INFANTS' SLEEP MOVEMENTS: THEIR RELATIONSHIP TO TEMPERAMENT AND MOTOR DEVELOPMENT DURING THE FIRST YEAR OF LIFE

Elina Jantunen

Master's Thesis
Department of Psychology
University of Jyväskylä

February 2003

JYVÄSKYLÄN YLIOPISTO
Psykologian laitos

JANTUNEN, ELINA RIITTA HELENA:
INFANTS' SLEEP MOVEMENTS: THEIR RELATIONSHIP TO TEMPERAMENT AND MOTOR DEVELOPMENT DURING THE FIRST YEAR OF LIFE

Pro gradu –työ, 18 sivua
Ohjaaja: Jukka Kaartinen
Psykologia
Helmikuu 2003

Tämän opinnäytetyön tarkoituksena oli tutkia vauvojen unenaikaisten liikkeiden yhteyttä ensimmäisen ikävuoden aikana tapahtuvaan temperamentin ja motoriikan kehitykseen. Vauvojen unenaikaisia liikkeitä rekisteröitiin SCSB -unipatjamenetelmällä. Lisäksi tutkimustilanteet videoitiin. 217 vauvan rekisteröinneistä mukaan tutkimukseen valittiin videointien perusteella 113 koehenkilöä, joiden rekisteröinnit sisälsivät vähintään 10 minuuttia kestävän keskeytyksettömän unijakson. Vauvojen temperamenttia tutkittiin kolmessa eri ikävaiheessa Rothbartin Infant Behavior Questionnaire (IBQ) –kyselylomakkeella. IBQ mittaa vanhempien arvioita vauvastaan erilaisissa arkipäivän vuorovaikutustilateissa. Vanhemmat täyttivät myös motoriikkapäiväkirjaa, johon kirjattiin tietoja vauvojen ensimmäisen ikävuoden aikana tapahtuvasta motorisesta kehityksestä. Kirjallisuudessa kerrotaan vauvojen kokonaiskehityksen olevan vahvasti biologispohjaista. Siksi oletettiin, että vauvojen unen aikana mitatuilla liikkeillä voisi olla yhteyttä temperamenttiin ja ensimmäisen vuoden aikana tapahtuvaan motoriseen kehitykseen. Vauvojen unenaikaisten liikkeiden ja motorisen kehityksen suhde oli tämän tutkimuksen kohteena myös, koska osalla koehenkilöistä oli perinnöllinen dysleksia riski. Aiemmissa tutkimuksissa kielellisiin häiriöihin on todettu liittyvän usein motorisia vaikeuksia. Tämän vuoksi ajateltiin, että vastasyntyneiden vauvojen unenaikaisten liikkeiden määrässä ja kestossa voisi olla eroja dysleksiariskiryhmän ja kontrolliryhmän välillä. Lisäksi asetettiin kaksi hypoteesia: 1) unenaikaisten liikkeiden ja IBQ:lla mitatun aktiviteetti tason välinen yhteys nousisi selkeimmin esille ja 2) unen aikana aktiiviset vauvat saavuttaisivat motorisia taitoja aiemmin kuin nukkuessaan vähemmän liikkuvat. Tutkimuksessa havaittiin, että riski- ja kontrolliryhmä eivät eronneet unenaikaisten liikkeiden määrän tai keston suhteen. Vauvojen unenaikaisten liikkeiden ja temperamentin väliset yhteydet jäivät heikoiksi. Kuitenkin pojilla havaittiin muutamia merkitseviä tuloksia: unenaikaisten liikkeiden ja aktivitteetti tason välillä oli negatiivinen korrelaatio yhden kuukauden iässä. Poikien unenaikaisten liikkeiden ja joidenkin motoristen taitojen välillä havaittiin niinikään negatiivinen korrelaatio. Se, miksi tutkimuksen päätulokset havaittiin vain pojilla jäi selittämättä. Tulevaisuudessa olisi mielenkiintoista toistaa tutkimus muutamien mittausmenetelmiä koskevien korjausten jälkeen ja tarkistaa olisivatko tulokset edelleen samansuuntaisia.

Avainsanat: vauvat, unenaikaiset liikkeet, SCSB –unipatjamenetelmä, temperamentti, IBQ, motorinen kehitys

INFANTS' SLEEP MOVEMENTS: THEIR RELATIONSHIP TO TEMPERAMENT AND MOTOR DEVELOPMENT DURING THE FIRST YEAR OF LIFE

Elina Jantunen
Department of Psychology, University of Jyväskylä, Finland

The sleep movements of infants were detected using Static Charge Sensitive Bed (SCSB) and video-recordings. From the recordings of 217 infants 113 subjects were selected to the present study based on the videotapes. The recordings, which were accepted to the study, had to include at least ten minutes of uninterrupted sleep. Infants' temperament was examined at three ages with Rothbart's Infant Behavior Questionnaire (IBQ). IBQ is a parent report method, consisting questions of the child's behavior in everyday caretaking situations. Parents also filled out a motor development diary of their infants' motor development during the first year of life. According to literature all infant development has strong biological bases and therefore it was assumed that sleep movements recorded in infancy could be related to temperament and motor development during the infants' first year of life. The relationship between infants' sleep movements and motor development was an interest of the present study, because part of the infants had a familial background of dyslexia. Based on the literature motor difficulties are often found to be related to language disturbances. Therefore it was examined whether there existed a difference in the amount or duration of sleep movements between dyslexia risk group and control group. In addition to this two hypothesis were made: 1) the most distinct results would be found between infants' sleep movements and temperament dimension Activity Level and 2) infants who were active during sleep would acquire motor milestones earlier than those who moved less asleep. The results of the present study revealed no differences in the amount and duration of sleep movements between the dyslexia risk group and control group. The correlations between infants' sleep movements and temperament remained weak. A few significant correlations emerged in boys: sleep movements correlated negatively with Activity Level at one month's age and also with a few gross motor milestones. Why these main results were found among boys remained unexplainable. In the future it would be interesting to replicate the study with a few corrections in the method and see if the results would turn out to be the same.

Keywords: Infants, Sleep movements, SCSB, Temperament, IBQ, Motor development

Introduction

The purpose of the present study is to examine infants' motor activity during sleep and it's relationship to child's later temperament and motor development. Temperament was evaluated at ages one, six and twelve months by Rothbart's (1978) Infant Behavior Questionnaire (IBQ). In the IBQ form parents were asked to answer questions of their infant's behavior in certain caretaking situations. Motor development was assessed during the child's first year of life using a motor development diary, which was also filled out by the parents (Lyytinen, Ahonen, Eklund & Lyytinen, 2000).

Sleep

Adult sleep can be classified into rapid eye movement (REM) sleep and four stages of non-rapid eye movement (NREM) sleep (Rechtschaffen & Kales, 1968). In 1971 Anders, Emde and Parmelee published manual for scoring infant sleep. This manual defined three sleep states in infants: Active-REM sleep (AS), Quiet sleep (QS) and Indeterminate sleep (IS) (Anders, Emde & Parmelee, 1971). Active-REM sleep is characterized by closed eyes with eye movements, frequent body, limb or face movements, and an irregular respiration pattern. Closed eyes, the absence of eye movements, and regular respiration is defined as Quiet sleep. (Parmelee Jr. & Stern, 1972). Transition periods between these states are classified as Indeterminate sleep (Anders et al., 1971; Parmelee Jr. & Sigman, 1983; Thoman, Denenberg, Sievel, Zeidner & Becker, 1981).

Development of sleep and wakefulness begins already in uterus. Infant sleep behavior changes rapidly as a result of central nervous system maturation and adaptation to extrauterine life (Hoppenbrouwers, Hodgman, Harper & Sterman, 1982). Newborn full-term infants spend two-thirds, approximately 16-17 hours of the 24 -hour-period, asleep. By 6 months they spend about half of their time asleep and half awake (Coons, 1987; Halpern, MacLean & Baumeister, 1995). At this same time the proportion of the 24 -hour-period spent in AS gradually reduces from one third to one fourth of sleep time (Coons, 1987).

The duration of the sleep cycle in infants is about 50-60 minutes (Kleitman & Engelman, 1953; Roffwarg, Muzio & Dement, 1966; Stern, Parmelee, Akiyama, Shultz & Wenner, 1969) when the sleep cycle of an adult is approximately 90 to 100 minutes (Anders & Weinstein 1972). Newborn infants enter sleep initially through AS and cycle at regular intervals with QS, i.e. there is as much AS in the first half of the newborn's sleep period as in the second half. Adults enter sleep with an initial sustained NREM period and have most of their REM sleep during the last third of the night (Anders & Weinstein 1972). In infants, tendencies for REM sleep period concentration in the later part of the nocturnal period have been reported after 3 months of age (Harper et al., 1981; Hoppenbrouwers et al., 1982).

