There was no significant negative correlation between normalized PBB concentrations in adipose tissue and any of the six memory tests. The statistical test for such correlations detected linear associations between PBB concentrations and memory performance where the PBB concentration in adipose might account for as little as 9 percent of the variability in memory performance.

Our findings indicate that among people exposed to PBB's, factors affecting psychological functioning may be more important causes of memory complaints and low scores on objective tests of memory than the level of PBB contamination.

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Rapid Eye Movement Storms in Infants: Rate of Occurrence at 6 Months Predicts Mental Development at 1 Year

Abstract. *Intense rapid eye movements (REM) during sleep were investigated as a possible indication of delay in the neurodevelopment of infants. The rate of occurrence of REM storms was determined by monitoring the sleep of 15 normal, first-born infants during weeks 2 through 5 and at 3, 6, and 12 months. The amount of REM within each 10-second interval of active sleep was rated on a four-point scale based on frequency and intensity of eye movements. When the babies were 12 months old, the Bayley Scales of Mental Development were administered. A significant negative correlation was found between the frequency of REM storms at 6 months and Bayley scores at 1 year. To verify this, an independent sample of 14 subjects was also studied. The negative correlation was confirmed. The findings support the suggestion that by 6 months of age REM storms express dysfunction or delay in the development of central inhibitory feedback controls for sleep organization and phasic sleep-related activities.*

During a longitudinal study (*1*) that included observations of the sleep of normal infants, a form of dramatic, intense rapid eye movement (REM) was observed. These REM bursts occur in active sleep and involve eye movement of very great amplitude, often accompanied by other facial movements such as brow raising and eye opening. In some instances the episodes have an almost seizure-like appearance, giving the clinical impression of instability in the controls of the central nervous system (CNS). We have adopted the term REM storm to describe this phenomenon, a designation that has been used to refer to REM bursts in some adults with severe sleep disturbance (*2*).

Our observations indicate that, in normal infants, the frequency of REM storms is relatively high during the neonatal period, then drops sharply after about 5 weeks of age, suggesting a developmental course for this form of phasic activity during active sleep. If the REM storms result from phasic fluctuation in inhibitory control, their diminution with age would reflect increasing stability of feedback mechanisms as the CNS matures. These considerations led us to investigate the relation between REM storms and CNS integrity as measured in terms of cognitive development. The frequency of REM storms in active sleep was studied through the first year of life and compared with developmental quotients obtained from the Bayley Scales of Mental Development administered at 1 year.

Two successive groups of infants were studied. Group 1 babies were the first 15 subjects enrolled in the larger project to undergo a 1-year developmental assessment, and consisted of eight males and seven females, all first-born infants. Group 2 babies were the next 14 subjects to be enrolled, and consisted of six males and eight females, seven of whom were first-born and seven second-born. All of the infants were full-term and normal at birth, as indicated by 5-minute Apgar scores of 9 or 10 (an infant in group 1 was delivered by cesarean section and had a 5-minute Apgar score of 7).

On weeks 2, 3, 4, and 5 the infants' sleep was monitored during continuous 7-hour observations of the infant and mother which were designed to record the normal flow of a day's activity in the home. When the infant was put into the crib for a nap, sleep states were observed and a simultaneous recording of respiration was obtained from a pressure transducer under the infant's crib pad. The amount of time the babies slept during each observation period was 3.6 $\pm$ 0.76 hours (mean $\pm$ standard deviation).

Observations of sleep at 3, 6, and 12 months were also made, starting when the infant was put to bed in the evening and lasting for approximately 2 hours (2.0 $\pm$ 0.20 hours). Because of illness or other unavoidable reasons, no data were obtained for three infants at 3 months in group 1 and three infants at 12 months in group 2.

Throughout each observation, behavioral states and state-related behaviors were recorded at 10-second intervals (*3*). The sleep states included active sleep, quiet sleep, and sleep-wake transition. During each epoch of active sleep the level of REM activity was rated on a four-point scale based on both the frequency and intensity of eye movement. Ratings ranged from the absence of any REM activity to the occurrence of an REM storm (*4*). Each level of REM was measured as a percentage of the time spent in active sleep, and all sleep measures were averaged over weeks 2 through 5.

