Routledge
Taylor & Francis Group

Attachment & Human Development

ISSN: 1461-6734 (Print) 1469-2988 (Online) Journal homepage: http://www.tandfonline.com/loi/rahd20

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To cite this article: Marie-Hélène Pennestri, Ellen Moss, Katherine O'Donnell, Vanessa Lecompte, Andrée-Anne Bouvette-Turcot, Leslie Atkinson, Klaus Minde, Reut Gruber, Alison S. Fleming, Michael J. Meaney, Hélène Gaudreau & on behalf of the Mavan Research Team (2015) Establishment and consolidation of the sleep-wake cycle as a function of attachment pattern, Attachment & Human Development, 17:1, 23-42, DOI: 10.1080/14616734.2014.953963

To link to this article: http://dx.doi.org/10.1080/14616734.2014.953963

Published online: 18 Sep 2014.

Attachment & Human Development, 2015
Vol. 17, No. 1, 23–42, http://dx.doi.org/10.1080/14616734.2014.953963

Establishment and consolidation of the sleep-wake cycle as a function of attachment pattern

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(*Received 20 May 2013; accepted 8 August 2014*)

The development of sleep-wake regulation in infants depends upon brain maturation as well as various environmental factors. The aim of the present study was to evaluate sleep duration and quality as a function of child attachment to the mother. One hundred and thirty-four mother–child dyads enrolled in the Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) project were included in this study. Attachment was assessed with the Strange Situation procedure at 36 months and maternal sleep reports were collected at 6, 12, 24 and 36 months. Differences in sleep characteristics were assessed with mixed models with one factor (attachment group) and one repeated measure (age). Children classified as disorganized had a significantly lower duration of nocturnal sleep, went to bed later, signaled more awakenings, had shorter periods of uninterrupted sleep (only at 12 months) and had shorter periods of time in bed (only at 6 months) than children classified as secure and/or ambivalent ($p < 0.05$). This is the first study to show that children with insecure disorganized attachment present a distinct sleep pattern in comparison with those with secure or ambivalent attachment between 6 and 36 months of age. Sleep disturbances could exacerbate difficulties in these families that are already considered vulnerable.

Keywords: sleep; attachment; development; disorganization; awakenings

Introduction

Sleep and development

The sleep-wake regulation is a function of the interaction between endogenous and exogenous factors (Jenni & O'Connor, 2005; Sadeh, Tikotzky, & Scher, 2010). Thus, the development of sleep consolidation in infants depends both on brain maturation and environmental factors (Anders, 1994). Sleep perturbations in childhood are highly prevalent (Johnson, 1991; Petit, Touchette, Tremblay, Boivin, & Montplaisir, 2007). A recent study showed that between 6 months and 3 years of age, non-specific sleep problems are reported by about 10% of parents (Byars, Yolton, Rausch, Lanphear, & Beebe, 2012). However, evaluating the prevalence of sleep disturbances in childhood is complicated by the different definitions and methodologies used in the literature. Depending on the actual measures, the prevalence of sleep problems can reach 20–30% (Gaylor, Burnham,

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Goodlin-Jones, & Anders, 2005; Lam, Hiscock, & Wake, 2003; Lozoff, Wolf, & Davis, 1985).

Dyssomnias refer to difficulties in initiating and/or maintaining sleep (American Psychiatric Association, 1994). In every-day life, this translates into difficulties falling asleep and/or frequent nighttime awakenings. In most studies, the evaluation of sleep disturbances is based on parental reports and therefore mainly relies on awakenings that are signaled by the infants. However, night awakenings, even if they are not observed by parents, are a common phenomenon in infants. Studies using objective measures, such as video recording (Gaylor, Goodlin-Jones, & Anders, 2001), actigraphy (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991; Scher, 2001) or polysomnography (Hoppenbrouwers, Hodgman, Arakawa, Geidel, & Sterman, 1988; Scholle et al., 2011) show that infants awake at least 1 to 3 times per night during their first years of life. It is thus more significant to describe infant behavior following an awakening, instead of focusing on the awakening per se (Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007). An important question concerns the reasons why some children signal their awakenings, while others are able to fall back to sleep by themselves.

Most longitudinal studies actually show a decline in the prevalence of sleep disturbances from one to six years of age (Petit et al., 2007; Wake et al., 2006). Thus, signaling an awakening can be considered a universal and transient phenomenon, but it can persist among some children and evolve into a sleep problem (Byars et al., 2012). Recognizing factors that contribute to the persistence of sleep disturbances is important for the early identification of children at risk of developing long-term sleep disorders and suggest novel interventions.

Attachment

Multiple factors, including parental characteristics and behaviors, as well as infant characteristics and genetics (Sadeh et al., 2010; Touchette, Petit, Tremblay, & Montplaisir, 2009) associate with sleep problems in children. As bedtime involves a separation from the caregiver, on most occasions the primary attachment figure, a theoretical association is proposed between sleep biology and attachment theory (Anders, 1994). Attachment is described as the emotional and enduring bond of the infant to the caregiver (Bowlby, 1969, 1973, 1980). Again, attachment relies both on physiological and psychological processes, as connection to the caregiver is essential for survival. Human and animal studies show the importance of the quality of the attachment relationship for socio-emotional development (Fox, Kimmerly, & Schafer, 1991; Moss, Dubois-Comtois, et al., 2011; van IJzendoorn, Bard, Bakermans-Kranenburg, & Ivan, 2009).