Physiological states of alertness-wakefulness, REM and NREM sleep develop during the perinatal period (Hoppenbrouwers, 1987). Sleep state proportions change with age. AS predominates in immature infants and declines during maturation, whereas the total number and duration of QS episodes increases with age. At term AS occupies 45 to 50% of total sleep time, IS 10 to 15% and QS 35 to 45%. By one year, the percentage of QS is greater than the percentage of AS, a reversal of the proportional relationship present at birth. Also the length of time infants are able to remain asleep continuously increases from about 4 hours at 2 weeks to 7 hours at 1 year. (Anders & Keener, 1985). The proportion of QS increases and AS decreases until late childhood when young adult normative amounts (20% REM sleep and 80% NREM sleep) are achieved (Dreyfus-Brisac & Monod, 1965; Feinberg & Carlson, 1968; Petre-Quadens, 1967). With Central Nervous System (CNS) maturation sleep stages demonstrate increased efficiency characterized by fewer intrusions of short arousals, body movements, and short sleep stages (Coons, 1987).

Body movements during sleep

The amount of body movements during sleep decreases with age both in term and preterm infants (Fukumoto, Mochizuki, Takeishi, Nomura & Segawa, 1981; Hakamada, Watanabe, Hara & Miyazaki, 1981; Parmelee Jr. & Stern, 1972; Prechtl, Fargel, Weinmann & Bakker, 1979, Prechtl & Nolte, 1984) until they reach the base level around the age 9 to 13 months (Fukumoto et al., 1981). At this same time the number of non-body movement epochs during sleep increases, reflecting brain maturation (Erkinjuntti, 1988; Fukumoto et al. 1981; Parmelee Jr. & Stern, 1972).

Fukumoto et al. (1981) divide body movements occurring during sleep into three categories: a) Gross movements (GM), b) Localized movements (LM) and c) Twitch movements (TM). Infant body movements have been suggested to reflect the integrity of brain function (Bekedam, Visser, de Vries & Prectl, 1985; Cambell, Kuyek, Lang & Partington, 1971; Fukuyama, Shionaga & Iida, 1979; Hakamada, Watanabe, Hara & Miyazaki, 1981, 1982; Hashimoto et al., 1981; Monod & Guidashi, 1976). Fukumoto et al. (1981) have suggested that different kinds of body movements are controlled by different levels of the CNS. The level of the CNS, which controls TM is lowest and that controlling GM is highest (Fukumoto et al., 1981; Kohyama, Shishikura, Nakano, Iwakawa & Mori, 1986). Fukumoto et al. (1981) argued that the mechanisms which control TM mature first, LM maturing second and GM last.

In QS, typical movements are startles or generalized phasic movements, which are brief symmetrical simultaneous contraction of 2 or 4 limbs. Also continuous tonic activity in chin muscles is present in QS (Hakamada et al., 1981). AS is characterized by generalized uncoordinated movement of 4 limbs and trunk (often including head), localized movements of part of the body, rhythmic jerky movements of an arm or leg and episodic, short tonic and phasic muscle activity in chin muscles (Hakamada et al, 1981).

Temperament

Temperament is assumed to have biological bases, which is influenced over time by heredity, life experience and maturation (Rothbart, 1981). It can be defined as individual differences in reactivity, activity and self-regulation (Rothbart & Derryberry, 1981, Rothbart, 1986). Infants' temperament seems to be characterized by relatively stable individual differences in behavior (Bates, 1987; Hubert, Wachs, Peters-Martin & Gandour, 1982; Rothbart, 1986). The term temperament is most often applied to behavioral qualities of emotion, attention and activity (Bates, 1989).

Bates (1989) has grouped together seven major temperament dimensions most frequently used in temperament studies. These temperament dimensions are the following: 1) Negative emotionality, 2) Difficultness, 3) Adaptability, 4) Reactivity, 5) Activity, 6) Attention regulation, 7) Sociability and positive emotionality.

Thomas and Chess (1977; 1980) have described three infant temperament styles. Temperamentally ‘easy’ babies were described by their mothers as regular, adaptable, approaching, mild and positive in mood. Temperamentally ‘difficult’ babies were seen as irregular, low in adaptability and initial approach, intense and negative in mood. ‘Slow-to-warm-up’ babies were described as exhibiting negative responses, and slow adaptability to new stimuli and their positive and negative reactions were characterized by mild intensity.

Because it can be assumed that temperament has a biological foundation, the other domains of behavior that are known to reflect biological function might also demonstrate a relationship to infant temperament (Halpern, Anders, Garcia Coll and Hua, 1994). For example, individual differences both in infant sleep movements that are known to reflect CNS maturation, and in activity level, which is found to be in part heritable and constitutional in nature (Saudino & Eaton, 1991; 1995; Stevenson & Fielding, 1985), could be assumed to reflect such relationship. However, the associations between sleep and temperament have usually been small in magnitude (Scher, Tirosh & Lavie, 1998).

Sleep wake-states, which are part endogenous to infants, reflect several dimensions of temperament including self-regulation, activity, arousal, irritability and soothability. The sleep-wake states are one way of getting information on the biological organization of the infants. (Keener, Zeanah & Anders, 1988). Infant temperament, as a key psychobiological concept, has been suggested as one of the modulators of sleep-wake regulation (Scher et al., 1998). For example Schaefer (1990) has observed a high incidence of ‘difficult’ temperament in young children referred for sleep problems. Halpern et al. (1994) proposed, that infant sleep-wake characteristics may be related to infant temperament in two ways: as behavioral mirrors reflecting similar aspects of infant biological organization and as nighttime behaviors that influence parental perceptions of temperament.

The development of motor skills during the first year of life

The growth process during the infant’s first year of life is truly amazing. The infant progresses from a helpless newborn to walking, active child. Infants’ movements are often described as random, ill-defined and primarily consisting on primitive reflexes (for more information of the reflexes see e.g. Cratty, 1979; Illingworth, 1970). Infants’ overall development is intimately related to the maturation of the nervous system (Illingworth, 1970). As the brain matures, reflexes are gradually inhibited throughout the first year and infant’s development begins to change toward more controlled way to move, which includes better integration of the sensory and motor skills. In addition, the physical growth of the child has a very definitive influence on its motor development. During the first year of life there are rapid gains of weight and length (Gallahue, 1982).

According to Gallahue (1982) infants face few major developmental tasks during the first year of life. First, the infant must establish and maintain the relationship of the body to the force of gravity in order to obtain an upright sitting posture and erect standing posture (stability). Secondly, the child must develop basic locomotor abilities in order to move through the environment (locomotion). Third, the infant must develop the abilities of reach, grasp and release in order that meaningful contact with objects may be made (manipulation) (Gallahue, 1982). Establishing control over the musculature in opposition to gravity is a process that follows a predictable sequence in all infants. The events leading to an erect standing posture begin with gaining control over the head and neck and proceed down to the trunk and the legs (Cratty, 1979; Gallahue, 1982). According to Cratty (1979) control of the larger muscles precedes the acquisition of control of the smaller muscles. He also suggests that there is a general tendency for children to mature in a proximal-distal manner, i.e. for motor functions closer to the midline of the body to become more accurate than those far away.

Developing the rudimentary movement abilities of infancy is a process which is influenced by both maturation and experience. Maturation determines the sequential emergence of movement abilities. Although the sequence of development is the same in all children the rate of development can vary from child to child (Gallahue, 1982; Illingworth, 1970). For example, a child has to learn to sit before he can learn to walk but the age at which children learn to sit and walk varies considerably. There is a sequence of development within each developmental field but the development in one field does not necessarily run parallel with another. For instance, although stages in the development of grasping and in locomotion (sitting and walking) are clearly delineated, development can be more rapid in one field than in another. Every child goes through an orderly sequence of development in locomotion from the development of head control to the stage of mature walking, running and jumping (Illingworth, 1970). Table 1 presents the approximate age of onset of locomotive and hand manipulation abilities in infants during the first year of life.

TABLE 1. Approximate ages of onset of locomotive and hand manipulation abilities in infants during the first year of life (Information of the table is adopted from Gallahue, 1982).

LOCOMOTION ABILITIES		
Control of head and neck	Turns to one side	Birth
	Turns to both sides	1 week
	Held with support	First month
	Chin off contact surface	Second month
	Good prone control	Third month
	Good supine control	Fifth month
	Lifts head and chest	Second month
Control of trunk	Attempts supine to prone position	Third month
	Success in supine to prone roll	Sixth month
	Prone to supine roll	Eight month
Sitting	Sits with support	Third month
	Sits with self-support	Sixth month
	Sits alone	Eight month
Standing	Stands with support	Sixth month
	Supports with hand holds	Tenth month
	Pulls to supported stand	Elevent month
	Stands alone	Twelfth month
Horizontal movements	Scooting	Third month
	Crawling	Sixth month
	Creeping	Ninth month
	Walk on all-fours	Elevent month
Upright gait	Walks with support	Sixth month
	Walks with handholds	Tenth month
	Walks with lead	Eleventh month
	Walks alone (hands high)	Twelfth month
	Walks alone (hands low)	Thirteenth month
HAND MANIPULATION ABILITIES		
Reaching	Globular ineffective	First to third month
	Definite corralling	Fourth month
	Controlled	Sixth month
Grasping	Reflexive	Birth
	Voluntary	Third month
	Two-hand palmar grasp	Third month
	One-hand palmar grasp	Fifth month
	Pincer grasp	Ninth month

Hypotheses

In the present study a relationship between the newborns' sleep movements and temperament was presumed to emerge. A following research hypotheses was made: Those infants who moved a lot during sleep were expected to be rated more active by their mothers in Rothbart's (1978) Infant Behavior Questionnaire (IBQ). Thus, children who moved less during sleep as babies were predicted to be seen less active. Rothbart's IBQ scale Activity Level was expected to have the highest correlations to sleep movements of infants asleep because it measures the level of the child's motor activity in the daily caretaking situations.

