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# Developmental trajectories of infant nighttime awakenings are associated with infant-mother and infant-father attachment security

Annemieke M. Witte [a,*], Marleen H.M. de Moor [a], Ohad Szepsenwol [b], Marinus H. van IJzendoorn [c], Marian J. Bakermans-Kranenburg [a,d], Dana Shai [e]

[a] Clinical Child & Family Studies, Faculty of Behavioral and Movement Sciences, Vrije Universiteit, Amsterdam, the Netherlands
[b] Department of Education, The Max Stern Yezreel Valley College, Israel
[c] Department of Psychology, Education, and Child Studies, Erasmus University Rotterdam, Rotterdam, the Netherlands
[d] Leiden Institute for Brain and Cognition, Leiden University Medical Center, Leiden, the Netherlands
[e] SEED Center, School of Behavior Sciences, Academic College Tel Aviv-Yaffo, Israel

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ABSTRACT

This longitudinal study examined developmental trajectories of infant sleep problems from 3 to 24 months old and investigated associations with infant-parent attachment security and dependency. In a sample of 107 Israeli families, number and duration of infant nighttime awakenings were measured at 3, 6, 9, and 24 months old, using mothers' and fathers' reports on the Brief Infant Sleep Questionnaire (BISQ). Infant–parent attachment security and infant-parent dependency was assessed at 24 months old, using the observer Attachment Q-Sort procedure (AQS) with both parents. Latent growth curve models showed a non-linear decline in number and duration of infant nighttime awakenings over time. A higher number and longer duration of infant nighttime awakenings at 3 months were associated with higher infant-father attachment security at 24 months. In contrast, longer infant nighttime awakenings at 3 months were predictive of lower infant-mother attachment security at 24 months. A steeper decrease in duration of infant nighttime awakenings was associated with higher infant-father attachment security and lower infant-mother attachment security. As a potential mechanism, paternal involvement in nighttime caregiving was explored in relation to infant-father attachment security. Results of our post-hoc analyses revealed no significant associations between paternal involvement in nighttime caregiving and infant-father attachment security. Our results highlight the need to examine potential mechanisms explaining the divergent associations of infant sleep problems with infant-mother and infant-father attachment security in future research.

## 1. Introduction

In the first few months of life, infant sleep involves multiple sleep-wake cycles during day and nighttime as circadian sleep-wake cycles have not yet been established (Davis, Parker, & Montgomery, 2004). At three months of age, infants begin to develop a circadian rhythm, marked by an increase in nighttime and a decrease in daytime sleep (Rivkees, 2003). At six months of age, most infants have

* Corresponding author.
*E-mail address:* a.m.witte@vu.nl (A.M. Witte).

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developed nocturnal sleep (Weinraub et al., 2012), which means that infants have one continuous period of uninterrupted sleep at night, also described as "sleeping through the night" (Henderson, France, Owens, & Blampied, 2010). Infants do not actually sleep the entire night; they develop self-regulated sleep which is defined as the ability to fall back asleep without needing parental support (Henderson et al., 2010). There is substantial individual variability in the development of self-regulated sleep. "Infant sleep problems" comprises various definitions, but has often been described in terms of difficulties falling asleep, nighttime awakenings, and a short duration of uninterrupted sleep, and are present in approximately 20–30 % of all infants and toddlers (Henderson et al., 2010; Martin, Hiscock, Hardy, Davey, & Wake, 2007; Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006). Sleep problems have been associated with a range of negative child and parental outcomes, including behavioral problems in children (see Field, 2017 for a review), and poor general health and depressive symptoms in parents (Hiscock & Wake, 2001; Martin et al., 2007).

Nighttime sleep typically involves a situation in which infants are alone in a dark room while having no interactive contact with a caregiver, which can be highly stressful for the infant (Higley & Dozier, 2009; Sadeh, Tikotzky, & Scher, 2010; Scher, 2001). Hence, infants may activate attachment behaviors (e.g., crying, protesting against separation) to seek proximity to an attachment figure (Higley & Dozier, 2009; Sadeh et al., 2010; Scher, 2001). Several studies have examined associations between infant sleep problems and attachment security, but results have been inconsistent (Bilgin & Wolke, 2019; McNamara, Belsky, & Fearon, 2003; Morrell & Steele, 2003; Scher, 2001; Scher & Asher, 2004; Simard, Chevalier, & Bedard, 2017; Weinraub et al., 2012).

Furthermore, empirical evidence suggests that the infant's level of dependency is related to lower sleep quality (Bélanger, Bernier, Simard, Bordeleau, & Carrier, 2015; Scher & Ascher, 2004). Whereas infant-parent attachment security is considered a relational feature, dependency is considered a temperamental feature. Behavioral genetic models indicate that individual differences in infant-parent attachment security can be largely explained by environmental factors, while a predominantly genetic origin has been found for the infant's dependency level (Bakermans-Kranenburg, Van IJzendoorn, Bokhorst, & Schuengel, 2004; Roisman & Fraley, 2008). This finding is in line with studies documenting the heritability of temperamental traits (Planalp & Goldsmith, 2020; Zwir et al., 2020). Moreover, research has shown that infant-parent attachment security and dependency are unrelated (Bakermans-Kranenburg et al., 2004; Scher & Asher, 2004; Waters & Deane, 1985). Activation of the attachment system and signs of dependency can be reflected in similar behaviors (e.g., resisting separation at bedtime, proximity seeking during the night), and distinguishing between infant-parent attachment security and infant-parent dependency is therefore necessary. The aim of the present longitudinal study is to examine developmental trajectories sleep problems in infants from 3 to 24 months old and to investigate associations with infant-mother and infant-father attachment security and infant dependency.