The gold standard for evaluating the quality of child attachment to the caregiver between ages 12 to 24 months is a structured laboratory paradigm, i.e., the Ainsworth Strange Situation Procedure (Ainsworth, Blehar, Waters, & Wall, 1978) with a modified version for toddlers and preschoolers aged 24–60 months (Cassidy & Marvin with the MacArthur Working Group on Attachment, 1992). During both procedures, the child's behavior is evaluated during a series of separations and reunions with the primary attachment figure, usually the mother. The infancy and preschool procedures differ in number of episodes, length of separations, and presence of a stranger during separations (for more details see Moss, Bureau, Cyr, Mongeau, & St-Laurent, 2004) but, for both, coding of attachment behavior is based on a four-category system.

Securely attached children readily seek proximity to and receive comforting from the caregiver when distressed, and increase exploration of the environment when the child

feels himself to be in a comfortable, nonthreatening situation. Child insecure patterns, *avoidance* and *ambivalence*, are adaptive strategies for maintaining proximity to attachment figures who are unresponsive to some aspect of child emotional behavior. Children who develop avoidant attachment patterns learn to inhibit the expression of distress and to distance themselves from the caregiver in stressful situations (Ainsworth et al., 1978; Main, 1981). Avoidance is believed to develop from repeated experiences of rejection by the caregiver. Conversely, children who develop the ambivalent category exaggerate distress and helplessness and are often in close proximity to the caregiver. The ambivalent pattern is believed to represent an adaptive response to parental inconsistency in responding to child distress (Moss, Bureau, et al., 2004).

A fourth group of children has been identified, who show *disorganized* attachment, i.e. they fail to show an organized strategy for seeking proximity to the attachment figure in times of distress and display sequences of behaviors that seemingly lack a goal and often appear contextually bizarre and incoherent (Main & Solomon, 1990). Caregivers of children with disorganized attachment show helpless or hostile behavior in the face of child distress and this pattern has been linked to dysfunctional parenting (Lyons-Ruth & Jacobvitz, 2008; Moss, Cyr, Bureau, Tarabulsy, & Dubois-Comtois, 2005). Disorganized attachment is considered the most problematic form of attachment and is associated with development of psycho-social problems across development (Moss et al., 2005; van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999).

Sleep and attachment

Falling asleep at night and waking up in the morning represents a separation from the caregiver followed by a reunion: a cycle occurring naturally every night throughout childhood (Anders, 1994). As attachment research is based on this separation-reunion paradigm, sleep-wake regulation could represent an ecologically relevant reflection of the attachment system. In addition, bedtime also involves being alone in the darkness, two universal fear stimuli proposed by Bowlby (1973). As there is a cumulative effect of maternal separation, being alone and being in the darkness during the transition to sleep, it can be particularly stressful for the infant and it is thus plausible that the attachment strategy is activated. However, only a few empirical studies have evaluated the association between sleep and attachment. Moreover, the methodology and results of these studies are not always consistent.

Some studies, the majority using maternal sleep reports and the Strange Situation Paradigm, have found an association between sleep and attachment classification in children (McNamara, Belsky, & Fearon, 2003; Morrell & Steele, 2003). One study compared attachment classification in infants with (n = 40) or without (n = 60) sleep problems at 14–16 months old; sleep problems were defined as settling and/or waking issues (Morrell & Steele, 2003). In this study, the rate of ambivalent attachment was higher in the sleep problems group than in infants without sleep problems. In addition, difficulties related to night awakenings were higher in infants with an ambivalent attachment than in those showing secure or avoidant attachment, while no significant difference was observed between ambivalent and disorganized children. Furthermore, ambivalent attachment predicted the persistence of sleep problems at two years old. Another large longitudinal study, which compared night awakenings between 15-month-old infants classified as either avoidant or ambivalent found more signaled awakenings in the ambivalent group at 6 months (McNamara et al., 2003). At 15 months, this difference

was no longer present, but the mean duration of night waking episodes was longer in the ambivalent group than in the avoidant group at this age.

In a study evaluating night awakenings during the first year of life, the authors showed that infants classified ambivalent at 12 months had more signaled awakenings through their first 6 months of life than did avoidant, secure or disorganized infants. In addition, they found that whereas all groups showed a decrease of night waking over this period, avoidant children were signaling less awakenings at 6 months. However, no differences between any of the groups were observed at 1 year of age (Beijers, Jansen, Riksen-Walraven, & de Weerth, 2011). Another study assessed attachment with the attachment story completion task and sleep using actigraphic measures in a sample of 34 preschool-aged children (Vaughn et al., 2011). Two scales were used to code the narrative tasks, i.e. coherence (ability to address or resolve conflict in the story) and security (awareness of emotion states appropriate to the story theme). The authors found that higher attachment security and coherence, considered as a continuum, was significantly associated with greater sleep efficiency and a lower waking duration after sleep onset. Finally, another recent study used path analyses to examine the relationship between attachment (assessed with the Attachment Q-Sort [AQS]) and maternal sleep reports (assessed with the Child Behavior Checklist [CBCL]). The authors found a significant path between attachment insecurity at 24 months and subsequent sleep problems at 36 months, but only in children with high negative emotionality (which was evaluated only at 6 months) (Troxel, Trentacosta, Forbes, & Campbell, 2013).

Other studies have found no association between sleep and attachment. At one year of age, there were no differences in night awakenings between secure or ambivalent infants in a non-risk sample of 94 children living in Israel (Scher, 2001). In fact, the proportion of infants described by their mothers as "night wakers" was relatively high in each group (secure: 55% and ambivalent: 60%). However, difficulties in falling asleep, as assessed by the mother, were more prevalent in securely attached children (particularly in the dependent-secure sub-classification) than in ambivalent children. In the same study, there was no association between attachment classification and night awakenings as measured objectively by actigraphy, in a subgroup of 37 infants. The same author found similar results in another sample of one year old infants (Scher & Asher, 2004). In this latter study, no association was found between security of attachment (assessed with the AQS procedure) and the number of night awakenings or sleep problems. Moreover, analysis of actigraphic measures for a subgroup of infants lead to the same null findings; no association was found between security of attachment and night awakenings or sleep efficiency.