Based on the literature (Paul, Cohen & Caparulo, 1983; Rintala, Pienimäki, Ahonen, Cantell & Kooistra, 1998; Robinson, 1987) language disturbances and motor difficulties are often related in children. A common finding has been that children with speech and language difficulties were delayed in early motor milestones, especially in independent walking (Haynes & Naidoo, 1991; Robinson, 1987; Trauner, Wulfeck, Tallal & Hesselink, 2000). The relationship between infants' movements during sleep and motor development during the first year of life was examined because part of our subjects had a familial background of dyslexia. Could these motor difficulties also be seen in other motor related areas, such as sleep movements? It was hypothesized that people with language difficulties would also differ in their amount and duration of sleep movements. If this kind of difference would be found, then in the future it would be interesting to study if people with language differences would differ in their amount and duration of sleep movements at different ages.

In addition, the relationship between infants' sleep movements and motor development during the first year of life was an interest of this study. If some relationship between these variables would be found, then in the future it would be interesting to study if the amount or duration of sleep movements could somehow predict motor development. It was hypothesized that those infants who moved a lot asleep would develop in their motor skills earlier. This assumption was made because babies who are active in their sleep could be more active to practice their motor skills also during the day and thus learn the motor skills earlier than children who were motorically more quiet in their sleep and thus possibly less active during the day.

Methods

The sleep movements of 217 newborn infants (116 males and 101 females) were recorded within one week after birth in the EEG laboratory of the Central Hospital of Central Finland. These recordings were carried out as a part of Jyväskylä Lognitudinal study of Dyslexia (JDL) (for more information of the JDL see e.g. Lyytinen et al, 2001). Families expecting a baby were contacted and requested to participate in the study. The risk group consisted of 115 infants with a familial background of dyslexia (one or both parents and at least one near relative dyslectic) and the matched control group consisted of 102 infants of families with no signs of dyslexia.

The Static Charge Sensitive Bed (SCSB) method was used to detect infants' body movements, ballistocardiogram (BCG) and respiration (Alihanka & Vaahtoranta, 1979; Alihanka, Vaahtoranta & Saarikivi, 1981). The SCSB is a movement transducer which enables a nonintrusive recording of infant body movements, ballistocardiogram and respiration. Neither electrodes nor equipment need to be attached to the body and the infant is lying comfortably on a mattress during the recording session. This minimizes the stress of being monitored and allows long-term recordings. In addition the method is simple and inexpensive. The method is sensitive to all kinds of movements bigger than the movement caused by the heartbeat (the BCG). The duration and amplitude of the body movement can be observed in such way that it is possible to distinguish, for example, between gross body movements and twitch movements (Erkinjuntti, Vaahtoranta, Alihanka & Kero, 1984). Figure 1 presents the basic structure of the SCSB mattress.

The sleep movement recordings were carried out during auditory ERP experiments, which lasted approximately two hours including the time that the attachment of the electrodes took. A standard sleep polygraphy, which included the recordings of electroencephalogram (EEG), electromyogram (EMG) and electro-oculogram (EOG), was performed to all subjects. EEG, EMG and EOG were all registered from the standard sites (Anders et al., 1971). Four different stimuli paradigms [1) mismatch negativity (MMN): pitch change (detection), 2) (MMN): vowel duration change, 3) equal probability and 4) control paradigm] were used for different children (for details of the ERP experiments see: Guttorm, Leppänen, Richardson & Lyytinen, 2001; Leppänen, Eklund & Lyytinen, 1997; Pihko et al., 1999;). Infants were presented auditory stimuli through a loudspeaker, located 60-80cm from the estimated head position. Two researchers were present and the infants' parents were invited to observe the experiment if they wished. The newborns were lying supine in a hospital crib during the recording situation. The SCSB transducer was placed under a normal mattress in the crib. Respiratory movements and BCG were filtered and amplified from the raw SCSB signal by using a BR-CPA8 preamplifier. The resulting three SCSB signals and the standard sleep polygraphy were recorded using a Racal Store 14 Instrumentation Recorder (speed 1 7/8). The Racal signals were digitalized off-line into a PC-computer by using Data Translation 2801A A/D –converter and the SCSB data were analyzed using BR99 software.

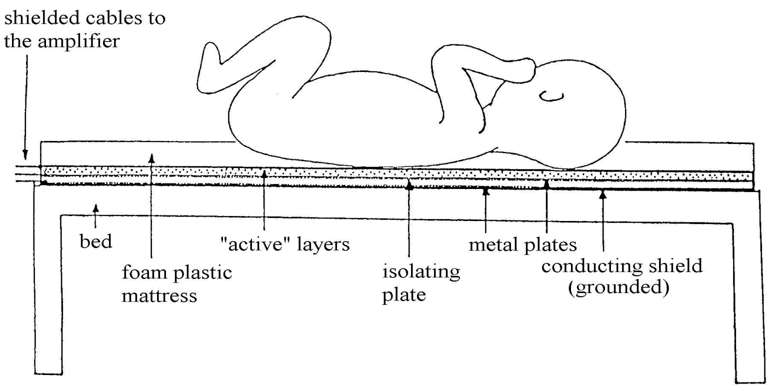

FIGURE 1. The structure of the Static Charge Sensitive Bed (SCSB) mattress (Erkinjuntti et al., 1984).

BR99 software is specially developed for SCSB analysis. The Biorec BR-99 (Biorec Oy, Helsinki, Finland), DOS-version 2.6 for PC's is a comprehensive 8-channel recording application. The BR99 comprises two main functional units, the patient data recording -program (RP) and the printing program (PP). RP records, collects and analyzes digital data, generated by the SCSB sensor and appropriately filtered by an amplifier device. PP enables the display, the printing, and the backing up of collected patient data. It also includes functions for drawing up daily, weekly and monthly summary reports of recorded data (Biomatt, Biorec BR-99 Monitoring System, User Manual, 1999).

The main categories of which reported parameters can be obtained by using BR99 are the following: Cardiac activity, Respiration, Motor activity and Sleep structure. In the present study Movement Time Report (MT report) was used to analyze the sleep data. MT report presents an analysis of the recorded movements in table form, in which the movements are classified into four categories or classes, according to their duration as presented in Table 2.

TABLE 2. Presents an example of BR99 movement analysis table of one subject.

Movement analysis. The time of the analysis 17:36 - 17:58

infant 058

The duration of the analysis : 00 h 23 min = 23 min = 1380 secs

Duration class	N of movs	%	Mean duration	Total duration	%	Movement dur/min	Movement dur/h
A	17	27.869	2.76	47	7.089	0.739	44.348
B	20	32.787	6.85	137	20.664	0.870	52.174
C	13	21.311	11.31	147	22.172	0.565	33.913
D	11	18.033	30.18	332	50.075	0.478	28.696
Total	61			663		28.826	1729.565

Duration classes : A 0-4.99 seconds
B 5-9.99 seconds
C 10-14.99 seconds
D 15-255 seconds (Continuous movements over 255 seconds are interpreted as one 255 seconds movement)

Duration class: Movement (duration) class, N of move: Number of movements per class, %: Percentage of movements per class, Mean Duration: Mean duration of movements per class, Total Duration: Total duration of movements per class, %: percentage of the movements' duration per class, Movement dur/min: mean value of the duration of movements in each class per minute, Movement dur/hour: mean value of the duration of movements in each class per hour.

Each infant's registration was also videotaped as a whole and short paper notes were written during the recording situation by one of the researchers. The videotapes were visually observed later by the author of the thesis. The purpose of the visual observation was to ensure that the movements detected by SCSB were definitely infant's own. Only body movements occurring during behavioral sleep were analyzed. The time when the infant was crying, awake, fed, lifted out of the crib, soothed or otherwise touched or moved, was written down and left outside the analysis. If the recording did not include at least ten minutes uninterrupted sleep, it was not included in the analysis. Based on this visual observation 113 children (68 males and 45 females) were chosen to the statistical analysis. From these children 56 (34 males and 22 females) belonged to the control group and 57 (34 males and 23 females) to the dyslexia risk group.

