investigating the influence of three rates of vertical rocking (0, 30, 50, and 70 rock/min at a four inch amplitude) on infant arousal level. Again the authors found an inverse relationship between rate of rocking and activity during rocking.

The results of studies examining the effects of frequency of rocking on infant arousal unanimously indicate that the higher the rate of rocking the greater the reduction of arousal level. The highest frequency of rocking employed in research is generally 90 rock/min, the reason being that rates any higher may be detrimental to infants.

Amplitude

As early as 1959 Knowles suggested that larger amplitudes of rocking may have a greater pacifying effect on infants than smaller amplitudes. There is only one study in the rocking literature, however, that examines the effect of amplitude of rocking on the activity level of infants. Pederson & Ter Vrugt (1973) compared the effects of vertical rocking on low and medium aroused two-month-old infants at a rate of 60 rock/min with an amplitude of 0, 2, or 5 inches. The experimental session consisted of a one minute baseline and 15 minutes of rocking.

As expected, the authors found a period x amplitude x initial state interaction. Rocking at a five inch amplitude inhibited activity in infants regardless of their initial state. Rocking at a two inch amplitude was sufficient to inhibit activity in low aroused infants, but not the highly aroused infants.

Linear Acceleration

Ter Vrugt (1970) postulated that the soothing effects of rocking are a function of both amplitude and frequency of rocking, i.e., a function of linear acceleration. In an attempt to test this hypothesis Pederson and Ter Vrugt (1973) conducted an experiment with a 2 x 3 factorial design involving two frequencies of rocking (30 and 60 rock/min) crossed with three amplitudes (3, 4, and 5 inches). In each of the six conditions there were a minimum of three low initial state and five high initial state two-month-old infants. The experimental session lasted 16 minutes, including a one minute baseline and a 15 minute rocking period. The results indicate that with the exception of the group rocked at a 4-inch amplitude at 30 cycles per minute, the results were ordered as a function of both frequency and amplitude of rocking.

Direction

Knowles (1959) claimed that vertical rocking was more effective in soothing infants than any other direction of rocking. He failed, however, to provide any data to substantiate his claim.

Pederson (1975) conducted the first study that systematically examined the effects of the direction of rocking on neonatal arousal. In his first experiment he employed a between-subject design that compared the soothing effects of up-and-down, side-to-side, and head-to-toe rocking on low and medium aroused infants. The duration of rocking was 15 minutes at rates of 45 and 60 cycles per minute, and an amplitude of five inches. The direction of rocking was not significant; however, Pederson conducted a second within-group experiment since he felt that a between-subject design may not have been sensitive. In the second experiment each subject was rocked in both the up-and-down and head-to-toe directions for 15 minutes each, with 10 minutes of no rocking between changes in direction. For all subjects the rate of rocking was 45 cpm with a five inch displacement. Once again, direction of rocking had no significant effect on the arousal level of neonates. From his research, Pederson concluded that direction of movement has no demonstrable effect on the arousal level of infants.

Byrne and Horowitz (1979) conducted a pragmatic experiment in an attempt to delineate the physical parameters responsible for the soothing effects of caregivers' rocking. The variables manipulated were direction (vertical versus horizontal) crossed with type (intermittent versus continuous) of rocking. In addition, there was a control group receiving no intervention, and another group receiving only upright holding to an adult's shoulder. Each of the experimental conditions involved bringing the infant to the experimenter's shoulder, and in the rocking condition, moving the experimenter's body so that the infant moved in a horizontal or vertical direction either intermittently or continuously. In the rocking conditions the frequency (30 cpm) and displacement (20.3 cm) remained constant with a duration of one to three minutes depending on the soothability of the infant. In the intermittent condition the experimenter completed a cycle of movement within one second followed by a one second pause, whereas in the continous movement condition the cycle was completed within two seconds. Therefore, although the infants in the intermittent and continous rocking conditions received the same number of rocks per minute, the total g force for each excursion was greater for the intermittent condition.

Byrne and Horowitz found that during post-intervention observation infants' behavioural state was affected differently by the type of movement. Continuous movement promoted significantly more drowsy than bright alert behaviour, whereas the opposite effect was found for the intermittent rocking condition. Furthermore, these effects were influenced by the direction of movement, in that intermittent vertical rocking produced significantly more bright alert behaviour, and continuous horizontal movement elicited significantly more drowsy behaviour in infants during post intervention observation.

Byrne and Horowitz suggested that the different rates of acceleration produced by the two types of rocking may account for the differential effect. That is, the faster rate of acceleration in the intermittent condition elicited more bright alert behaviour, whereas the slower rates of acceleration produced by continuous stimulation enhanced drowsy behaviour. No explanation for the effects of direction of movement was offered.

Research examining the effects of different physical parameters of rocking on infant state clearly indicate that the faster the rate of rocking the greater the magnitude of arousal reduction. Tentatively one can also conclude that the larger the amplitude of rocking the greater the soothing effect. It appears that soothing is probably a joint function of frequency and amplitude with larger accelerations having the most effect. The results concerning direction of rocking are less conclusive because the only two studies that have examined the effects of direction on rocking have yielded different results. Pederson's (1975) well-controlled study clearly demonstrated that direction had no effect on soothing. On the other hand, the interaction of direction with type of movement reported by Byrne & Horowitz

(1979) makes it difficult to draw any definite conclusions.

Hypotheses Attempting to Explain the Effects of Rocking

In a review of the literature Ter Vrugt (1970) found four hypotheses that attempt to explain the pacifying effects of rocking. Buckman (1894; cited in Peiper, 1963, p.606) anecodotally postulated that infants have "primordial memory traces" and that rocking meets a need in that it simulates the movement of branches and is reminiscent of tree-dwelling anthropoid ancestors

A second hypothesis is that rocking is a sham.device that simulates the mother's presence. Peiper (1963) suggested that since an infant can not recognize his or her mother visually or auditorily, recognition may be accomplished by the movement senses stimulated by rocking. Von Phaundler (1915; in Peiper, 1963) and Peiper (1963) both believed that the cradle is a replacement for the child's "naturally moving bed on his mother's lap, in her arms, or her back" (Peiper, 1963, p. 606).

The third and most common hypothesis is the prenatal hypothesis, which postulates that there is a relationship between the postnatal need for stimulation and the prenatal kinesthetic stimulation experienced by the infant because of his or her mother's movement and visceral activity. For a review of this literature refer to Ter Vrugt (1970).

A fourth hypothesis states that rocking produces physiological changes in the infant. Zahorsky (1934; cited in Ter Vrugt, 1970) hypothesized that rocking (1) may act as a cooling device, (2) has a soporific influence, and (3) assists the pendular movement of the intestine in digestion and absorption.

Ter Vrugt (1970) proposed a fifth hypothesis, which he called a vestibulo-baroreceptive hypothesis, to account for the soothing effects produced by rocking. He claimed that the effects of rocking may be a result of (1) the action of the vestibular apparatus on the baroreceptive areas of the body, or (2) an independent action of the vestibular apparatus on the inhibitory areas of the brain, especially those areas controlling sleep and wakefullness. Korner and Thomas (1970), Korner (1979), and Pederson and Ter Vrugt (1973) have all noted that the vestibular system is one of the earliest developed and is functional at birth, and that this relative maturity of the vestibular system may make it an important mediator for early stimulation.