The Bayley Scales of Mental Develop-

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ment were administered to each infant at 12 months of age by a psychometrician who knew nothing about the early observations of the infants. In the group 1 infants, neither the amount of active or quiet sleep nor the total REM at any age was related to the Bayley scores. However, there was a significant negative correlation between REM storms at 6 months and Bayley scores at 1 year ($r = -.65$, $P < .01$). The REM storm rate was relatively low at this age, and in fact ten of the subjects had scores of zero. Therefore, the REM storm data were also analyzed with a biserial r test, yielding a value of $-.59$ ($P < .05$).

For group 2 infants the correlation between REM storms at 6 months and Bayley scores at 1 year was $-.88$ ($P < .01$). This finding replicated that obtained for group 1 and was the only significant finding consistent across the two groups. Of the 14 subjects in group 2, five had scores of zero for REM storms at 6 months. Therefore, the relation was further examined by dividing the ranked scores for the 14 subjects into three groups based on the rate of REM storms at 6 months: no REM storms ($N = 5$), moderate rates ($N = 5$), and high rates ($N = 4$). The mean Bayley scores for these groups were 112.6, 104.8, and 88, respectively. An analysis of variance revealed a significant linear trend across means [$F(1, 11) = 5.2$, $P < .05$]. Figure 1 presents the rate of REM storms over the 12 months for the two groups combined.

Several sources of potential bias in the findings were explored. Although sex differences have been found in some sleep measures (*5*), no such differences were found for either the 6-month REM storm rates or the Bayley scores in either group of infants. There were no differences in group 2 between the first- and second-born infants in either REM storm rates at 6 months or Bayley scores. Six of the infants in group 2 had siblings in group 1 and one had a sibling in group 2; there were no significant correlations in REM or Bayley scores between these first- and second-born sibling pairs. Thus, there is no evidence that our results were influenced by either of these factors. The findings, from two independent samples, demonstrate that the rate of REM storms at 6 months is predictive of mental development at 1 year (*6*).

We could find no other report describing a study in which the amplitude of REM in infants or children was assessed. In fact, REM intensity is generally defined strictly on the basis of frequency (*7*); accordingly, previous studies have investigated both the overall frequency and the distribution or clustering of REM during periods of active sleep. These temporal characteristics have been found to discriminate between normal and abnormal children (*8*), but they have not been reported to discriminate differences among normal individuals. Similarly, in the present study temporal characteristics alone (REM frequency) did not have predictive validity. Only the REM storm measure, which takes into account both frequency and amplitude, predicted developmental scores. This finding indicates that REM amplitude, as well as clustering and overall frequency, is an important expression of the phasic CNS activity that occurs during the sleep of infants.

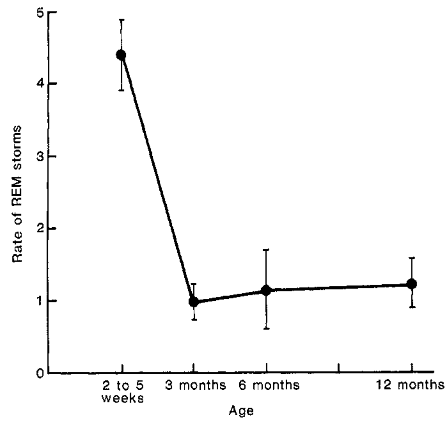

Fig. 1. Rate of REM storms during active sleep in the two groups of subjects.

As a sleep phenomenon in infancy, REM storms may be viewed as resulting from immature inhibitory feedback controls in the CNS pathways responsible for sleep organization and sleep-related eye movements. Eye movements are triggered in the pontine vestibular nuclei, and specific neural networks responsible for burst patterns (as opposed to single eye movements) have been described (*9*). Bursting is facilitated by input from the occipital cortex and is inhibited by input from the frontal cortex—influences that are further mediated in the midbrain (*10*). Thus, control over burst patterning should become more refined as encephalization progresses, leading to the observed decrease in the incidence of REM storms with age. Failure of these control systems to develop may reflect a more general disturbance of CNS organization. The findings of this study suggest that the persistence of REM storms at 6 months of age is an expression of inadequacy in the developing CNS.

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Foot-Length Asymmetry, Sex, and Handedness

Levy and Levy (*1*) found that right-handed males had longer right feet and right-handed females had longer left feet, while the reverse relationship occurred in non–right-handed individuals. We have analyzed data obtained and classi-