The three longest artefact free sleep periods of each subject were selected and data based on each periods' MT report (see example on Table 2) were transferred to SPSS. On SPSS the total amount of movements per minute (FRE) and the total duration of movement (in seconds) per minute (DUR) was counted by summing together data of the three longest artefact free periods. In addition, these same variables were counted to each subjects' longest period of sleep. These variables were FRE/LPS for the total amount of movements of the longest period of sleep and DUR/LPS for the total duration of movement of the longest period of sleep. These four variables were used in all SPSS analyses.

The infants' temperament was measured at three ages: 1 month old, 6 months old and 12 months old. The infants were assessed with Rothbart's (1978) Infant Behavior Questionnaire (IBQ), in which parents were asked questions about their infant's behavior in certain caretaking situations. The following 6 temperament characteristics were studied: *Activity Level, Smiling and Laughter, Distress and Latency to Approach Sudden or Novel Stimuli, Distress to Limitations, Soothability*, and *Duration of Orienting*. The explanations for the contents of each dimension are listed in Table 3. The last dimension was measured only at ages 6 and 12 months. These temperament factors were compared to sleep movement variables to find out whether there were any relationship between sleep movements and child's later temperament. However, due to loss of research subjects at different stages of the study and because of only partly filled IBQ forms the temperament data is not complete for all the 113 subjects and varies from dimension to dimension between 83 and 100.

TABLE 3. The definitions of the six IBQ dimensions adopted from the original Infant Behavior Questionnaire, Rothbart, 1978.

TEMPERAMENT DIMENSIONS BY ROTHBART	MEASURES	DEFINITION
Activity Level	Activity of the motor system	The level of the child's gross motor activity, including movement of arms, legs, squirming, and locomotion
Smiling and Laughter	The affect of joy	Facial expressions of upturned, extended mouth and positive vocalization, smiling and laughter from the child in any situation
Distress and Latency to Approach Sudden or Novel Stimuli	The child's distress	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 in caretaking situations	Is measured while the child is a) waiting for food, b) refusing food, c) being in confining place or position, d) being dressed or undressed, e) being prevented access to an object toward which the child is directing his/her attention
Soothability	Effectiveness of soothing techniques	Effectivenessof soothing techniques in reduction of fussing, crying of distress in the child
Duration of Orienting	Sustained involvement with a single object or activity	Is measured when there has been no sudden change in stimulation and is used as a measurement of both attention span and distractibility, pointing up the possibility of important individual differences in the development of attention

The IBQ includes also questions related to infants' sleeping. These 11 questions about sleeping were examined separately in relation to the SCSB measures of infants sleep movements.

After the child was released home from the hospital, the parents were sent a motor development diary (Lyytinen, et al., 2000). The diary consisted of a checklist with instruction and clarifying pictures of the motor skills the parents had to observe. Checklist on motor development consisted 12 gross motor and 14 fine motor items (see Table 4). During the child's first year of life parents observed their child's motor development and filled the diary. To ease the diary filling parents received a calendar where they could see the calendar week and child's chronological life week. They marked in the diary the life week when the asked motor milestone emerged the first, the second and the third time. The time of the second observation was used in the analysis.

TABLE 4. The descriptions of the motor development composite variables (adopted from Viholainen, Ahonen, Cantell, Lyytinen & Lyytinen, 2002)

VARIABLE	INCLUDING FOLLOWING GROSS MOTOR ITEMS
Head control	Raises head
	Turns head towards parents
Turning	Rolls from prone to supine
	Rolls from supine to prone
Sitting	Crawls: stomach in contact with floor
	Sits alone with support of hands
	Sits alone without support
Upright posture	Raises self into a sitting position
	Creeps on hands and knees
	Stands by pulling on furniture
Walking	Moves around by holding onto furniture
	Walks alone 10-15 steps
VARIABLE	**INCLUDING FOLLOWING FINE MOTOR ITEMS**
Fist coordination	Both fists tightly clenched
	Palmar grasp: holds finger tightly
	Holds fists open or slightly clenched
Reaching	Plays with hands
	Reaches with a half-open hand
	Brings toy to mouth
Grasping	Reaches for an object to touch
	Grasps an object offered to him/her
	Transfers an object from hand to hand
Manipulation	Holds two objects at same time
	Beginning thumb-forefinger grasp
	Drops an object intentionally
	Pincer grasp: straight forefinger and thumb
	Bangs two objects together

The 26 items of the motor diary were grouped together into nine categories according to their developmental function. The five gross motor variables were *head control, turning, sitting, upright posture,* and *walking*. The four fine motor variables were *fist coordination, reaching, grasping,* and *manipulation*. The more precise descriptions of these composite variables are listed in Table 4. Scores in motor measures were standardized by using the mean and standard deviation of the control group. The standardized value indicates how much each child's performance differs from the mean difference of the control group. These standardized values were used in all analyses (more details in Viholainen, Ahonen, Cantell, Lyytinen & Lyytinen, 2002). This data based on the developmental diary was available for 100 children of 113 selected for the present study.

Results

There were great inter-individual differences in the amount of infant's sleep movements. Figure 2 demonstrates twenty minute sleep periods of motorically quiet and restless subjects.

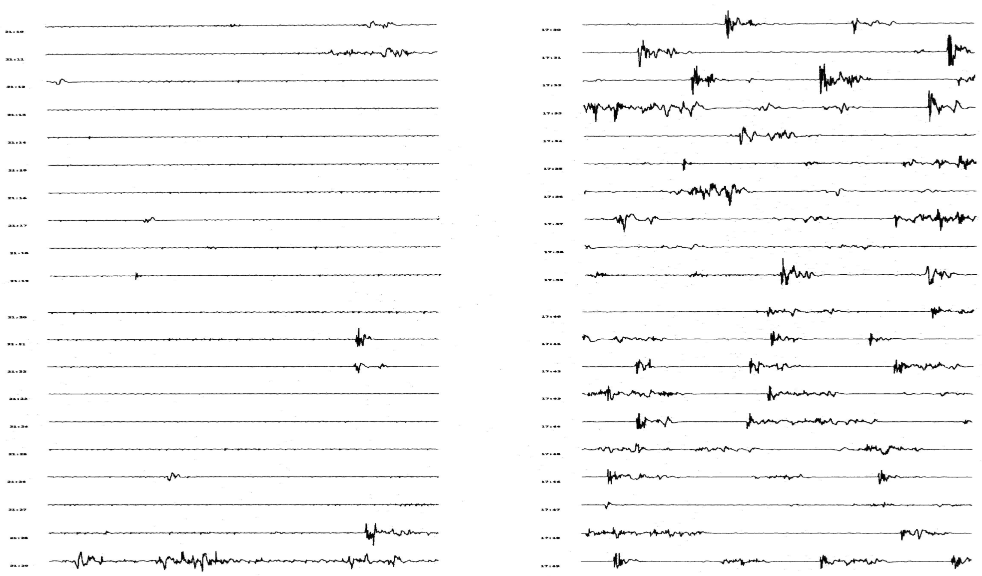

FIGURE 2. Examples of twenty minute sleep periods of two differing infants. The difference in the amount of movements of these two infants is quite obvious when the BR-99 minute by minute printouts of their movements are placed side by side like this. The subject, whose movement lines are presented on the left has moved only now and then during this twenty minute period, whereas the lines on the right clearly prove that the subject has moved about two to three times per minute.

Group differences

Analysis of variance (Anova) was used to investigate whether there were differences between the genders or between risk and control groups in related to temperament, sleep movement and motor development variables. In addition, the possible effect of the different ERP stimuli paradigms on sleep movements were examined. However, no differences were found at movements during sleep between those infants who heard different stimuli. Infants, who were excluded from our study based on the behavioral sleep observation, did not differ in any of the temperament dimensions of those infants, who were accepted in the study. The duration of the longest sleep period (LPS) was studied. No differences were found between these groups (control boys, control girls, risk boys, risk girls) when the length of the longest sleep period was examined.

Differences were found neither between genders nor between risk or control children related to amount or duration of sleep movements. However, it was discovered that control girls were significantly the motorically most quiet compared to risk girls [$F(1,54) = 4.431$, $p = .041$] and control boys [$F(1,54) = 4.702$, $p = .035$]. The difference between control girls' and risk boys' amounts of sleep movements was not significant [$F(1,54) = 3.292$, $p = .075$] although it is clearly visible at Figure 3. Risk girls moved most as noticeable in Figure 3. The difference between Risk girls' and Control and Risk boys' movements was not statistically significant. There was no difference in amounts of sleep movements between the boys' groups.