Rationale for the Present Study

Persistent stereotypic behaviours in both animals and humans are generally considered pathological (e.g., caged animals or autistic and mentally retarded humans). During infancy, however, rhythmic stereotypic movements are a normal transient developmental event (Thelen, 1979, 1980, 1981a, 1981b). Thelen (1981a) found that the amount and rate of stereotypies performed by infants was inversely related to the amount of rocking and bouncing the infant received from caretakers. Apparently rocking is important enough that if it is not provided for infants, they will compensate by self stimulatory movements.

Thus there may be a relationship between infants' internal rhythms and the external rhythms provided by rocking. It is the opinion of the author and her colleagues that rocking may be an effective soother for crying infants because it acts on the infant's physiological system, but not in the manner described by Zahorsky (1934; cited in Ter Vrugt, 1970). Rather, rocking may reduce or prevent crying by imposing an external rhythmic organization on an infant who has become disorganized physiologically and behaviourally.

Since the hypotheses of the present study were formulated, two other researchers have independently developed similar general conceptualizations. Weissbluth (1984) has expressed his belief that crying results from asynchrony or disorganization of biological rhythms, including respiration. Lester (1985) is of the opinion that unexplained crying during the first three months of life is the result of shifts in the organization of the central nervous system. He has hypothesized that external rhythms organize the infant's internal rhythms, which in turn lowers arousal and leads to more organized behaviour. More specifically, Lester has hypothesized that external rhythm (e.g.

rocking) entrains the infant's internal rhythm. The specific mechanism of entrainment has not formed and does not form part of the hypotheses in the present study.

Research has examined the effects of rocking on behavioural state and visual behaviour, but the only research that has examined the effects of rocking on the infant's physiological system has used heart rate. A pilot study conducted by the author examined the effects of two rates of rocking in 6- to 8-week-olds' respiration, heart rate and muscle response. Visual inspection of the data revealed an immediate perceptible effect of rocking on respiration.

The present study was designed to determine if there is a relationship between frequency of horizontal rocking and the rate and regularity of respiration.

As previously discussed, the effects produced by rocking are believed to be influenced by rocking rate and amplitude, and by the infant's behavioural state. In the present study, amplitude of rocking is held constant, and rocking rate is the independent variable. The dependent variables are respiration rate and regularity, and infants' behavioural state.

The hypotheses are:

(1) Rate of respiration will be faster during rocking than than during no rocking.

(1a) Rate of respiration will be faster during the higher rocking rate.

(2) Respiration will be more regular during rocking than no

rocking.

(2a) Respiration will be more regular during the higher rocking rate.

(3) Behavioural state will change during rocking, with crying infants becoming awake and noncrying, and awake infants falling asleep.

B. METHOD

Subjects

Thirty-nine healthy 6- to 8-week-old infants participated in the study. An age range of 6 to 8 weeks was chosen because this is the age of maximum crying for both normal and "colicky" infants (Illingworth, 1954; Meyer and Thaler, 1971; Paradise, 1966; Rebelsky and Black, 1972; Tennes and Carter, 1973). Eight of these subjects could not be used: three due to experimental error, three because of lack of respiration record due to equipment malfunction, and two because their mothers employed additional soothing methods, e.g., pacifier, holding hands. Five of the remaining 31 subjects were placed in a particular experimental group (fast rocking first) because they fussed or cried during the initial no-rock period and their mothers requested that they be rocked. Their results were analyzed separately.

The mean age of the 26 subjects used in the main analysis was 50 days, ranging from 41 to 56 days. Mothers' and fathers' mean ages were 30 and 34 years respectively, with the mothers having completed 15 years and the fathers 14 years of education.

Interested mothers in maternity wards of four greater Vancouver hospitals returned a postcard in response to a request to register their infants in the University Infant File. Mothers of infants of the appropriate age were contacted by telephone and arrangements made. During the telephone conversation the experiment was briefly explained and it was suggested that mothers feed their infant prior to leaving home, or in the subject room prior to the experimental session. Over half the infants were fed within 30 minutes prior to the experimental session, with the remaining infants being fed one to two hours prior to the session.

Infants were randomly assigned to one of four conditions. Assignment was independent of sex since no sex differences have been found in any of research reviewed. It was originally planned to group infants according to their prestimulus state. This was not possible for several reasons. Firstly, mothers were reluctant to put their crying infants in a control group. Secondly, most infants were awake since they had been handled while the thermister was being attached.

Apparatus

The experimental sessions were conducted in a 3 x 3 meter subject room. Signals were cabled from the subject room to an adjacent control room. A rocking baby carriage was positioned on a 61 by 91.5 cm wooden platform and driven by a shunt wound motor (Bodine model no. 577) with a basic speed range of 1.5 to 56 revolutions per minute. Speed of the motor was controlled by an adjustable speed/torque drive system (Bodine model no. 903). Motor turning was converted to a reciprocating action that allowed a total displacement of 1.5 to 5.5 inches at .5 inch increments when attached to the rear axle of the carriage. The movement of the baby carriage assembly was monitored by a variable resistor mounted on the transfer arm of the rotating to reciprocal converter (locally designed and constructed by H. Gabert and W. Tressel of the technical support staff of the psychology department at Simon Fraser University). Figure 1 shows the experimental apparatus.

A Sony F 2-25 low impedance microphone was attached to the frame of the carriage so that it was approximately 20 cm above the infant's face. Respiration was monitored by a Fenwal standard glass probe thermistor (model no. GB41P2). The subject room was also equipped with a digital button box to record the onset and offset of rocking, and toggle switch boxes connected to an Apple IIE microcomputer were employed to record observers' judgments of infant state.

Electrical signals representing the frequency and displacement of the rocker, vocalization, nasal air temperature change, and the digital button press, were cabled to the control room where they were introduced to the recording console. Following appropriate signal conditioning, data were digitized (dwell of 50 msec) at the input of the Nova 3/D computer (96 kw with an RDOS operating system with a 10 megabyte disc). Data were both written on magnetic tape and buffered back to the recording console where they were monitored on an XY display. Off-line data could be reviewed, filtered, analyzed, and plotted on an XY plotter.

Procedure

The experiment was discussed with and demonstrated to the mother, and a consent form signed (see Appendix A). The mother was assured that she was in control and that the experiment would be terminated if she requested, with no questions asked. Information concerning the infant pre-, peri-, and postnatally was obtained. The mother was seated in the subject room during the experimental session and was asked to complete a questionnaire concerning her infant's crying behaviour and preferred modes of soothing. The nasal thermistor was positioned just below one nare and taped to the infant's face. The mother held the infant for several minutes to allow the infant to become desensitized to the recording equipment. The infant was then placed in the motorized rocker on his or her back or side, with the exception of one infant who was placed on her stomach.

Table 1 shows the design of the study. For the two experimental groups the session consisted of a two minute no-rock period (NR1), six minutes of rocking at one speed (R1), six minutes of no rocking (NR2), six minutes of rocking at the other speed (R2), and a 10 minute post-rocking period.

The two experimental groups of infants were rocked at both 27 rocks/min (.45 Hz) and 50 rocks/min (.83 Hz) with a five inch amplitude. The difference between the two groups was the order in which they received the different frequencies of rocking, with half the subjects receiving the faster rate of rocking first (FS), and other half receiving the slower rate of rocking first (SF). The only difference between the experimental and control groups was that the control group received no rocking during the 30 minute session. To control for the sound of the motor, the rocker was disconnected from the buggy; however, the rocker motor was run as in the experimental condition.