Finally, a recent study assessed attachment at 18 months and sleep quality at two years of age in 55 children. Attachment was measured with the Strange Situation Paradigm, using a continuous approach rather than categories, and sleep was assessed both with maternal reports and actigraphy. Children with higher resistant (ambivalent) attachment behavior had longer nocturnal wake duration when assessed by maternal reports. However, this association was not found when sleep was measured by actigraphy (Simard, Bernier, Belanger, & Carrier, 2013).

In sum, empirical results concerning the association between sleep and attachment are rare and not always consistent. The most consistent finding is a higher rate of signaled awakenings in ambivalent children compared with other attachment groups, which is coherent with attachment theory. The ambivalent pattern is thought to be an adaptive response to parental inconsistency in responding to child distress. By exaggerating emotional displays of sadness and anger, ambivalent children keep the parent involved with them, even though the attention is activated by negative emotion. However, even this

finding is not consistent; some authors found either weak effects or differences that were not stable between multiple time points, while others found no effect at all.

The discrepant findings may be due to several key factors. The majority of these studies focused on night awakenings and did not evaluate other sleep measures, such as sleep duration, sleep latency or sleep schedules. In addition, measurement of attachment was inconsistent. For instance, disorganized attachment classification was not often assessed. This is surprising, since these children are considered a population particularly at risk for psychopathology. Moreover, the fact that disorganized attachment is not always assessed means that these children are distributed among the other groups, which could lead to these incongruent results. To that effect, studies that rely on the AQS yield a global security score but do not permit classification scores or consideration of disorganization. Finally, as sleep is a developmental process, a longitudinal assessment of sleep patterns over a longer period could describe more accurately the establishment and consolidation of the sleep-wake cycle.

The aim of the present study was thus to provide a more comprehensive evaluation of sleep, including sleep duration and quality as a function of child attachment classification, at different stages of development, using multiple maternal report sleep measures.

Methods

Participants

One hundred and thirty-four mother–child dyads (71 girls, 63 boys) for whom both sleep and attachment data were available participated in the study. Subjects were part of a larger cohort, the Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) study. MAVAN is a longitudinal study designed to measure the effects of the environment on infant development. Mothers were recruited during pregnancy, between 13 and 20 weeks gestation, from obstetric clinics in Montreal, Québec (Canada). They were included if they were 18 years and older and fluent in English or French. Women with serious obstetric complications, chronic illness, congenital diseases or any other serious medical conditions were excluded. Babies with serious complications during delivery, serious medical conditions or born at $\leq$ 37 weeks gestation were excluded as well. All subjects signed a consent form approved by the ethics committee of the Douglas Mental Health University Institute (Montreal).

Measures and procedures

Sleep measures

Twenty-five questions pertaining to sleep were adapted from the Self-Administered Questionnaire for the Mother (Petit, Touchette, Paquet, & Montplaisir, 2002). At 6, 12, 24 and 36 months, mothers answered questions about the sleeping habits of their child during the previous weeks and the following questions were retained: (a) At what time do you put your child to bed for the night? (bedtime); (b) How much time does your child take to fall asleep at night? (sleep latency); (c) What is the total length of your child's sleep during the night? (nocturnal sleep duration); (d) During the night, how many consecutive hours does your child sleep without waking up? (longest period of uninterrupted sleep); (e) At what time does s/he wake up in the morning? (wake time); (f) Does your baby wake up at night to drink? If yes, how many times?; and (g) Does your baby wake up at night (for reasons other than to drink)? If yes, how many times? The two

last questions were combined to assess the number of signaled awakenings. Duration of time in bed was also calculated from bedtime and wake time.

Preschool Separation–Reunion Procedure (PSRP)

Attachment was measured at 36 months with the Preschool Separation–Reunion Procedure (PSRP). The PSRP is a modified and developmentally appropriate version of the Ainsworth Strange Situation used to measure attachment security in preschool-aged children (Cassidy & Marvin with the MacArthur Working Group on Attachment, 1992). Moss and collaborators provided strong support for the construct validity of attachment separation-reunion measures for the preschool period in demonstrating important associations with maternal psychosocial, child behavior problem and mother–child interactive measures (Moss, Bureau, et al., 2004).

The task consists of a baseline interaction, followed by two separation and reunion episodes. Each episode lasts five minutes. Following the lab-based assessment, attachment security categorization was based on video recording. Four categories were assessed: secure, ambivalent, avoidant and disorganized (see Moss, Bureau, et al., 2004 for further definitions). Trained observers coded the videotapes with strong agreement ($k = 0.83$).

Additional variables

Birth weight percentile, mother mood (as measured by the Center for Epidemiologic Studies Depression Scale [CES-D; Radloff, 1977]) at 36 months and socio-economic status (SES) were assessed. SES was based on the household income and mother's education. The low income cut off of Statistics Canada was used (after tax) and was adjusted for the number of persons in the family. SES was broken into three categories: high SES (high income and high mother education; $n = 91$); middle SES (low income and high mother education or high income and low mother education; $n = 21$); low SES (low income and low mother education; $n = 6$). Sixteen mothers refused to give information on their socio-economic status.

Statistical analyses

Statistical analyses were performed with *IBM SPSS Statistics20.* Differences in sleep variables between groups and over time were assessed with mixed models with one factor (attachment group) and one repeated measure (age). A p-value of < 0.05 was used to define statistical significance. The best fitting model was the autoregressive (1). Mixed models present several advantages for the analysis of repeated-measures data, in comparison to repeated-measures analysis of variance (ANOVAs) (Gueorguieva & Krystal, 2004). First, mixed models properly account for correlation between repeated measures on the same subject and present more flexibility to model time effects. In addition, this model, in contrast with ANOVAs, uses all available data even if there are missing data at some time points. In the present study, less than 10% of data was missing.