There were differences between boys and girls at different temperament factors. Girls got bigger values at scale *Distress and Latency to Approach Sudden or Novel Stimuli* than boys both at 1 month old [$F(1,97) = 4.490$, $p = .037$] and at 6 months old [$F(1,92) = 4.223$, $p = .043$]. Boys got bigger values at scale *Soothability* than girls at 6 months old [$F(1,88) = 6.925$, $p = .010$]. When risk and control groups were compared, risk group got bigger values at scale *Distress to Limitations* than control group at 6 months old [F(1,91) = 8.325, p = .005]. Risk girls got bigger values again at scale *Distress and Latency to Approach Sudden or Novel Stimuli* than risk boys both at 1 month old [F(1,45) = 5.616, p = .022] and 6 months old [F(1,41) = 4.793, p = .034]. Risk girls got bigger values at scale *Distress to Limitations* than control girls at 6 months of age [F(1,37) = 4.681, p = .037].

There were no differences between genders related to neither of the motor development variables (gross and fine motor). There were also no differences between risk and control children. However, risk girls were found to learn slower to reach objects than risk boys [F(1,47) = 6.024, p = .018] and control girls [F(1,39) = 5.170, p=.029]. The difference between risk girls and control boys was not statistically significant [F(1,92) = 3.204, p = .077].

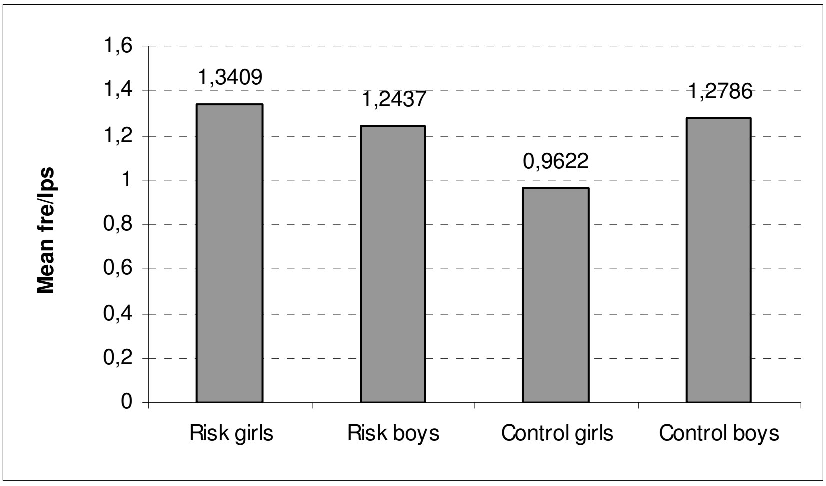

FIGURE 3. The amount of sleep movements in different groups of subjects. (Mean fre/lps: mean amount of movements per minute during the longest period of sleep)

Factor analysis

Principal Component Analysis with Oblimin Rotation was used to detect the possible connections between the three variables under examination. The number of factors was varied. However, despite the number of factors, the sleep movement and motor development variables always appeared on their own factors. The temperament variables accumulated depending on the number of factors from 1 to 4 factors but not on the same factors as sleep movement and motor development variables. The correlations between these factors generally remained very low.

Correlations

When the factor analysis did not reveal particularly remarkable results, the data was analyzed in more detail using the Pearson correlation.

The temperament dimensions

When the Pearson correlation was run for the whole population a few significant correlations were found between the sleep movements variables and Rothbart's IBQ dimensions. The correlations detected were not systematic, nor did they reveal any continuity between different ages when they were measured. Thus, these correlations seemed quite detached.

On the group level some systematic correlations were found. In boys more significant correlations were found compared to girls. In risk group the amount of significant correlations was a little bit higher than in control group. In general these correlations were neither clear nor logical or interpretative in a simple manner.

In boys significant correlations were found between the sleep movement variables and temperament dimension *Activity Level*. Both the amount and duration of sleep movements correlated negatively with the *Activity Level* measured at one month's age. The same kind of correlation was also found between the amount of sleep movements of the longest sleep period and *Activity Level* in boys at the same age. These correlations reveal that those boys whose amount and duration of sleep movements during sleep at birth are higher have lower *Activity Level* at one month age and, on the contrary, boys who are motorically more quiet during sleep have higher *Activity Level*. However, these correlations did not show continuity further at the ages of six and twelve months. All the results clarified above are illustrated in detail at Table 5.

TABLE 5. The correlations between sleep movements and Activity level at one, six and twelve months old. infants. Significant correlations have been boldfaced in the table (<.05).*

	ACTIVITY LEVEL 1M	**ACTIVITY LEVEL 6M**	**ACTIVITY LEVEL 12M**
WHOLE GROUP			
DUR	-.18	-.05	-.10
FRE	-.08	-.01	.02
DUR/LPS	-.19	.06	-.05
FRE/LPS	-.14	.06	-.00
GIRLS			
DUR	.06	-.17	-.33
FRE	.08	.01	-.25
DUR/LPS	-.03	.04	.01
FRE/LPS	.03	.10	-.09
BOYS			
DUR	**-.29 ***	.02	.01
FRE	-.18	-.04	.15
DUR/LPS	**-.27 ***	.07	-.09
FRE/LPS	**-.26 ***	.03	.03
RISK GROUP			
DUR	-.16	.01	.01
FRE	-.04	.09	-.05
DUR/LPS	-.18	.04	-.02
FRE/LPS	-.15	.12	-.03
CONTROL GROUP			
DUR	-.20	-.08	-.13
FRE	-.18	-.12	.05
DUR/LPS	-.20	.08	-.05
FRE/LPS	-.19	-.01	.01

THE SLEEP VARIABLES: DUR: The duration of movements during sleep, FRE: The amount of movements during sleep, DUR/LPS: The duration of movements of the longest period of sleep, FRE/LPS: The amount of movements of the longest period of sleep.
ACTIVITY LEVEL 1M, 6M, 12M: Activity Level is one of Rothbart's IBQ dimensions, which was assessed at three ages: one, six and twelve months old infants.

In addition, a few more significant correlations were found between sleep movement variables and Rothbart's IBQ temperament dimensions. However, these correlations seemed to be quite detached from each other and quite inexplicable. The following table (Table 6) comprises all the significant correlations found. A few correlations even reached the significance at level <.01 but still the results remain quite vague. None of the correlations show continuity through ages one, six and twelve months.

No clear tendency was found between Rothbart's IBQ sleep -related questions and infants' sleep movements. Some significant correlations were found at different ages but no reasonable, systematic results nor gender differences were found.

Motor development variables

On the whole population no significant correlations appeared between sleep movement variables and learning gross motor skills. The sleep movement and motor development variables had again negative correlations in boys, but in girls no significant correlations were found. When sleep movement variables and learning fine motor skills were examined, no correlations were found between these variables neither in risk nor control group.

TABLE 6. The correlations between sleep movement variables and Rothbart's IBQ dimensions. Only those dimensions in which some significant correlations have been found, have been listed in this table. Significant correlations have been boldfaced in the table (<.05, ** <.01).*

	S&L 1M	S&L 6M	S&L 12M	DNO 1M	DNO 6M	DNO 12M	SOO 1M	SOO 6M	SOO 12M	ORI 6M	ORI 12M
WHOLE GROUP											
DUR	-.08	-.01	-.12	-.09	-.06	-.13	-.02	**-.24***	.04	-.06	.03
FRE	-.05	.01	-.12	-.01	.07	.03	.08	-.17	-.18	.16	.09
DUR/LPS	-.06	-.07	**-.22***	-.08	.01	.02	.00	-.19	-.05	-.03	-.07
FRE/LPS	-.08	-.02	-.13	-.02	.13	.09	.14	-.14	-.13	.11	-.02
GIRLS											
DUR	-.23	-.03	.01	-.15	-.23	-.22	-.02	-.18	-.16	-.09	.09
FRE	-.11	-.06	-.01	.10	.06	.06	.08	-.02	-.23	.22	.13
DUR/LPS	-.17	-.17	-.17	.05	-.05	.10	-.03	-.13	**-.44****	-.09	-.13
FRE/LPS	-.10	-.06	-.02	.15	.14	.16	.10	-.04	**-.36***	.11	-.05
BOYS											
DUR	-.02	-.01	-.18	-.07	.00	-.09	-.01	-.24	.13	-.06	.00
FRE	-.01	.06	-.17	-.12	.06	.02	.07	-.25	-.07	.11	.08
DUR/LPS	-.01	-.00	-.25	-.18	.06	-.04	.01	-.24	.13	.01	-.03
FRE/LPS	-.06	.02	-.18	-.18	.15	.03	.15	-.23	-.01	.12	.01
RISK GROUP											
DUR	-.16	-.11	**-.33***	.13	.26	.20	.11	-.15	-.27	.04	-.07
FRE	.04	.05	-.26	.16	**.33***	**.40***	.15	.06	-.14	**.35***	.08
DUR/LPS	-.12	-.14	**-.35***	.11	.27	.30	.10	-.14	-.31	.06	-.16
FRE/LPS	-.02	.03	-.25	.09	.26	**.37***	.22	.05	-.20	.28	-.05
CONTROL GROUP											
DUR	-.05	.02	-.04	-.26	-.20	**-.29***	-.12	**-.31***	.22	-.11	.06
FRE	-.12	-.00	-.01	-.20	-.13	-.17	-.01	**-.41****	-.09	-.06	.10
DUR/LPS	-.03	-.02	-.15	-.25	-.13	-.13	-.09	-.24	.13	-.11	-.02
FRE/LPS	-.14	-.03	-.01	-.16	.03	-.09	.03	**-.34***	-.06	-.11	.01

THE ROTHBART'S DIMENSIONS: S&L: Smiling and Laughter, DNO: Distress and Latency to Approach Sudden or Novel Stimuli, SOO: Soothability, ORI: Duration of Orienting, 1M, 6M, 12M: All these dimensions were assessed at three ages: one, six and twelve months old infants.
THE SLEEP VARIABLES: DUR: The duration of movements during sleep, FRE: The amount of movements during sleep, DUR/LPS: The duration of movements of the longest period of sleep, FRE/LPS: The amount of movements of the longest period of sleep.