Throughout the experimental session two independent observers stood beside the rocker on either side, within the field of vision of the infant. The infant's state was continuously rated on a modified 7-point scale adapted from Prechtl (1974) (Appendix B). The infant was required to remain in a new state for five seconds before the observers rated it as a change. The rating was performed by flipping one of seven switches on the toggle switch box which fed to the Apple computer. The eighth switch and the digital button press were employed to indicate a change from rocking to non-rocking or vice versa.

Preparation of Data for Analysis

State

An ABC system computer software program (Gabert, 1982) represents state data as the proportion of time spent in each state for observer 1, observer 2, and agreement between observers 1 and 2. Data were divided into one minute intervals.

In order to perform statistical analysis on the behavioural state data, three broad and general state clusters were formed from the state categories that were most similar behaviourally. The two sleep states and the drowsy state were combined to produce state 1 (sleep-drowsy), the two waking states formed state 2 (waking), and state 3 (fuss-cry) consisted of fussing and crying. Such behavioural state clusters could possibly be ordinally scaled but there are no conclusive data to support such scaling.

The proportion of time an infant spent in each of the three state clusters during each of the six conditions was calculated for both observers individually and then averaged, yielding three percentages that equalled 100% for each condition for each subject.

Inter-Observer Agreement on State Ratings

Appendix C presents the individual kappas (Cohen, 1960) for each subject. Three subjects received a kappa of .17 or less because they remained predominantly in the same state for the duration of the experimental session. Mean kappa for the 2 observers' state ratings for the remaining 26 subjects was .81 with a range from .63 to .95.

Respiration

Respiration data were analyzed using a peak detection algorithm (locally designed by H. Gabert of the psychology department technical support staff at Simon Fraser University) which was used to compute peak average times (PAT) and peak standard deviations (PSD). A composite average of the interval times between peaks was derived from the first 25 positive and first 25 negative peaks within a window (window displays 1:42 minutes of data). The standard deviation of the interval times between peaks was also computed from the same data. Windows were positioned so that the last window in each condition ended at the end of the condition. Figure 2 shows the ideal positioning of windows. During the two minute no-rock baseline there was one window, three intervals for each of the six minute conditions, two windows for post-rock 1, and three windows for the second post-rock condition. For each group of subjects peak average time and peak standard deviation scores were both averaged across windows within each of the following conditions: NR1,R1,NR2,R2,PR1,PR2. In the case of poor respiration records the window was moved several seconds (never more than 10 seconds) further ahead in time to the first point at which the record was readable.

Missing Data

As a result of missing data not all 26 infants were employed in each of the analyses. Refer to table 2 for a breakdown of the total number of subjects in each group, the number having complete respiration data, and the number having complete state data. State data were not obtained for 2 infants due to malfunction of the Apple system, and there are no respiration data during or following the second rocking condition for 3 subjects.

C. RESULTS

Since this is an exploratory study with a small number of subjects .08 or better will be accepted as the significance level.

Order Effects in No-Rock Conditions

A three-factor mixed design was used to analyze the no-rock conditions for both peak average time (PAT) and peak standard deviation (PSD). The two between-subject factors were Order and Group, each having two levels: fast-slow (FS) and slow-fast (SF); experimental and control, respectively. The within-subject factor was Condition, consisting of two levels: no-rock 1 (NR1), and no-rock 2 (NR2). Analyses of variance (ANOVAs) revealed no significant differences for either PAT (Table 1 of Appendix D) or PSD (Table 1 of Appendix E).

Since these analyses revealed that the two no-rock "baseline" conditions did not differ from each other, for the purpose of further analysis the two rocking conditions in the SF groups were switched, with R1 (27 rock/min) becoming R2, and R2 (50 rock/min) becoming R1. The conditions in the FS groups remained in their original order. All further analyses are based on this revision, shown in Table 3.

Peak Average Time

Mean PAT for the four groups of subjects for each of the five conditions are presented in Table 4.

Peak average time was analyzed using a three-factor mixed design. The two between-subject factors were Order (FS-SF) and Group (experimental-control), and the within-subject factor was Condition. The five Condition levels were: NR1, R50, NR2, R27, PR. Although visual inspection of the means in Table 4 reveals lower PATs for the rocking conditions, especially the R50 condition, no significant differences were found (Table 2 of Appendix D).

This lack of insignificant results may be consistent with the hypothesis that the greatest effect on respiration would be during R50 for the two experimental groups, since such an effect would be diluted in an overall analysis with five conditions. Therefore, a four-factor mixed ANOVA was conducted including a within-subject factor, Block, having two levels: block 1 consisted of NR1 and R50, and block 2 consisted of NR2 and R27. The other within-subject factor was Condition, consisting of two levels: no-rock, and rock. The two between-subject factors were Order (FS-SF) and Group (experimental-control). Table 5 shows the summary of the ANOVA. A significant Order x Group effect was found ($F(1,19)=3.70$ $p<.07$) suggesting that averaging across blocks and conditions, the difference between the experimental and control groups differed depending on the order in which they received the two different rates of rocking (or in the case of the control group, the sound of rocking). Averaging across conditions the FS experimental group (M=1.39) breathed at a faster rate than its control group (M=1.65), whereas the SF experimental group (M=1.52) breathed at a similar rate to its control group (M=1.58). Since these results were obtained by averaging across the four conditions they are of no relevance to the hypotheses of the study.

A significant Condition x Group effect was also found ($F(1,19)=3.34$, $p<.08$), showing that the difference between the experimental and control groups differed in the rock and no-rock conditions. Figure 3 shows this interaction. In order to clarify the nature of this interaction t-tests were conducted on the experimental and control groups separately, comparing the rock and no-rock conditions. No significant differences were found for the control group ($t(19)=.27$ $p<.80$), whereas a parallel t-test revealed that the infants in the experimental group breathed significantly faster during rocking (M=1.38) than during no rocking (M=1.59) ($t(19)=3.43$ $p<.01$).

To determine more precisely where there were differences between conditions a two-factor (Order and Group) ANOVA was conducted on each of the two rocking conditions. There were no significant differences for the R27 condition (Table 3 of Appendix D). A Group effect was significant for the R50 condition ($F(1,21)=5.93$ $p<.02$) showing that the experimental groups breathed faster (M=1.31) than the control groups

($\underline{M}$=1.61)(Table 6).

Overall, the data suggest that infants breathed faster during rocking than during no rocking and that this effect was mainly the result of the faster rate of rocking. Infants breathed fastest during fast rocking, slowest when not rocked, and at some intermediate rate when rocked slowly.

Peak Standard Deviation

Mean PSD for the four groups of subjects in each of the five conditions is presented in Table 7.

A three-factor mixed analysis of variance with Order (FS-SF) and Group (experimental-control) as between-subject factors and Condition (NR1, R50, NR2, R27, PR) as the within-subject factor was used to analyze PSD. Although visual inspection of the means in Table 6 reveals lower PSD for the experimental groups in the R50 condition, no significant differences were found (Table 2 in Appendix E).

As with PAT it was felt that this lack of results might be due to the fact that there is only an effect during one condition (R50) for only the experimental group. Therefore, a four-factor mixed ANOVA was conducted including a within-subject factor, Block, having two levels: block 1 consisted of NR1 and R50, and block 2 consisted of NR2 and R27. The other within-subject factor was Condition, consisting of two levels: no-rock, and rock. The two between-subject factors were Order

(FS-SF) and Group (experimental-control). As indicated in Table 3 of Appendix E, no significant differences were found.