Pearson correlations were used to assess the association amongst demographic variables (birth weight percentile, gender, SES and maternal mood) and sleep measures to evaluate these variables as potential covariates. The threshold for significance was fixed conservatively at $p < 0.01$, considering the multiple comparisons.

Results

Descriptive analyses

Of the 134 children, 70 (52.2%) were securely attached, 9 (6.7%) were classified as insecure-avoidant, 23 (17.2%) were classified as insecure-ambivalent and 32 (23.9%) were disorganized. Disorganized attachment was the most common insecure subcategory of the sample. Considering the low percentage of avoidant children, they were excluded from further analyses. Results are presented for analyses comparing children with secure, ambivalent and disorganized attachment (Table 1). Attachment classification was not related to gender ($X_2 = 1.78$; $p = 0.43$).

The correlations between sleep measures are presented in Table 2. Not surprisingly, the majority of sleep measures were correlated with each other.

Sleep measures as a function of attachment and age

No interaction was found between age and group for nocturnal sleep time ($F_{6,\ 295} = 0.62$, $p = 0.71$). However, as expected, a main effect of age ($F_{3,295} = 12.8$, $p < 0.001$) and a main effect of group ($F_{2,128} = 3.20$, $p = 0.04$) were observed (Figure 1). Pairwise comparisons showed that across the different time points, children classified as disorganized slept about half an hour less than children classified as ambivalent ($p = 0.02$) and tended to have a shorter duration of sleep than children classified as secure (about 15 minutes; $p = 0.08$). No significant difference was observed between the secure and ambivalent group for nocturnal sleep time.

No statistically significant age by group interaction was found for number of awakenings ($F_{6,\ 290} = 1.92$, $p = 0.08$; Figure 2). Again, as expected, there were both an age ($F_{3,288} = 8.8$, $p < 0.001$) and group ($F_{2,128} = 3.15$, $p < 0.05$) effect. Regardless of the time point, disorganized children were reported to be more prone to signal their awakenings

Table 1. Attachment classification.

	Girls	Boys	Total
Secure	40	30	70
Ambivalent	11	12	23
Disorganized	14	18	32
Total	65	60	125

Table 2. Correlations between sleep measures.

	1	2	3	4	5	6	7
1. Nocturnal sleep duration	–	− .24**	.50**	− .52**	.38**	.77**	− .19**
2. Number of awakenings	–	–	− .72**	.24**	.04	− .16**	.08
3. Uninterrupted sleep	–	–	–	− .40**	.11*	.41**	− .10*
4. Bedtime	–	–	–	–	.30**	− .60**	.11*
5. Wake time	–	–	–	–	–	.59**	.05
6. Time in bed	–	–	–	–	–	–	− .06
7. Sleep latency	–	–	–	–	–	–	–

Note: *$p < .05$, two tailed; ** = $p < .01$, two-tailed.

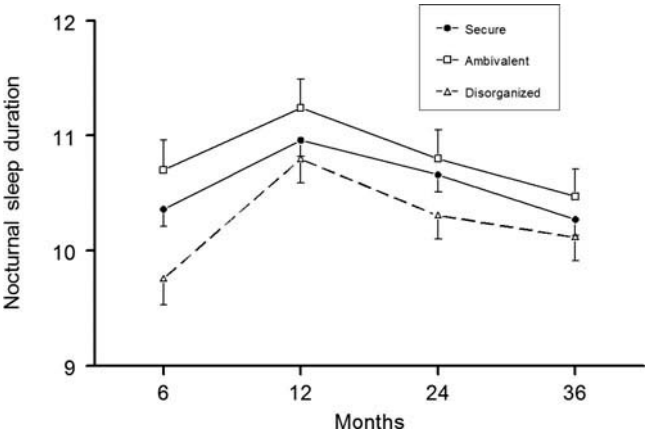

Figure 1. Nocturnal sleep duration as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

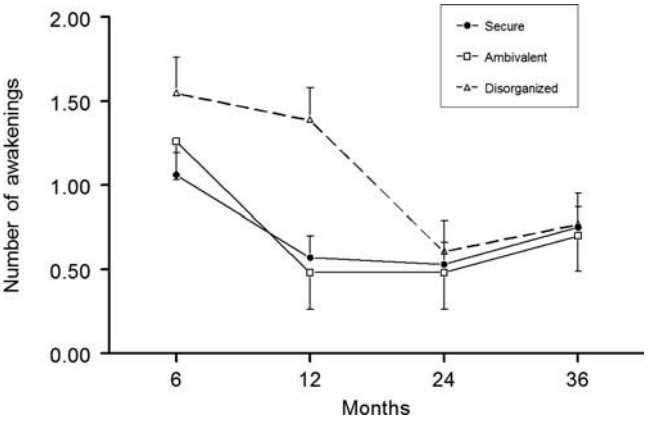

Figure 2. Number of awakenings as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

than secure children ($p = 0.02$) and showed a trend to signal more often than ambivalent children ($p = 0.06$). Again, no differences were observed between secure and ambivalent children for number of awakenings.

An age by group interaction was found for the longest period of uninterrupted sleep ($F_{6,306} = 2.5$, $p = 0.02$; Figure 3). Simple effects showed a significant group difference, but at 12 months of age only ($F_{2,382} = 10.9$, $p < 0.001$). Tukey post-hoc showed a substantial significant ($p < 0.05$) difference between children classified as disorganized and ambivalent (7.15h versus 10.40h), and between children with disorganized and secure attachment patterns (7.15h versus 9.39h) at 12 months of age. No significant difference was observed between secure and ambivalent groups for the longest period of uninterrupted sleep.