In boys the amount, duration of sleep movements and the duration of the sleep movements of the longest sleep period all correlated negatively with the age when infants learned to turn from prone to supine and supine to prone. Thus, if the amount or duration of movements was high, the skill to turn was acquired earlier, and vice versa.

The duration of sleep movements of the longest sleep period also correlated negatively with learning the upright posture in boys. This could mean that those boys whose duration of sleep movements was high, learned earlier the upright posture. On the other hand, those boys whose duration of sleep movements was lower learned this skill later.

The duration of sleep movements of the longest sleep period correlated negatively with learning the skill of walking. Those boys whose duration of sleep movements was higher seemed to reach the skill of walking earlier but those boys whose duration of sleep movements was lower learned to walk later.

The correlative study of the sleep movement variables and learning fine motor skills did not reveal any significant correlations in the whole population or in genders and groups. All the correlations, which were found between the sleep movement variables and gross motor variables are listed in Table 7.

TABLE 7. The correlations between sleep movements and gross motor variables. Significant correlations have been boldfaced (<.05).*

	HC	TU	SI	UP	WA
WHOLE GROUP					
DUR	-.10	-.14	-.03	-.15	-.13
FRE	-.11	-.16	-.01	-.06	-.02
DUR/LPS	-.12	-.14	-.04	-.15	-.14
FRE/LPS	-.16	-.13	-.02	-.07	-.07
GIRLS					
DUR	-.09	.13	-.03	.01	.01
FRE	.03	-.03	-.02	.06	.14
DUR/LPS	-.10	.14	.04	.08	.11
FRE/LPS	-.12	-.05	-.04	.01	.08
BOYS					
DUR	-.11	**-.28***	-.04	-.23	-.20
FRE	-.21	**-.25***	.00	-.14	-.13
DUR/LPS	-.14	**-.31***	-.08	**-.28***	**-.29***
FRE/LPS	-.18	-.21	-.00	-.13	-.19
RISK GROUP					
DUR	-.12	-.06	-.08	-.18	-.12
FRE	-.13	-.16	-.02	-.07	-.00
DUR/LPS	-.15	-.02	-.10	-.17	-.17
FRE/LPS	-.18	-.09	-.11	-.13	-.14
CONTROL GROUP					
DUR	-.10	-.17	.01	-.12	-.13
FRE	-.09	-.17	.00	-.06	-.06
DUR/LPS	-.11	-.24	.01	-.13	-.11
FRE/LPS	-.12	-.20	.08	-.02	.00

THE SLEEP VARIABLES: DUR: The duration of movements during sleep, FRE: The amount of movements during sleep, DUR/LPS: The duration of movements of the longest period of sleep, FRE/LPS: The amount of movements of the longest period of sleep.
THE MOTOR DEVELOPMENT VARIABLES: HC: Head control, TU: Turning, SI: Sitting, UP: Upright posture, WA: Walking

Discussion

The interest of the present study was in finding out whether sleep movements recorded at birth had any relationship to infants' temperament at one, six and twelve months age. In addition, the study wanted to clarify whether the infant sleep movements and motor development during the child's first year of life were connected. This was done because part of the subjects had a familial background of dyslexia and earlier studies have demonstrated that language disturbances and motor difficulties are often related in children (Rintala et al., 1998; Robinson, 1987). Difference in the amount and duration of sleep movements was expected between risk and controls. Also a hypothesis of an advanced motor development in motorically active sleepers was made.

There seem to be no earlier studies on infants' sleep movements and temperament relationship. However, most of the earlier findings on sleep and temperament links tend to suggest that temperament characteristics and sleep-wake organization are interrelated. The correlations found have been small in magnitude, failed to follow a consistent profile, and/or focused on different temperamental dimensions (Scher et al., 1988). In the present study some correlations were found between infant sleep movements and different temperament dimensions measured by Rothbart's IBQ at different ages. Most of these correlations didn't seem to be explainable because the significant correlations found emerged in different groups, genders and ages. For this part, the results of this study were quite similar to earlier findings of temperament and sleep.

Temperament dimension Activity Level, measured by Rothbart's IBQ, was hypothesized to show the most distinct relationship to infants' sleep movements. However, the relationship between infants' sleep movements and Activity Level did not emerge at the whole group. At one month old boys Activity Level was found to be related to sleep movements recorded after birth. This is interesting because factor analytic temperament studies have consistently found Activity Level to be a major descriptive dimension of behavior (Goldsmith et al., 1987; Rothbart & Bates, 1998). Boys are generally found to be more active than girls and the magnitude of this difference has been found to increase with age (Eaton & Enns, 1986). One possible explanation for this gender difference is that early genetically based sex differences cause male infants to be more active than female infants (Kohnstam, 1989). Bardwick (1971) has argued that boys seem to be more active than girls at birth, whereas girls show greater motor passivity and sensitivity to stimuli. Buss (1988) concludes that the sex differences in prenatal levels of hormones (e.g. androgens) could produce early sex differences on Activity Level. These findings might explain why the correlations between sleep movements and Activity Level in this study were found only at boys. Maybe in the present study the control-risk group distribution effected on the results because risk girls were found to be more motorically active than control girls and as active as risk boys and control boys. It could be possible that the control girls' results reflected the usual amount of sleep movements in girls and the risk girls for some reason moved as much as both risk and control boys, i.e. like boys usually. The difference in the amounts of sleep movements of risk girls and control girls resulted in that the girls' sleep movements as a group were inconsistent. Perhaps due to this dispersion the results emerged only at boys whose amount of sleep movements were more consistent as the whole group's level.

The relationship between infants' sleep movements and none of temperament dimensions did show stability across ages 1, 6 and 12 months. Chess and Thomas (1990) have pointed out that a temperamental pattern or characteristic may be stable for a period and then change. Rothbart (1986) has argued that findings of discontinuities in temperamental stability are meaningful in terms of maturational change during the first year of life. Changes in temperament may take place during periods of rapid maturation (Rothbart & Derryberry, 1981). Temperament characteristics could also be modified by changes in behavioral organization, such as those based on maturation of neurological organization, which takes place early in life (Bates, 1989). According to Belsky, Fish and Isabella (1991), the degree of continuity that characterizes temperament during infancy appears to vary according to the dimension examined and the measurement approach used. Based on these findings it is no wonder that stability across these three ages was not found.

Not even the relationship between sleep movements and Activity Level found in one month old boys, show continuity at 6 and 12 months age. It could be possible that the temperament at one month old infant is the most biological-based and due to this the relationship emerged only at one month's age because the sleep movements were recorded at birth and thus these variables were both biologically based. Cratty (1979) has suggested that the general level of activity evidenced by a newborn child is probably to a large degree genetically determined and highly individual. By the time child reaches the ages 6 and 12 months the nurture, socialization, caretaker-child interaction and child's own maturation have begun to shape the temperament and because of this the temperamental features could show more stability at later age. Maybe if the sleep movements had been recorded at these same ages, the relationship could have shown stability also later. Buss (1988) has argued that the trait of activity is likely to stabilize only after several months and definitely by the end of the first year. He has suggested that an unconfounded measure of activity is difficult in the first months of life. Eaton (1994) has found that Activity Levels change with age, at first increasing and then later decreasing.

The present results on the relationship between infant's sleep movements and the motor development during the first year of life were not unambiguous. Some of the results proved to be as hypothesized and some not. On the whole population no significant results were found. However, again in boys some of the gross motor development variables correlated negatively with the sleep movement variables. Those boys who were motorically active at sleep seemed to learn these skills earlier compared to the age the whole group acquired those skills. The skills that are possibly learned earlier by the boys who were active during sleep in infants were turning, learning the upright posture and walking. Touwen (1976) has found that boys develop somewhat faster in gross motor areas, while girls tended to be more forward in functional areas, which required more subtle motor activities. Also, Largo, Weber, Molinari, Comenale Pinto and Duc (1985) found that boys were slightly more advanced in most areas of locomotion. A possible explanation for the slightly more advanced development of locomotion of boys might be their larger lean body-mass compared with girls. Garn (1966) found that muscle mass at six months of age was predictive of walking unaided at one year.