Since visual inspection of the means in Table 7 revealed a lower PSD during R50, a two-factor (Order and Group) ANOVA was conducted on each of the experimental conditions in spite of the overall nonsignificant results. There were no significant Group differences for the R27 condition (Table 4 of Appendix E). There was, however, a significant Group effect for R50 ($F(1,21)=7.09$ p .015), indicating that the experimental groups ($M=.46$) breathed more regularly than the control groups ($M=.82$) during fast rocking (Table 8).

Overall, these results suggest that infants who were rocked at the fastest speed (50 rocks/min) breathed more regularly than the infants who only heard the sound of the fast rocking.

State

It was not possible to conduct an analysis of state on all five conditions because of problems with the computer program. It was possible, however, to conduct a five-factor mixed ANOVA including a within-subject factor, Block, having two levels: block 1 consisted of NR1 and R50, and block 2 consisted of NR2 and R27. The other within-subject factors were Condition and State. Condition consisted of two levels: no-rock, and rock; and State consisted of three levels: state 1 (sleep-drowsy), state 2 (waking), and state 3 (fuss-cry). The two between-subject factors were Order (FS-SF) and Group (experimental-control). Only a four way interaction (Block x Condition x State x Order) was found (Table 1 of Appendix F). This interaction is not only uninterpretable but also irrelevant to our purpose, as it does not involve Group. Visual inspection of the data for each state cluster within each condition revealed no apparent effects of rocking on state, so no further analyses were performed.

Relation of Effects of Prestimulus State to Respiration

A separate two-factor mixed ANOVA was conducted on the fast-slow (FS) experimental group, including the 5 subjects who cried during the baseline and were not used in the main analyses. The between-subject factor was Prestimulus State having three levels (1 - sleep, drowsy; 2 - waking; 3 - fuss-cry), and the within-subject factor was Condition, consisting of five levels: NR1, R50, NR2, R27, PR. Tables 1 & 2 of Appendix G show the summaries of the ANOVAs that indicate that no significant differences were found for either PAT or PSD.

It was felt that this failure to obtain significant differences due to there being an effect during only one condition, R50. Therefore, two three-factor mixed ANOVAs were conducted including an additional within-subject factor, Block, having two levels: block 1 consisted NR1 and R50, and block 2 consisted of NR2 and R27. The other within-subject factor was

Condition, consisting of four levels: NR1, R50, NR2, R27. The between-subject factor was Prestimulus State, which had three levels. In analyzing PSD no significant differences concerning Prestimulus State were found (Table 3 of Appendix G). A parallel analysis for PAT revealed a significant three way interaction for Block x Condition x Prestimulus State ($F(1,9)=5.31$ $p<.03$), indicating that the interaction of state with condition was different in the two blocks. Table 9 gives a summary of the ANOVA. Figure 4 shows the mean PAT for each Prestimulus State group in each condition.

To clarify the nature of the three way interaction two two-factor mixed ANOVAs were conducted, one within each block. Analysis of NR1 and R50 (Table 9) revealed a significant Condition effect ($F(1,11)=6.30$ $p<.03$), indicating that infants breathed faster during fast rocking (M=1.27) than during no rocking (M=1.50). A parallel analysis of NR2 and R27 revealed no significant differences (Table 4 of Appendix G). As the results of neither of these analyses involved prestimulus state, it can only be concluded that prestimulus state was not an important factor affecting respiration in this study.

Relation of prestimulus state to subsequent behavioural state

It was not possible to conduct an analysis of state on all five conditions because of problems with the computer program. It was possible, however, to conduct a four-factor mixed ANOVA having three within-subject factors and one between-subject factor. The three within-subject factors were Block, Condition, and State. Block had two levels; block 1 consisted of NR1 and R50, and block 2 consisted of NR2 and R27. Condition had two levels; no-rock and rock, and State consisted of three levels; state 1 (sleep-drowsy), state 2 (waking), and state 3 (fuss-cry). The between-subject factor was Prestimulus State having three levels: 1 sleep-fuss, 2 waking, and 3 fuss-cry. Similar to the overall state analysis previously discussed an uninterpretable four-way interaction was found (Table 5 of Appendix G). It is interesting to note, however, that although the three groups of infants differed in state during the baseline, there were no significant differences in state during or after R50. Furthermore, infants in the crying group, cried 97% of the time during the baseline, but only cried 2% of time during R50.

D. DISCUSSION

This study was undertaken to explore the effects of rocking on infant respiration and to determine whether this is a viable area for continued research. Since it was an exploratory study with a limited number of subjects, a lenient level of significance was employed.

The results of the study lend some support to three of the five hypotheses. Some evidence was found for hypotheses 1 and 1a. That is, (1) infants breathed faster during rocking than during no rocking, and (1a) this effect was greater during the faster rate of rocking. Thus the data support the conclusions drawn from the pilot study.

The study does not provide evidence that the faster the rocking the faster the infant breathes, but it also does not rule out this relationship. Although infants who received 27 rocks/min did not breath at a significantly different rate from infants who only heard the sound of the slow rocking, R27 may have had some effect on respiration. Not only was the difference between the rock and no-rock means in the hypothesized direction, but averaging the two experimental groups (R50 and R27) revealed that together they breathed faster than the control groups during rocking, and that they breathed faster during rocking than during no rocking. It is possible that the use of a larger number of infants might reveal that 27 rocks per minute is sufficient to change respiration from its no-rock rate.

The records of the 17 infants who had complete rocking and respiration data for R50 were visually inspected for evidence of entrainment. Eleven of the infants showed no evidence of entrainment for the duration of the six minute rocking condition, although many breathed only slightly slower or faster than that of the rocking rate. Two of the infants showed entrainment for 3 minutes and 30 seconds of the six minute period: one breathing at the same rate as that of the rocking, and the other breathing twice as fast as that of the rocking. An additional four infants also showed periods of entrainment: one for 1 minute and 45 seconds, two for one minute each, and another having two 30 second intervals of entrainment during the six minute conditon. These results suggest that rocking at 50 rock/min does not necessarily entrain respiration, although entrainment may occur in some cases.

The results concerning the regularity of respiration are less conclusive. Although the data did not support hypothesis 2 that respiration would be more regular during rock than no rock, hypothesis 2a was supported in that infants breathed more regularly during fast rocking than during the mere sound of fast rocking. These results fit our assumption that rocking helps organize respiratory activity.

While the results discussed above are encouraging in the sense of fitting some of the hypotheses they are simultaneously disappointing because not all the hypotheses were supported, and even in the case of positive results, the probabilities obtained were not always within conventional levels of statistical significance. There are two possible explanations for the lack of robustness of the respiration results. The first is that perhaps horizontal rocking does not have a strong effect on respiration. The author does not adhere to this view. The second is the limited sample size. With such a small number of subjects an infant who breathes very differently from the others could have a large influence on the results. Such was the case with one of the three subjects in the FS control group. Of all the infants in the study, this infant breathed the most regularly during the baseline, and he maintained this regularity for the duration of the study, remaining asleep throughout the entire experimental session. Only the use of a larger number of control subjects will permit the more exact determination of the magnitude and reliability of the results.

It had been hypothesized that behavioural state would change during rocking. This hypothesis was not upheld; no effect of rocking on state was found. There are several possible reasons for this lack of results. The author rejects the possibility that rocking actually has no appreciable effect on behavioural state. Such an explanation is highly unlikely, since most of the literature indicates that rocking affects state (Ambrose, 1969; DeLicia, 1969; Gorodon & Foss, 1966; Knowles, 1959; Korner & Thoman, 1970; Pederson, 1975; Pederson & Ter

Vrugt, 1973; Van den Daele, 1970).