No age by group interaction was found for bedtime ($F_{6,\ 304} = 0.97$, $p = 0.44$). As anticipated, we observed an age ($F_{3,304} = 15.53$, $p < 0.001$) and a group ($F_{2,127} = 5.86$, $p = 0.004$) effect on time of bedtime (Figure 4). Regardless of the time point, children

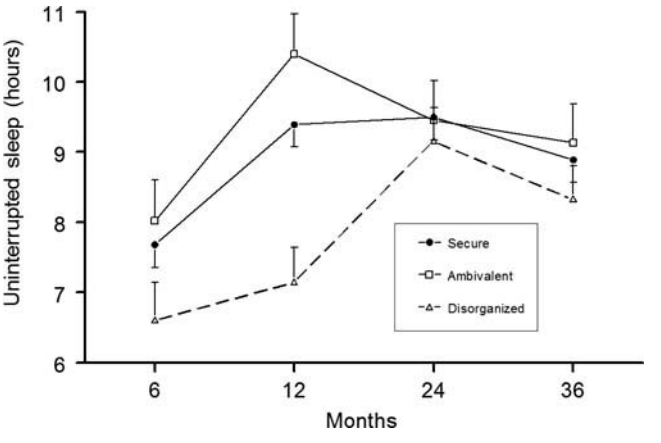

Figure 3. Longest period of uninterrupted sleep as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

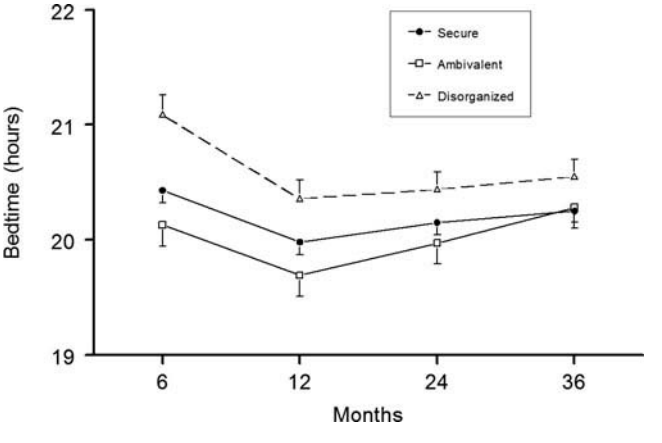

Figure 4. Bedtime as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

classified as disorganized went to bed about a half-hour later than children classified as secure ($p = 0.007$) and ambivalent ($p = 0.002$). No significant difference was observed between the secure and ambivalent group for time of bedtime.

No interaction was found between age and group for time of awakening ($F_{6, 312} = 0.86$, $p = 0.53$) (Figure 5). Nor were there age ($F_{3, 310} = 0.28$, $p = 0.84$) or group ($F_{2, 151} = 2.61$, $p = 0.08$) effects detected (Figure 5).

However, an age by group interaction was found for the duration of time in bed ($F_{6,299} = 2.21$, $p < 0.05$) (Figure 6). Simple effects showed a significant group difference, but at 6 months of age only ($F_{2,390} = 9.38$, $p < 0.001$). Tukey post-hoc showed that at 6 months of age, children with disorganized attachment patterns spent about 1 hour and 20 minutes less time in bed than children with ambivalent attachment patterns ($p < 0.05$). No significant differences were observed between the secure and ambivalent or disorganized group for the duration of time in bed.

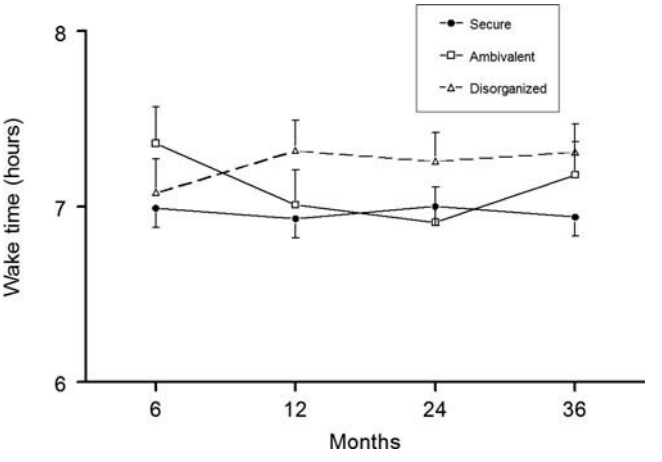

Figure 5. Wake time as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

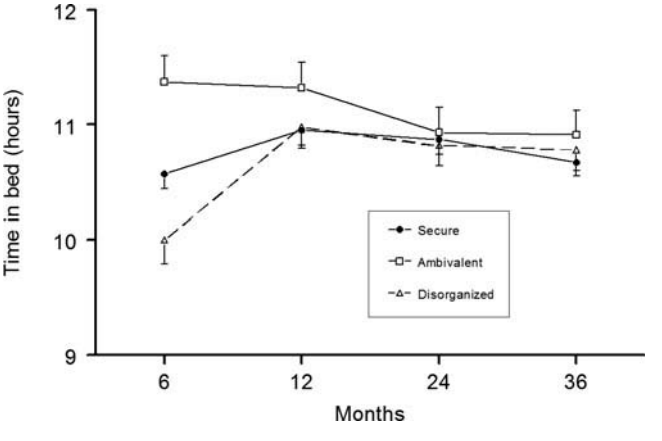

Figure 6. Period of time in bed as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

Finally, no interaction was found between age and group for sleep latency ($F_{6,\ 304} = 0.57$, $p = 0.76$) (Figure 7). An age effect ($F_{3,\ 303} = 12.99$, $p < 0.001$) was observed but no group effect ($F_{2,\ 150} = 0.42$, $p = 0.66$) was present for sleep latency.