All the significant results emerged at the gross motor development. None of the variables measuring fine motor development were related to the amount or duration of sleep movements in infants. One explanation for this finding could be that normal variations are much broader and more typical in gross motor than in fine motor development. Fine motor parameters should be mastered in a much narrower time frame (Illingsworth, 1970). Possibly because of these factors, no significant differences were found related to fine motor development.

Difference in the amount and duration of sleep movements was expected to emerge between risk and control groups. However, the risk group was not found to differ from the control group neither in their amount nor duration of sleep movements recorded at birth. Thus, according to the present study children with a familial risk for dyslexia do not differ in their sleep movements from children with no such risk. However, it is still possible that the control-risk distribution has affected on some of the research results, because of the above-mentioned differences between the amount of sleep movements in risk and control girls. The results might also have been affected by the sleep state in which the child was in the recording situation. Those children, who were in QS, were probably more likely to be chosen to this study than children in AS, because at the latter sleep state children got more easily upset and thus their recordings lacked ten minutes uninterrupted sleep period needed to be a part of the research sample. This could have led to distortion of the material: the data might have included primarily QS, during which the amount of movements is usually smaller

It could be possible that one measurement is not enough to give the whole picture of each child’s general amount of movements. The recordings for this study were usually done daytime. Maybe it would be useful to measure movements 3-5 times at different times of the day. One measurement can easily be ruined, if for example, the baby is hungry, is crying and restless or has a stomachache. It could also be useful to measure sleep movements at one, six and twelve months old, thus at the same ages, the Rothbarts’ test was used. This would probably be a more reliable way to examine the relationship between early temperament and infant sleep movements. Perhaps both measurements (SCSB and IBQ) should be repeated with shorter intervals, for example at ages one, three, six, nine and twelve months because the motor development diary is filled out during a first year of life. These repeated measures would give a good ground for examining the relationship between these three variables. However, considering the present study these kinds of measurements had not been possible to carry out because the SCSB recordings were done as part of a larger study with other aims (see more: Guttorm et al., 2001; Leppänen et al., 1997; Pihko et al. 1999).

The main results of the present study amazingly emerged only at boys. The sleep movements correlated significantly with Activity Level at one month’s age and with a few gross motor development variables, both in boys. The reason for this remains a mystery. Perhaps some confounding third variable caused these correlations. One possibility underneath this could have been the difference in the amount of sleep movements in the risk girls and control girls discussed above. It would be interesting to revise this study in the future with a few changes in method that were suggested earlier. This revised study would give more precise information of the relationship between sleep movements and temperament and motor development during the first year of life.

Acknowledgements

I would like to thank Dr. Jukka Kaartinen for his guidance and dedication when supervising this Master’s Thesis. Thanks also to Kenneth Eklund, Helena Viholainen and Tomi Guttorm for answering my questions concerning their own special area of the Jyväskylä Longitudinal Study of Dyslexia (JLD). Special thanks go to Mika Sirviö for supporting me during the writing process and also to my parents for encouraging me to study during the school years.

References

Alihanka, J. & Vaahtoranta, K. (1979) A static charge sensitive bed. A new method for recording body movements during sleep. *Electroencephalography and Clinical Neurophysiology, 240, 731-734.*

Alihanka, J., Vaahtoranta, K. & Saarikivi, I. (1981) A new method for long-term monitoring of the ballistocardiogram, heart rate and respiration. *American Journal of Physiology, 240,* R384-R392.

Anders, T., Emde, R. & Parmelee, A. (Eds.) (1971) *A manual of standardized terminology,techniques and criteria for scoring of states of sleep and wakefulness in newborn infants*. Los Angeles: UCLA Brain information, NINDS Neurological information Network.

Anders, T.F. & Keener, M. (1985) Developmental course of nighttime sleep-wake patterns in fullterm and premature infants during the first year of life. I. *Sleep, 8, 173-192.*

Anders, T. & Weinstein, P. (1972) Sleep and its disorders in infants and children: A review. *Pediatrics,50, 312-324.*

Bardwick, J. (1971) Psychology of women. New York: Harper & Row, 1971.

Bates, J.E. (1987) Temperament in infancy. In J.D. Osofsky (Ed.) Handbook of infant development (2nd ed.) New York: Wiley.

Bates, J.E. (1989) Concepts and measures of temperament. In: Kohnstamm, G.A., Bates, J.E. and Rothbart, M.K. (Eds), *Temperament in Childhood,* Wiley, New York, p. 3-26.

Bekedam, D.J., Visser, G.H.A., de Vries, J.J. & Prectl, H.F.R. (1985) Motor behaviour in the growth retarded fetus. *Early Human Development, 12, 155-165.*

Biomatt, Biorec BR-99 Monitoring System, User Manual, 1999; Biorec oy Atomitie 5 B, P.O.Box 85, FIN-00371 Helsinki, FINLAND.

Belsky, J., Fish, M. & Isabella, R. (1991) Continuity and discontinuity in infant negative and positive emotionality: family antecedents and attachment consequences, *Developmental Psychology, 27, 421-431.*

Buss, A.H. (1988) *Personality: Evolutionary Heritage and Human Distinctiveness.* Hillsdale, NJ: Lawrence Erlbaum.

Campbell, D., Kuyek, J., Lang, E. & Partington, M.V. (1971) Motor activity in early life. *Biol. Neonate, 18, 108-120.*

Chess, S. & Thomas, A. (1990) Continuities and discontinuities in temperament. In: Robins, L. and Rutter, M. (Eds), *Straight and Devious Pathways from Childhood to Adulthood,* V.P., Cambridge, pp.205-220.

Coons, S. (1987). Development of sleep and wakefulness during the first 6 months of life. In C. Guilleminault (Ed.), *Sleep and its disorders in children*, (pp.17-27) New York: Raven Press.

Cratty, B.J. (1979) *Perceptual and motor development in infants and children.* (2nd ed.), Prentice-Hall, INC., Englewood Cliffs, N.J.

Dreyfus-Brisac, C. & Monod, N. (1965) Sleep of premature and full-term neonates: a polygraphic study. *Proc R Soc Med, 58, 6-7.*

Eaton, W.O. (1994) Temperament, development, and the five factor model: lessons from activity level. In C.F. Halverson, G.A. Kohnstamm and R.P. Martin (Eds.), *The Developing Structure of Temperament and Personality from Infancy to Adulthood.* (pp. 173-187). Hillsdale, NJ: Erlbaum.

Eaton, W.O. & Enns, L.R. (1986) Sex differences in human motor activity level. *Psychological Bulletin, 100, 19-28.*

Erkinjuntti, M. (1988) Body movements during sleep in healthy and neurologically damaged infants. *Early Human Development, 16, 283-292.*

Erkinjuntti, M., Vaahtoranta, K., Alihanka, J. & Kero, P. (1984) Use of the SCSB method for monitoring of respiration, body movements and ballistocardiogram in infants. Early Human Development, 9, 119-126.

Feinberg, I. & Carlson, V. (1968) Sleep variables as a function of age in man. *Arch.Gen. Psychiat., 18, 239.*

Fukumoto, M., Mochizuki, N., Takeishi, M., Nomura, Y. & Segawa, M. (1981) Studies of body movements during night sleep in infancy. *Brain and development, 3, 37-43.*

Fukuyama, Y., Shionaga, A. & Iida, Y. (1979) Polygraphic study during whole night sleep in infantile spasms. *Euopean Neurology, 18, 302-311.*

Gallahue, D. (1982) *Understanding motor development in Children.*Wiley, 1982.

Garn, S.M. (1966) Body size and its implications. In Hoffman, L.W., Hoffman, M.L. (Eds.) *Review of Child Development Research, 529-561.* New York: Russell Sage Foundation.

Goldsmith, H.H., Buss, A.H., Plomin, R., Rothbart, M.K., Thomas, A., Chess, S., Hinde, R.A. & McCall, R.B. (1987) What is temperament? Four approaches. *Child development, 58, 505-529.*

Guttorm, T.K., Leppänen, P.H.T., Richardson, U. & Lyytinen, H. (2001) Event-Related Potentials and Consonant Differentiation in Newborns With Familial Risk for Dyslexia. *Journal of Learning Disabilities, vol.34, n.6, p.534-544, Nov.-Dec. 2001.*

Hakamada, S., Watanabe, K., Hara, K. & Miyazaki (1981) Development of the motor behavior during sleep in newborn infants. *Brain and Development, 3, 345-350.*

Hakamada, S., Watanabe, K., Hara, K. & Miyazaki (1982) Hydraencephaly: sleep and movement characteristics. *Brain and Development, 4, 45-49.*

Halpern, L.F., Anders, T.F., Garcia Coll, C. & Hua, J. (1994) Infant Temperament: Is there a relation to sleep-wake states and maternal nighttime behavior? *Infant Behavior and Development,17, 255-263.*

Halpern, L.F., MacLean, W.E., Jr. & Baumeister, A.A. (1995) Infant sleep-wake characteristics: Relation to neurological status and the prediction of developmental outcome. *Developmental Review, 15, 255-291.*

Harper, R.M., Leake, B., Miyhara, L., Mason, J., Hoppenbrouwers, T., Sterman, M.B. & Hodgman, J. (1981) Temporal sequencing in sleep and waking states during the first 6 months of life. *Exp Neurol,, 72, 294-307.*

Hashimoto, T., Endo, S., Fukuda, K., Hiura, K., Kawano, N., Suzue, J., Kokawa, T. & Miyao, M. (1981) Increased body movements during sleep in Gilles de la Tourette syndrome. *Brain and development, 3, 31-35.*

Haynes, C. & Naidoo, S. (1991) *Children with Specific Speech and Language Impairment. Clinics in Developmental Medicine, No.119.* London: MacKeith Press.