Another possible explanation that might be entertained concerns the fact that the method employed to represent and analyze state in the present study was different from the methods employed in previous studies. Several studies have employed a single mean state score, assuming that infant behavioural state can be conceptualized as an ordinal scale of arousal (e.g., Pederson, 1975; Pederson & Ter Vrugt, 1973). No such assumption was made in the present study. Instead, for the purposes of analysis three state scores were derived (sleep-drowsy, waking, and fuss-cry), and each of these was treated as a separate score. Another difference in the treatment of state is that several of the previous studies (e.g., Byrne & Horowitz, 1979) did not examine all states, but rather simply examined the proportion of time that infants spent in each of two states. The author has considered the possibility that the lack of state results may be due to differences in representing and analyzing state, but has come to the conclusion that such an explanation is unlikely. Inspection of the data does not indicate any reasonable hope that clear results would be found with the use of mean state scores or with a more restricted number of specific categories.

A more probable explanation for the failure to obtain meaningful significant state differences may be that most rocking studies have employed at least one group of crying babies, whereas no crying infants were included in the main analyses of the present study because, at parents' request, infants who cried during the baseline were rocked at 50 rocks/min during R1 rather than continuing in the group to which they had originally been randomly assigned. Such infants were included, however, in a separate analysis looking at prestimulus state. All five of the infants who cried during the NR1 baseline stopped crying and moved to either a waking or sleep-drowsy state when rocked at 50 rocks/min. Furthermore, at this rate of rocking they breathed at a rate similar to that of infants who had been in different prestimulus states. The exclusion of crying babies from the main study, while it may be a contributing factor to the failure to find significant effects of rocking on state, is unlikely to be the entire explanation. Pederson and Ter Vrugt (1973) found significant state decreases in awake, non-crying infants rocked at accelerations less that that used in the present research. Again, appeal must be made to the small number of subjects in the control group of the present study. The three infants in the FS control group were unusual in state. As previously mentioned one infant slept for the duration of the experimental session. The other two remained in a waking state throughout, except during PR, when one of them fussed and cried for 12% of the time. Infants in the other control group (SF), however, behaved as had been expected; their fussing and crying increased over the duration of the experimental session.

In summary, while it is not possible to explain completely the failure to find effects on state, the two most likely contributing factors are the exclusion of crying infants from the main study and the small number and unusual behaviour of control subjects. One advantage of the fact that rocking did not have an effect on state is that this establishes that the respiration results found are not merely a result of state changes.

Suggestions for future research

Overall, the results of the study are encouraging enough that future research on the effects of rocking on respiration should be undertaken. Firstly, the present study should be continued to include a larger number of subjects, especially in the control groups. If, as expected, this leads to more impressive results, then it would be worth conducting variations to determine which parameters (rocking amplitude, direction, and duration of rocking and position of the infant) have the greatest effect on respiration. Furthermore, it would be interesting to see if the type of rocking mothers employ in actual caregiving situations also affects infant respiration.

Since nothing was known concerning the effect of rocking on respiration, this study was performed on normal infants rather than on infants who deviate from the norm. As soothing is most important for infants who cry excessively it is advantageous to determine whether the same effects can be found with so-called colicky infants. If positive results were found for colicky infants it would be advisable to see if the "cure" is related to the "cause", that is, to undertake a study of whether colicky infants' respiration is slower, more irregular, or more disorganized than that of non-colicky infants. It may also be profitable to look at how rocking affects the rate and regularity of respiration in other problem populations such as premature infants and infants with respiratory problems. Korner et al. (1978) have shown that oscillating waterbeds significantly reduce apnea in premature infants in hospitals, but no information was provided concerning whether or not these infants breathed more regularly and/or at a faster rate.

Since the rate and irregularity of respiration decrease with age during the first few months of life (Adamson et al., 1981; Hoppenbrower et al., (1978) it would be interesting to see how rocking affects respiration at different ages for both normal infants and infants with problems.

Finally, future research might attempt to discover whether other soothing methods have an effect on respiration. To date, the literature indicates that respiration is responsive both to after feeding (Adamson et al., 1981; Ashton & Connolly, 1971) and that respiration rate decreases during swaddling (Lipton, Steinschneider, & Richmond, 1960). While it may be too much to hope for at present, it is at least a plausible hypothesis that the commonality underlying the capacity of different types of stimuli to soothe infants is their capacity to change and organize the infant's respiration.

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Table 1

Experimental Design

		NR1	R1	NR2	R2	PR1	PR2
FS	Exp		50 rock/min		27 rock/min		
	Ctr		50 sound only		27 sound only		
SF	Exp		27 rock/min		50 rock/min		
	Ctr		27 sound only		50 sound only		

Table 2

Total number of subjects in each group having complete respiration and behavioral state data.

Group	Total no. of subjects	No. having complete data for PAT & PSD	No. having complete state data
FS exp	10	9	9
FS ctr	4	3	4
SF exp	9	8	8
SF ctr	3	3	3
	26	23	24

Table 3

Revised design switching the two rocking conditions in the SF groups.

		NR1	R50	NR2	R27	PR1
FS	E		R1		R2	
	C		R1		R2	
SF	E		R2		R1	
	C		R2		R1	

Table 4

Mean PAT for the four groups of subjects for each of the five conditions.

		NR1	R50	NR2	R27	PR	*N*
FS	E	1.44	1.30	1.46	1.34	1.54	9
	C	1.78	1.77	1.53	1.52	1.58	3
SF	E	1.84 (8)	1.33 (8)	1.60 (8)	1.56 (8)	1.52 (7)	8(7)
	C	1.45	1.60	1.55	1.46	1.46	3

Table 5

Summary of the four factor mixed ANOVA of PAT during NR1, R50, NR2, and R27.

Source	df	MS	F	p
Mean	1	166.76	1261.16	
Order	1	0.02	0.14	0.71
Group	1	0.17	1.28	0.27
O x G	1	0.49	3.70	0.07 *
Error	19	0.13		
Blocks	1	0.07	0.37	0.55
B x O	1	0.04	0.23	0.64
B x G	1	0.09	0.49	0.49
B x O x G	1	0.07	0.38	0.54
Error	19	0.19		
Condition	1	0.17	2.84	0.11
C x O	1	0.01	0.24	0.63
C x G	1	0.20	3.34	0.08 *
C x O x G	1	0.04	0.60	0.45
Error	19	0.06		

(table continues)

Source	*df*	MS	*F*	*p*
B x C	1	0.02	0.16	0.69
B x C x O	1	0.01	0.10	0.75
B x C x G	1	0.14	1.30	0.27
B x C x O x G	1	0.14	1.26	0.27
Error	19	0.11		

Table 6

Summary of the two factor ANOVA of PAT during R50.

Source	*df*	MS	*F*	*p*
Mean	1	43.16	463.42	
Order	1	0.00	0.03	0.87
Group	1	0.55	5.93	0.02 *
O x G	1	0.02	0.23	0.64
Error	21	0.09		

Table 7

<u>Mean PSD for the four groups of subjects for each of the five conditions.</u>

		NR1	R50	NR2	R27	PR	*n*
FS	E	0.65	0.48	0.54	0.54	0.72	9
	C	0.87	0.67	0.50	0.48	0.58	3
SF	E	0.88 (8)	0.46 (8)	0.88 (8)	0.78 (8)	0.45 (7)	8(7)
	C	0.77	0.96	0.85	0.77	0.84	3

Table 8

Summary of the two factor ANOVA of PSD during R50.