No associations were found between birth weight percentile, gender, SES or maternal mood and sleep measures (all $p > 0.01$) (Table 3). If added as covariates, gender, birth weight percentile and maternal mood do not alter any finding. However, the interaction between attachment and awakenings becomes significant when SES is added as a covariate ($F_{6,246} = 2.31$, $p = 0.03$). Simple effects showed a significant group difference, at 12 months of age only ($F_{2,330} = 5.17$, $p < 0.01$). Sidak post-hoc showed that at 12 months, children classified as disorganized signaled more awakenings than children classified as secure or ambivalent ($p < 0.05$).

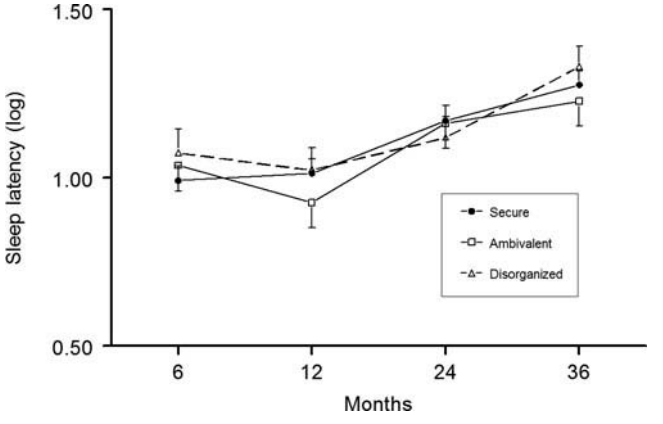

Figure 7. Sleep latency (log) as a function of attachment security between 6 and 36 months of age. Data are presented as mean ± SEM.

Table 3. Correlations between demographic variables and sleep measures.

	Nocturnal sleep duration	Number of awakenings	Uninterrupted sleep	Bedtime	Wake time	Time in bed	Sleep latency
Birth weight percentile	.02	.10*	− .07	− .05	− .05	.009	− .01
Gender	.02	− .07	.03	− .10*	− .10*	.001	− .02
SES	.06	− .11*	.05	− .03	− .03	.006	− .06
Maternal mood	− .01	.002	− .01	.06	− .10	.06	.002

Note: * $p < .05$ and $> .01$, two-tailed.
SES: Socio-economic status.

Discussion

This longitudinal study shows that attachment security is associated with the development of the sleep-wake cycle between 6 and 36 months. More specifically, children classified as disorganized appeared to show distinct sleep patterns, as reported by mothers. Children with disorganized attachment patterns showed a shorter duration of nocturnal sleep than secure and/or ambivalent children. They also had more fragmented sleep, as they were signaling more awakenings and had a shorter period of uninterrupted sleep.

Importantly, our results show that parents of children with disorganized attachment patterns also differ in their parental practices, since these children go to bed later and have a shorter period of time in bed. This implies that not only is their sleep marked with many awakenings, but in addition, their window of opportunity for sleeping is limited. In contrast, other sleep measures such as time of awakening in the morning or sleep latency at bedtime seems to be less sensitive to attachment disorganization.

Not surprisingly, an age effect was present for almost every sleep measure, as sleep patterns are evolving rapidly during the first years of life. For several of our sleep measures, the association with attachment was present regardless of the evaluated time point. However the effects were more striking in younger infants and tended to diminish

with age. No clear differences were observed between the sleep of ambivalent and secure children, which suggest a specific effect of disorganization.

To that effect, scoring of the disorganization was a vital aspect of this study design. This allowed us to establish that children with disorganized attachment show distinctive sleep patterns. Regarding night awakenings, our results are in contrast with previous studies (Beijers et al., 2011; Morrell & Steele, 2003). One possible explanation for this discrepancy is the possibility that children with disorganized attachment patterns use different strategies during night awakenings (Beijers et al., 2011). Therefore, some awakenings could be signaled while others are not, which could lead to inconsistent findings. Nevertheless, one strength of the present study was to measure many sleep variables instead of focusing only on awakenings. Therefore all the different variables reflect unique sleep dimensions and yield to a consistent picture of the association between disorganized attachment and sleep perturbations in infants at different stages of development.

Disorganized attachment, sleep and development

Several studies show that disorganized attachment is associated with the development of both externalizing symptoms (Brumariu & Kerns, 2010; Carlson, 1998; Fearon, Bakermans-Kranenburg, van IJzendoorn, Lapsley, & Roisman, 2010; Groh, Roisman, van IJzendoorn, Bakermans-Kranenburg, & Fearon, 2012; Moss et al., 2006; Moss, Rousseau, Parent, St-Laurent, & Saintonge, 1998; O'Connor, Bureau, McCartney, & Lyons-Ruth, 2011) and internalizing symptoms (Moss, Cyr, & Dubois-Comtois, 2004; O'Connor et al., 2011). More specifically, at 36 months of age, mothers and teachers of children with disorganized attachment patterns report higher levels of externalizing problems compared to secure or insecure children (Moss, Bureau, et al., 2004). These problems persist to school-age (Moss et al., 2006). At 5 years old, 71% of children showing hostile or aggressive behaviors, as rated by their teacher, were classified as having a disorganized attachment (Lyons-Ruth, Alpern, & Repacholi, 1993). Moreover, disorganized attachment is also associated with subsequent psychopathology (Zeanah, Keyes, & Settles, 2003). Thus, in a prospective longitudinal study, disorganized attachment was associated with behavioral problems at preschool, elementary school and high school as well as a higher level of psychopathology at 17 years old (Carlson, 1998).