Hoppenbrouwers, T. (1987) Sleep in infants. In C. Guilleminault (Ed.), *Sleep and Its Disorders in Children* (pp.1-15). New York: Raven Press.

Hoppenbrouwers, T., Hodgman, J.E., Harper, R.M. & Sterman, M.B. (1982) Temporal distributionof sleep states, somatic activity, and autonomic activity during the first half year of life. *Sleep, 5, 131-144.*

Hubert, N.C., Wachs, T.D., Peters-Martin, P. & Gandour, M.J. (1982) The study of early temperament: Measurement and conceptual issues. *Child Development, 53, 571-600.*

Illingworth, R.S. (1970) *The development of the infant and young child: Normal and Abnormal.* 4th ed. E&S Livingstone, Edinburgh and London.

Keener, M.A., Zeanah, C.H. & Anders, T.F. (1988) Infant temperament, sleep organization and nighttime parental interventions. *Pediatrics, 81, 762-771.*

Kleitman, N. & Engelmann, T.G. (1953) Sleep characteristics in infants. *J Appl Physiol, 6, 269-282.*

Kohnstam, G. (1989) Temperament in childhood: cross-cultural and sex differences, In G.A. Kohnstam, J.E. Bates and M.K. Rothbart (Eds), *Temperament in childhood* (pp. 483-508) New York: Wiley.

Kohyama, J., Shishikura, J., Nakano, I., Iwakawa, Y. & Mori, K. (1986) Sleep study on patients with severe brain damage –polysomnographical examination. *Brain Development, 8, 583-589.*

Largo, R.H., Weber, M., Molinari, L., Comenale Pinto, L. & Duc, G. (1985) Early locomotion development: significance of prematurity, cerebral palsy and sex. *Developmental Medicine and Child Neurology, 27, 183-191.*

Leppänen, P.H.T., Eklund, K.M. & Lyytinen, H. (1997) Event-Related brain potentials to change in rapidly presented acoustic stimuli in newborns. *Developmental Neuropsuchology, 13(2), 175-204.*

Lyytinen, H., Ahonen, T., Eklund, K., Guttorm, T.K., Laakso, M.-L., Leinonen, S., Leppänen, P.H.T., Lyytinen, P., Poikkeus, A.-M., Puolakanaho, A. Richardson, U. & Viholainen, H. (2001) Developmental pathways of children with and without familial risk for dyslexia during the first years of life. *Developmental Neuropsychology, 20, 535-554.*

Lyytinen, P., Ahonen, T., Eklund, K. & Lyytinen, H. (2000) Ääntelyn ja motoriikan kehityksen seurantamenetelmä. Jyväskylän yliopiston Lapsitutkimuskeskus, Niilo Mäki Instituutti, 2000.

Monod, N. & Guidasci, S. (1976) Sleep and brain malformation in neonatal period. *Neuropaediatrie, 7, 229-249.*

Parmelee, A.H. Jr. & Sigman, M.D. (1983) Perinatal brain development and behavior. I. In M.M. Haith& J.J. Campos, (Eds.) *Infancy and developmental psychobiology.* II. In P.H. Mussen (Ed.), *Handbook of child psychology.* New York: Wiley.

Parmelee, A.H. Jr. & Stern, E. (1972) Development of states in infants. *Sleep and Maturing Nervous System*, 199-228. Ed. Clemente, D.C., Purpura, D.P. and Mayer, F.E. Academic Press, New York.

Paul, R., Cohen, D.J. & Caparulo, B.K. (1983) A longitudinal study of patients with severe developmental disorders of language learning. *J Am Acad Child Psychiatry, 22, 525-534.*

Petre-Quadens, O. (1967) Ontogenesis of paradoxical sleep in the human newborn. *Journal of Neurological Science, 4, 154-157.*

Pihko, E., Leppänen, P.H.T., Eklund, K.M., Cheour, M., Guttorm, T.K. & Lyytinen, H. (1999) Cortical responses of infants with and without a genetic risk for dyslexia: I. Age effects. *Neuroreport, 10, 901-905*

Prechtl, H.F., Fargel, J.W., Weinmann, H.M., & Bakker, H.H. (1979) Postures, motility and respiration of low-risk preterm infants. *Developmental Medicine and Child Neurology, 21, 3-27.*

Prechtl, H.F.R. & Nolte, R. (1984) Motor behaviour of preterm infants. *Clinics in Developmental Medicine, 94, 79-92.*

Rechtschaffen, A. & Kales, A. (Eds.) (1968) *A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects.*Washington, D.C.: U.S. Government Printing Office.

Rintala, P., Pienimäki, K., Ahonen, T., Cantell, M. & Kooistra, L. (1998) The effects of a psychomotor training programme on motor skill development in children with developmental language disorders. *Human Movement Science, 17, 721-737.*

Robinson, R.J.(1987) The causes of language disorder: introduction and overview. In Proceedings of the first international symposium on specific speech and language in children, 1-9.

Roffwarg, H.P., Muzio, J.N. & Dement, W.C. (1966) Ontogenetic development of the human sleep-dream cycle. *Science, 152, 604-619.*

Rothbart, M.K. (1978) Infant Behavior Questionnaire, 1978 Version.

Rothbart, M.K. (1981) Measurement of temperament in infancy. *Child development, 52, 569-578.*

Rothbart, M.K. (1986). Longitudinal observation of infant temperament. *Developmental Psychology, 22, 356-365.*

Rothbart, M.K. & Bates, J.E. (1998) Temperament. In W. Damon (Series Ed.) and N. Eisenberg (Vol. Ed.), *The Handbook of Child Psychology: Vol. 3. Social, Emotional and Personality Development (5th edn.). New York: Wiley, pp. 105-176.*

Rothbart, M.K. & Derryberry, D. (1981) Development of individual differences in temperament. In M.E. Lamb & Brown, A.L. (Eds.) *Advances in developmental psychology* (Vol. 1, pp. 37-86).Hillsdale, N.J.: Erlbaum.

Saudino, K.J. & Eaton, W.O. (1991) Infant temperament and genetics: an objective twin study of motor activity level. *Child Development, 62, 1167-1174.*

Saudino, K.J. & Eaton, W.O. (1995) Continuity and change in objectively assessed temperament: a longitudinal twin study if activity level. *British Journal of Developmental Psychology, 13, 81-95.*

Schaefer, C.E. (1990) Night waking and temperament in early childhood. *Psychological Reports, 67, 192-194.*

Scher, A., Tirosh, E. & Lavie, P. (1998) The relationship between sleep and temperament revisited: Evidence for 12-month-olds: A research note. *J Child Psychol Psychiatr, 39, 785-788.*

Stern, E., Parmelee, A.H., Akiyama, Y, Shultz, M.A. & Wenner, W.H. (1969) Sleep cycle characteristics in infants. *Pediatrics, 43, 65-70.*

Stevenson, J. & Fielding, J. (1985) Ratings of temperament in families of young twins. *British Journal of Developmental Psychology, 3, 143-152.*

Thoman, E.B., Denenberg, J.H., Sievel, J., Zeidner, L.P. & Becker, P. (1981) State organization in neonates: Developmental inconsistency indicates risk for developmental dysfunction. *Neuropaediatrics, 12, 45-54.*

Thomas, A. & Chess, S. (1977) Temperament and development. New York: Brunner/Mazel.

Thomas, A. & Chess, S. (1980) The dynamics of psychological development. New York: Brunner/Mazel.

Touwen, B.C.L. (1976) *Neurological development in infancy. Clinics in Developmental Medicine, 58.* London: Heinemann.

Trauner, D., Wulfeck, B., Tallal, P. & Hesselink, J. (2000) Neurological and MRI profiles of children with developmental language impairment. *Developmental Medicine and Child Neurology, 42, 470-475.*

Viholainen, H., Ahonen, T., Cantell, M., Lyytinen, P. & Lyytinen, H. (2002) Development of early motor skills and language in children at risk for familial dyslexia. *Developmental Medicine and Child Neurology, 44, 761-769.*