Source	*df*	MS	*F*	*p*
Mean	1	8.25	82.11	
Order	1	0.09	0.86	0.37
Group	1	0.71	7.09	0.01 *
O x G	1	0.08	0.76	0.39
Error	21	0.10		

Table 9

Summary of the three factor mixed ANOVA of PAT for the Prestimulus State groups during NR1, R50, NR2, NR2, and R27.

Source	*df*	MS	*F*	*p*
Mean	1	101.18	215.37	
Prestimulus State	2	0.22	0.47	0.64
Error	9	0.47		
Blocks	1	0.03	0.16	0.70
B x PS	2	0.18	1.03	0.40
Error	9	0.18		
Condition	1	0.18	3.93	0.08
C x PS	2	0.04	0.54	0.60
Error	9	0.07		
B x C	1	0.12	4.17	0.07 *
B x C x PS	2	0.15	5.31	0.03 *
Error	9	0.03		

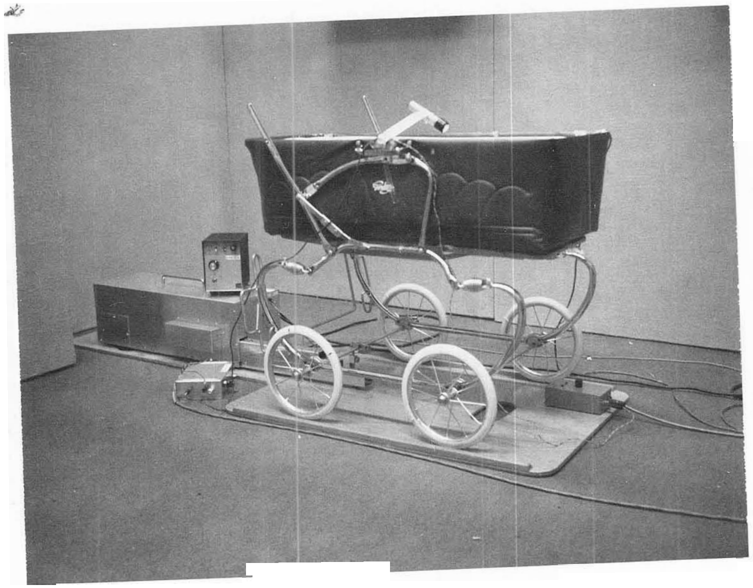
Table 10

Summary of the two factor mixed ANOVA of PAT for the Prestimulus State group during NR1 and R50.

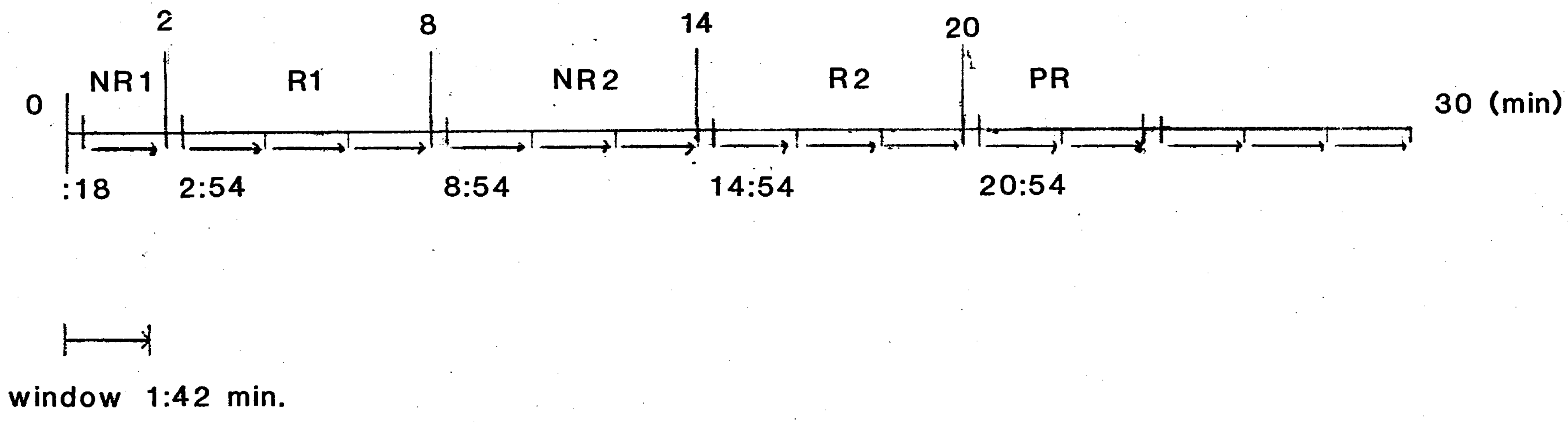
Source	*df*	MS	*F*	*p*
Mean	1	53.62	183.10	
Prestimulus State	2	0.07	0.23	0.80
Error	11	0.29		
Condition	1	0.33	6.30	0.03 *
C x PS	2	0.11	2.08	0.17
Error	11	0.05		