The sleep literature shows that reduced sleep duration in children is associated with daytime behavioral problems (Dahl, 1996; Touchette et al., 2007) and internalizing problems (Paavonen, Porkka-Heiskanen, & Lahikainen, 2009). An association was observed between less sleep at night and the presence of a psychiatric disorder (Lavigne et al., 1999). Fragmented sleep has also been associated with lower performance on neurobehavioral functioning and higher rates of behavioral problems in school-age children (Sadeh, Gruber, & Raviv, 2002). In addition, delayed bedtime has been associated with depression in children (Lin, Tung, Hsieh, & Lin, 2011).

The present results suggest that poor quality of sleep and sleep fragmentation could act as partial mediators in the relationship between disorganized attachment and these behavioral and affective outcomes, at least in some children. However, the nature of the association between attachment and sleep problems, if it can be shown to be reliable, may be complex and may involve a number of factors also known to be implicated in the connection between childhood psychopathology and sleep. For instance, Teti and Crosby tested a model in which maternal presence during the night (defined as the presence of the mother in the same room or close physical contact) acted as a mediator between maternal

depression and child awakenings (Teti & Crosby, 2012). In that study, the association between maternal depressive symptoms and child awakenings was no longer statistically significant after controlling for maternal presence with the infant during the night. Thus, it cannot be excluded that parenting behaviors during the night could also contribute to the link between attachment and quality of sleep in our own study.

Attachment and sleep disturbances

Sleep data in the present study are reported by mothers. It is therefore important to consider potential influences on this measure. First, signaled awakenings are those that alert the mother. This measure does not record awakenings not signaled to the mother. Non-signaled awakenings might reflect instances where the child is able to self-soothe and go back to sleep. However, it is also possible that the child has learned that signals of awakening yield no response. It has already been proposed that avoidant children, in particular, signal fewer awakenings, even if they wake as often as other children (Beijers et al., 2011; McNamara et al., 2003). Unfortunately, we did not have enough avoidant children to include these children in our analysis and test this hypothesis. Nevertheless, it is possible that children classified as disorganized are not waking up more often, but are more prone to signal their awakenings than secure or ambivalent children. This issue is currently under investigation.

Another variable associated with child's awakening is maternal behavior. In a study evaluating nighttime maternal responsiveness and attachment at one year old, children with a secure attachment tended to signal more often their awakenings then insecure children (although this difference failed to reach statistical significance), suggesting that secure children expect a maternal response (Higley & Dozier, 2009). Moreover, using video recording of nighttime interaction, the same study showed that mothers of securely attached children were more prone to soothe their children when they were crying during the night than mothers of insecure children. Authors of this study concluded that consistent and sensitive responses to infant signals of distress are associated with attachment security, even during the night. As sleep and attachment are evolving gradually during the first years of life, it is possible that securely attached infants are signaling their awakenings when they are younger, but eventually learn to self-soothe following consistent and sensitive responses of their mother. In contrast, children with disorganized attachment who do not necessarily learn that their mother is available to comfort them would still have sleep perturbations later on, which could explain results of the present study.

The parent's history of attachment could also interact with results of the present study and the perceptions of the mother. It has been proposed that parents' attachment's style could influence the interaction between mother and child and influence the sleep of the child and/or attachment style (Moore, 1989). Children of insecurely attached mothers, assessed by the Adult Attachment Interview, had more sleep disorders than children of securely attached mothers (Benoit, Zeanah, Boucher, & Minde, 1992). In fact, 100% of mothers of children with sleep disorders were classified as insecure, in comparison with 57% of mothers of children without sleep disorders. However, a more recent study did not replicate these findings, showing no association between adult attachment and self-soothing in their infants (Burnham, Goodlin-Jones, Gaylor, & Anders, 2002). This issue thus remains to be clarified. Awakenings reported by the mothers may also be a reflection of the mother's vigilance.

In the present study, mothers of children classified as disorganized also reported a later bedtime than mothers of secure or ambivalent children. It is not clear whether parents

simply choose this schedule or if this is the result of persistent bedtime difficulties with their child. Parents may delay the moment of putting their child to bed to avoid family conflicts with children that protest. However, time of awakening was not different amongst the three groups. Since bedtime was delayed but not time of awakening, mothers of infants with disorganized attachment patterns reported that their children spent less time in bed at 6 months of age. This finding suggests that infants who would later be classified disorganized not only show more sleep disturbances, but also do not have the opportunity to sleep as long as the others, which could lead to lower duration of nocturnal sleep, as observed in the present study.

Treatment of sleep disturbances

Sleep disturbances have been linked to a wide range of family conditions that are, in turn, related to the behavioral, emotional and physical health of the child (Dahl & El-Sheikh, 2007). At the same time, difficulties related to mother–child relationships and family climate have been described in families of children classified as disorganized (Carlson, 1998; Moss, Cyr, & Dubois-Comtois, 2004). Sleep disturbances are thus likely to exacerbate problems in already vulnerable families.

Parent–child interactions at bedtime and during the night have been associated with the establishment of a sleep-wake cycle (Sadeh et al., 2010). In fact, minimal interaction has been associated with more consolidated sleep, whereas more interaction is associated with sleep disturbances (Adair, Bauchner, Philipp, Levenson, & Zuckerman, 1991; Sadeh, Mindell, Luedtke, & Wiegand, 2009). The actual tendency is then to target behavioral techniques at bedtime and during the night to decrease gradually the interaction with their child (Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006). However, some authors have proposed that it could be appropriate to reconsider these strategies, at least in some populations (Blunden, Thompson, & Dawson, 2011). Indeed, the present study suggests that, in some mother–child dyads, more profound difficulties can be present. It could be important to work on the quality of relationship between mother and child, instead of just focusing on nighttime behavior. We thus wonder if it is indeed beneficial to teach these parents to delay their responses and involvement toward their child during the night.