Figure 1

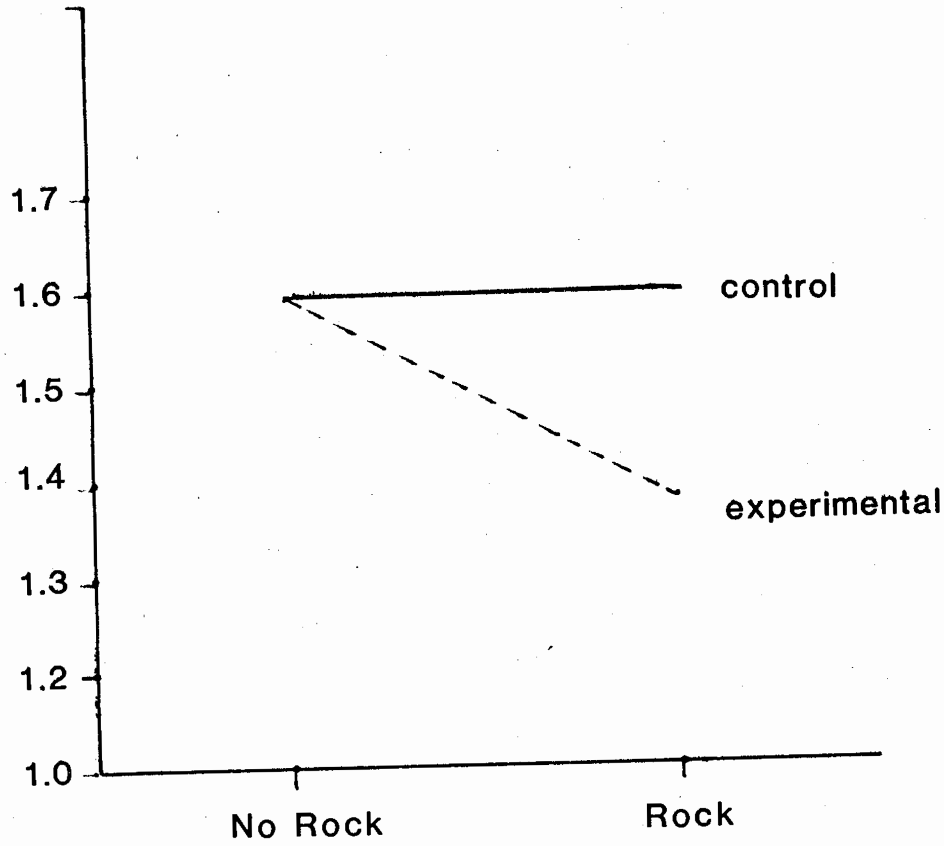
Experimental Apparatus



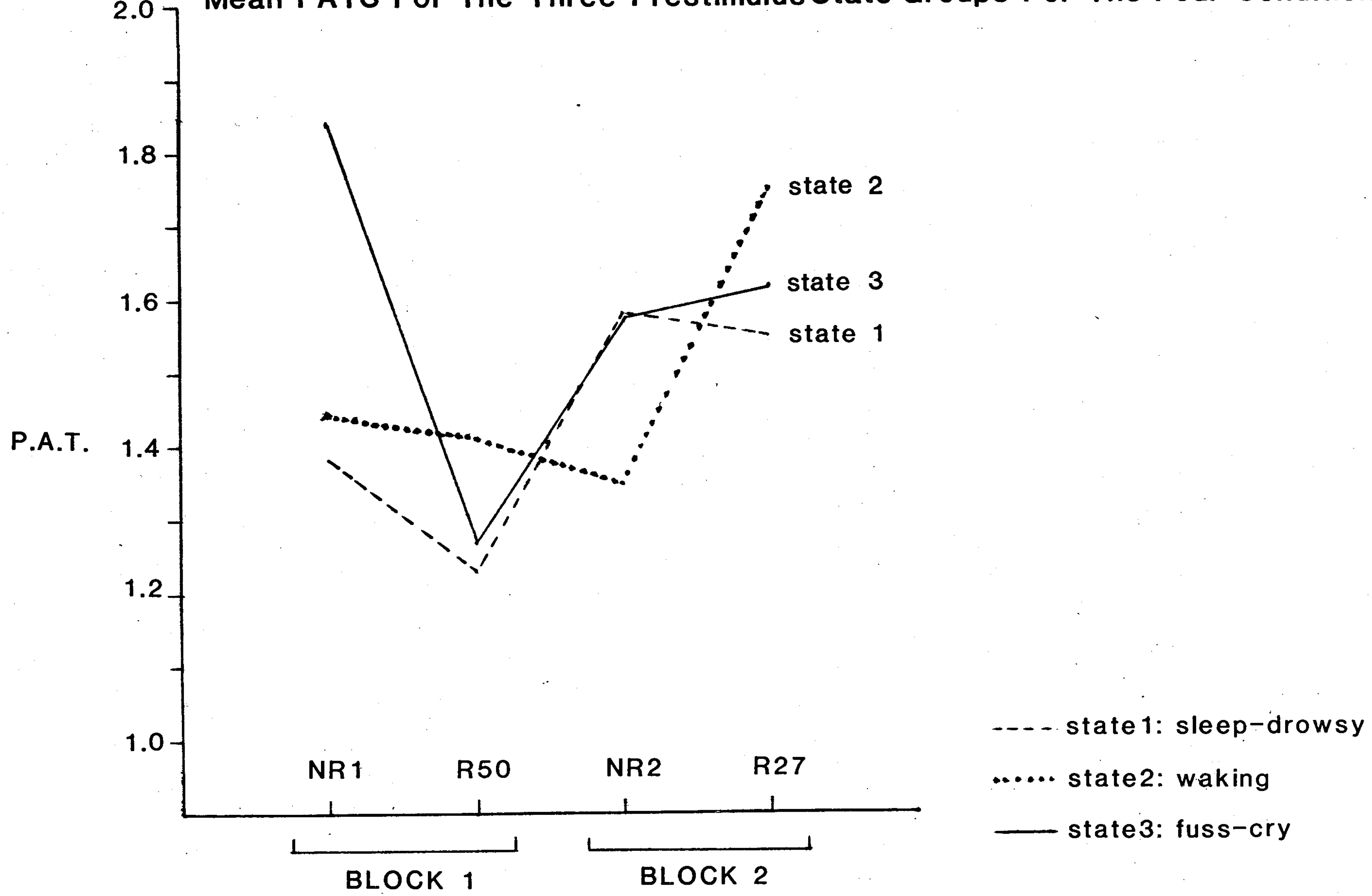
Ideal Positioning of Windows For Peak Detection Program



Condition By Group Interaction For PAT



Mean PATS For The Three Prestimulus State Groups For The Four Conditions



APPENDIX A

CONSENT FORM

As parent/guardian of _______________ I consent to my baby engaging in the procedures specified in the document entitled PSYCHOPHYSIOLOGICAL RESEARCH ON INFANTS: ROCKING/RESPIRATION STUDY, to be carried out in the human psychophysiological research laboratory, CC4205, Simon Fraser University, at the following time _______________ in a research project supervised by Dr. Christopher M. Davis and Dr. Elinor W. Ames of Simon Fraser University.

I certify that I understand the procedures to be used and the risks involved in taking part. I know that I have the right to withdraw _______________ from the project at any time. I further understand that I will be the one to make all the decisions regarding my baby's wellbeing and care (feeding, changing, dressing, comforting, etc.) throughout the entire procedure. I realize that any complaint about the research may be brought to the chief researchers named above, or to Dr. Roger Blackman, Chairman of the Psychology Department, Simon Fraser University.

I understand that I will receive from Dr. Elinor Ames a copy of the result of this study, upon its completion.

Date:_______ Name (please print):___________

Signature:_________________

Address:___________________

Signature of witness:___________________

PSYCHOPHYSIOLOGICAL RESEARCH ON INFANTS: ROCKING/RESPIRATION STUDY

Rocking is a method frequently used by parents to sooth their babies. In this research we are studying how rocking causes infants to stop crying. We are interested in what happens to infants' breathing when they are being rocked at different speeds and also when they are not being rocked.

During the study the baby lies in a baby buggy which can be made to rock back and forth automatically by an attached motor. A tiny thermometer is placed beneath the baby's nostrils to allow us to record his or her breathing by measuring temperature changes in the air moving in and out of the nostrils. A microphone is attached to the side of the buggy to record any vocalizations that may occur.

The baby's breathing and vocalizing and rocking of the buggy are recorded on computer by the equipment in Dr. Davis' psychophysiology lab next door. In addition, the baby's state (i.e., whether the baby is alert, asleep, crying, etc.) is observed and recorded on the Apple microcomputer in the same room as the baby.

The parent is free at any time to terminate any part of this procedure, and will make all decisions regarding the baby's wellbeing and care (feeding, changing, dressing, comforting, etc.) throughout the entire session.

APPENDIX B

<u>Infant Behavioral State Scale</u> (adapted from Prechtl, 1974).

State 1 (Quiet sleep):	eyes closed, no body movement.
State 2 (active sleep):	eyes closed, body movement.
State 3 (drowsy):	eyelids slowly opening & closing; may be some movement.
State 4 (quiet waking):	eyes open, no movement.
State 5 (active waking):	eyes open, movement.
State 6 (fussing):	intermittent whimpers and/or cries.
State 7 (crying):	continuous uninterupted crying, body tension.

APPENDIX C

Individual Kappas for each subject.

Subject	Kappa	Subject	Kappa
2	.94	21	.88
5	-	22	.76
6	.78	23	.89
7	.83	25	.91
8	.70	26	.63
9	.81	29	.82
10	0	30	.89
14	.76	31	.17
15	0	32	.95
16	.93	33	.74
17	.73	34	-
18	.72	37	.94
19	.81	38	.86

APPENDIX D

Nonsignificant ANOVAs of PAT.

Table D-1

<u>Summary of the three factor ANOVA of PAT during the two no rock conditions.</u>

Source	df	MS	F	p
Mean	1	94.75	802.15	
Order	1	0.11	0.97	0.34
Group	1	0.02	0.19	0.67
O x G	1	0.15	1.24	0.28
Error	22	0.12		
Condition	1	0.02	0.11	0.74
C x O	1	0.01	0.04	0.85
C x G	1	0.00	0.01	0.91
C x O x G	1	0.11	0.52	0.48
Error	22	0.20		

Table D-2

Summary of the three factor mixed ANOVA of PAT during NR1, R50, NR2, R27, and PR.

Source	*df*	MS	*F*	*p*
Mean	1	203.33	1129.79	
Order	1	0.00	0.01	0.94
Group	1	0.14	0.78	0.39
O x G	1	0.41	2.28	0.15
Error	18	0.18		
Condition	4	0.07	0.58	0.68
C x O	4	0.02	0.19	0.94
C x G	4	0.11	1.01	0.41
C x O x G	4	0.07	0.64	0.63
Error	72	0.11		

Table D-3

Summary of the two factor ANOVA of PAT during R27.

Source	*df*	MS	*F*	*p*
Mean	1	38.12	409.60	
Order	1	0.01	0.13	0.72
Group	1	0.02	0.23	0.63
O x G	1	0.06	0.68	0.42
Error	20	0.09		

APPENDIX E

Nonsignificant ANOVAs of PSD.

Table E-1

Summary of the three factor ANOVA of PSD during the two no-rock conditions.

Source	*df*	MS	*F*	*p*
Mean	1	21.08	141.06	
Order	1	0.45	3.03	0.10
Group	1	0.00	0.04	0.85
O x G	1	0.04	0.26	0.62
Error	22	0.15		
Condition	1	0.02	0.14	0.72
C x O	1	0.14	0.82	0.37
C x G	1	0.02	0.10	0.76
C x O x G	1	0.03	0.16	0.69
Error	22	0.17		

Table E-2

Summary of the three factor mixed ANOVA of PSD during NR1, R50, NR2, R27, and PR.

Source	df	MS	F	p
Mean	1	39.91	171.29	
Order	1	0.48	2.07	0.17
Group	1	0.24	1.02	0.33
O x G	1	0.11	0.47	0.50
Error	18	0.23		
Condition	4	0.07	0.66	0.62
C x O	4	0.08	0.76	0.55
C x G	4	0.11	1.00	0.41
C x O x G	4	0.11	1.03	0.39
Error	72	0.11		

Table E-3

Summary of the four factor mixed ANOVA of PSD during NR1, R50, NR2, and R27.

Source	*df*	MS	*F*	*p*
Mean	1	34.07	144.30	
Order	1	0.73	3.10	0.09
Group	1	0.12	0.52	0.48
O x G	1	0.00	0.00	0.97
Error	19	0.24		
Blocks	1	0.04	0.31	0.59
B x O	1	0.18	1.28	0.27
B x G	1	0.24	1.74	0.20
B x O x G	1	0.00	0.02	0.90
Error	19	0.14		
Condition	1	0.17	2.45	0.13
C x O	1	0.00	0.00	0.96
C x G	1	0.10	1.42	0.25
C x O x G	1	0.13	1.82	0.19
Error	19	0.07		

(table continues)

Source	df	MS	F	p
B x C	1	0.04	0.40	0.53
B x C x O	1	0.02	0.21	0.65
B x C x G	1	0.09	0.88	0.36
B x C x O x G	1	0.10	0.95	0.34
Error	19	0.11		

Table E-4

Summary of the two factor ANOVA of PSD during R27.

Source	*df*	MS	*F*	*p*
Mean	1	7.24	66.80	
Order	1	0.27	2.49	0.13
Group	1	0.00	0.01	0.94
O x G	1	0.01	0.08	0.77
Error	20	0.11		

Table F-1

<u>Summary of the five factor mixed ANOVA of state during NR1, R50, NR2, and R27.</u>

Source	*df*	MS	*F*	*p*
State	2	52828.32	11.78	
S x O	2	13451.06	3.00	0.06
Group	2	3817.43	0.85	0.44
S x O x G	2	757.63	0.17	0.85
Error	34	4485.32		
B x S	2	704.86	0.52	0.60
B x S x O	2	177.99	0.13	0.88
B x S x G	2	1623.60	1.19	0.32
B x S x O x G	2	530.81	0.39	0.68
Error	34	1360.46		
C x S	2	518.00	0.67	0.52
C x S x O	2	122.81	0.15	0.85
C x S x G	2	402.78	0.52	0.60
C x S x O x G	2	164.73	0.21	0.81

Error	34	769.96

(table continues)

Source	df	MS	F	p
B x C x S	2	3964.19	4.77	0.01
B x C x S x O	2	2234.57	2.69	0.08
B x C x S x G	2	440.81	0.53	0.59
B x C x S x O x G	2	1055.58	1.27	0.29
Error	34	831.49		

APPENDIX G

Nonsignificant ANOVAs of PAT, PSD, and State for the Prestimulus State groups.

Table G-1

Summary of the two factor mixed ANOVA of PAT for the Prestimulus State groups during NR1, R50, NR2, R27, and PR.

Source	*df*	MS	*F*	*p*
Mean	1	132.61	189.78	
Prestimulus State	2	0.27	0.38	0.69
Error	9	0.70		
Condition	4	0.18	2.05	0.11
C x PS	8	0.09	1.10	0.38
Error	36	0.09		

Table G-2

Summary of the two factor mixed ANOVA of PSD for the Prestimulus State groups during NR1, R50, NR2, R27, and PR.

Source	*df*	MS	*F*	*p*
Mean	1	21.11	66.68	
Prestimulus State	2	0.08	0.25	0.79
Error	9	0.32		
Condition	4	0.16	1.66	0.18
C x PS	8	0.06	0.69	0.70
Error	36	0.09		

Table G-3

Summary of the two factor mixed ANOVA of PSD for the Prestimulus State groups during NR1, R50, NR2, and R27.

Source	*df*	MS	*F*	*p*
Mean	1	15.40	61.10	
Prestimulus State	2	0.14	0.57	0.59
Error	9	0.25		
Block	1	0.02	0.21	0.65
B x PS	2	0.11	0.98	0.41
Error	9	0.11		
Condition	1	0.19	2.14	0.18
C x PS	2	0.03	0.30	0.75
Error	9	0.09		
B x C	1	0.24	8.62	0.02
B x C x PS	2	0.02	0.83	0.47
Error	9	0.03		

Table G-4

Summary of the two factor mixed ANOVA of PAT for the Prestimulus State groups during NR2, and R27.

Source	*df*	MS	*F*	*p*
Mean	1	52.27	156.91	
Prestimulus State	2	0.28	0.83	0.47
Error	9	0.33		
Condition	1	0.02	0.33	0.58
C x PS	2	0.02	0.52	0.61
Error	9	0.05		

Table G-5

Summary of the four factor mixed ANOVA of State for the Prestimulus State groups during NR1, R50, NR2, and R27.

Source	*df*	MS	*F*	*p*
Block	2	6517.91	1.67	0.21
B x PS	4	6365.21	1.63	0.20
Error	20	3893.93		
C x B	2	85.46	0.07	0.93
C x B x PS	4	5150.08	4.37	0.01
Error	20	1178.69		
S x B	2	2139.07	3.79	0.04
S x B x PS	4	3663.03	6.50	0.00
Error	20	563.92		
C x S x B	2	2149.35	0.11	0.11
C x S x B x PS	4	4549.41	5.16	0.01
Error	20	882.08		