In their study, Morrell and Steele obtained different results, showing that ambivalent attachment was associated with sleep problems (Morrell & Steele, 2003). However, they also suggest that using behavioral techniques are likely to maintain both sleep and attachment difficulties. Taken together, these studies show that sleeping problems are sometimes associated with relational issues and that the whole family dynamic should be evaluated instead of focusing on behavioral techniques during the night. For instance, attachment-based intervention which identifies the parent–child dysfunctional pattern more specifically and builds on reinforcing parental competence in interactive situations (Moss, Dubois-Comtois, et al., 2011) might be beneficial.

In the present study, the proportion of disorganized attachment was 23.9%. Considering that, in a sample of 2104 low-risk children in North America, the prevalence of disorganized attachment was 15% and up to 48% in high risk populations, it becomes crucial to evaluate the family functioning and not just sleep time (van IJzendoorn et al., 1999). Since disorganized attachment is often associated with maltreatment, parental insensitivity or parental unresolved loss or trauma (Moss, Bureau, St-Laurent, & Tarabulsy, 2011; van IJzendoorn, 1995; van IJzendoorn et al., 1999), some families might be limited in their ability to consistently follow instructions regarding nighttime

behaviors. This is an important issue that remains to be clearly resolved (Blunden et al., 2011; O'Connor, 2011; Sadeh, Mindell, & Owens, 2011).

It is possible that parental behaviors influence infants' sleep. However, children with sleep disturbances may present greater demand for parental intervention. The results of a study suggest that parental behaviors, such as being present at sleep onset or giving food or drink after awakenings, develop in reaction to prior sleep problems (Simard, Nielsen, Tremblay, Boivin, & Montplaisir, 2008). Thus, empirical evidence suggests bi-directional effects (Sadeh & Anders, 1993, Sadeh et al., 2010; Tikotzky & Sadeh, 2009).

Strengths and limitations

Our study does not directly examine causal relations. Since some differences in sleep measures are more apparent in our sample at 6 and 12 months of age and attachment is measured only at 36 months, it is possible that prior sleep problems contributed to the differences in attachment style considering that a lack of sleep could impact on different developmental outcomes. The stability of attachment across ages is still debated; however results of a meta-analysis including diverse samples of children aged between 12 and 72 months of age indicated that attachment is generally stable across the infancy and preschool period (van IJzendoorn et al., 1999).

Sleep-wake regulation in infants is complex and other variables not measured in the current study could influence the sleep quality of children. For example, temperament, co-sleeping or breastfeeding have been associated with sleep and sleep practices. However, in the present sample, gender, socio-economic status, birth weight and mother's depression were not highly nor consistently correlated with sleep measures.

In addition, this study relied on maternal reports of infant sleep. It may be that different results would be obtained with objective measures of sleep at home, such as actigraphy. To that effect, a recent study of Simard et al. showed longer sleep duration when estimated by mothers in comparison with actigraphy and a reduced discrepancy between objective and subjective measures in children with more ambivalent attachment behavior (Simard et al., 2013). Nevertheless, subjective reports present the advantage of reflecting what is perceived by the mother in natural setting. In addition, it is worth mentioning that we did not see any relation between the measure of maternal mood and that of reported sleep quality in the present study.

Despite these limitations the study has several strengths. This is the first study evaluating sleep as a function of attachment style, with multiple time points ranging from 6 months to 36 months. This longitudinal assessment permitted analyses over time for most sleep measures. Considering that children were evaluated until 36 months, which is older than the majority of previous studies, the present study not only addresses the establishment of sleep-wake cycle, but also describes sleep consolidation.

Moreover, contrary to other studies linking sleep and attachment, the present study also shows consistency between different sleep measures, which reflects the robustness of the results. Finally, the coding of disorganization in the present sample allowed for the possibility of showing that these children clearly showed a distinct pattern, in comparison with secure or organized-insecure (in this case ambivalent) children. This effect would have been lost if disorganized attachment was not assessed. In addition, attachment was assessed with laboratory observations, as opposed to other measurements of attachment.

Conclusion

In conclusion, this study showed that children with disorganized attachment patterns had a shorter duration of nocturnal sleep, were going to bed later, were signaling more awakenings, had a shorter period of uninterrupted sleep and had a shorter period of time in bed than secure and/or ambivalent children, as assessed by their mothers, between 6 and 36 months of age. Other studies are needed to verify if this pattern is still present in older children classified as disorganized. Finally, long-term follow up of these children would permit analyses of sleep disturbances in relation to internalizing and externalizing problems in the future, which would permit verification of the hypothesis that sleep perturbations act as a mediator in the association between disorganized attachment and psychopathology or behavioral difficulties.

Acknowledgements

The authors thank Jean Paquet for helping with statistical analysis and are grateful to the MAVAN research team: Jim Kennedy, Robert Levitan, Steve Matthews, John Lydon, Marla Sokolowski and Meir Steiner. This portion of the MAVAN study is funded by grants from the Canadian Institutes of Health Research to Michael J. Meaney. The authors gratefully acknowledge additional support from the Norlien Foundation (Calgary, Canada), the WOCO Foundation (London, Canada) and the Faculty of Medicine of McGill University. Marie-Hélène Pennestri was supported by a post-doctoral fellowship from the Canadian Institutes of Health Research.

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