### 1.1. Infant sleep trajectories

During the first years of life, most infants show a decrease in the number of nighttime awakenings and time spent in wakefulness at night, although not all infants follow similar developmental patterns (Goodlin-Jones, Burnham, Gaylor, & Anders, 2001; Hysing et al., 2014; Jenni, Borbély, & Achermann, 2004; Tikotzky & Sadeh, 2009; Weinraub et al., 2012). For example, a longitudinal study including more than 1200 infants used quadratic growth models and identified two distinct developmental courses of infant nighttime awakenings from 6 to 36 months old (Weinraub et al., 2012). The first group showed flat developmental courses from 6 to 36 months old (mothers reported approximately 1 infant nighttime awakening per week). The second group showed a non-linear decrease from 6 to 36 months old, with mothers reporting 6–7 infant nighttime awakenings per week at 6 months, which declined to 2 reported infant nighttime awakenings per week at 15 months old, and decreased to approximately 1 reported infant nighttime awakening per week from 24 months to 36 months, thereby reaching the same number of infant nighttime awakenings as the first group. In another study, including a sample of 151 infants, parental reports also indicated a non-linear decrease in the duration of infant nighttime awakenings over time (Mäkelä et al., 2018). Results showed that the duration of infant nighttime awakenings was approximately 24 min at 8 months old, which decreased to approximately 9 min at 18 months old. No change in the duration of infant nighttime awakenings were found between 18 and 24 months old (Mäkelä et al., 2018).

### 1.2. Infant sleep, attachment security and infant dependency

Empirical evidence for associations between infant sleep problems and attachment security has been limited and inconsistent (Bilgin & Wolke, 2019; McNamara et al., 2003; Morrell & Steele, 2003; Scher, 2001; Scher & Asher, 2004; Simard et al., 2017). For example, research showed that 12-month-old infants with a secure versus insecure infant-mother attachment relationship did not differ in video recorded number of nighttime awakenings or in signaling their awakening to their parents (Higley & Dozier, 2009). A meta-analysis including 16 studies (2783 children between the age of 6 and 38 months) showed only small to moderate associations between sleeping behaviors and infant-mother attachment security. Effect sizes were dependent on type of attachment classification (e.g., security vs. resistance), sleep outcomes (i.e. sleep problems, nighttime awakenings, sleep duration), sleep measurements (questionnaires vs. others), and age of the child (Simard et al., 2017). Results of this meta-analysis showed a positive association between sleep efficiency (i.e., proportion of time the child is asleep) and infant-mother attachment security ($k = 4$, $r = .18$, 95 % CI [.001, .35]), and a positive association between sleep problems and infant-mother attachment security ($k = 5$, $r = .09$, 95 % CI [.04, .15]). Note that due to the recoding of variables, the positive correlation coefficient between sleep problems and infant-mother attachment security refers to a negative relationship between these variables (i.e., more sleep problems being associated with less infant-mother attachment security) (Simard et al., 2017). A more recent study, not included in Simard and colleagues' (2017) meta-analysis, found no associations between mother-reported infant cry and sleep problems at 3 and 18 months old and a secure or insecure attachment (avoidant versus resistant) with the mother at 18 months old (Bilgin & Wolke, 2019). However, results did show that mother-reported

infant cry and sleep problems were related to a disorganized attachment classification (Bilgin & Wolke, 2019). The authors provided two possible explanations for these findings. First, mothers of infants with a disorganized attachment classification may display more anxious and frightening responses to their infants' cry behavior and sleeping problems, resulting in the development of a disorganized infant-mother attachment relationship. Second, early cry and sleep problems may be an indicator of early infant regulatory problems, which may increase the risk for the development of a disorganized infant-mother attachment relationship (Bilgin & Wolke, 2019). Research examining the relation between infant sleep problems and the quality of the infant-father attachment relationship has been scarce. This is surprising as fathers play a significant role in children's well-being and functioning (Bakermans-Kranenburg, Lotz, Alyousefi-van Dijk, & Van IJzendoorn, 2019; Cabrera, Volling, & Barr, 2018). Moreover, infants develop attachment relationships with both mothers and fathers (Ainsworth, 1967; Bowlby, 1969). Additionally, socio-cultural and economic advances have led to significant transformations in modern and Western family life (Abraham & Feldman, 2018). The expected norm that fathers work full-time is changing as an increasing minority of fathers works part-time (Bünning & Pollmann-Schult, 2016). Research has further shown that fathers have increased their involvement in child rearing and caregiving practices over the past several decades (Bakermans-Kranenburg et al., 2019; Lamb, 2000; O'Brien, Brandth, & Kvande, 2007). Therefore, the present study focuses on mothers as well as fathers in order to gain more insight into how infant sleep problems are related to attachment security with both parents.

An initial study found no relation between the reported number of infant nighttime awakenings at 7, 12, and 14 months old and the quality of the infant-father attachment relationship (secure versus disorganized) at 14 months old (Zentall, Braungart-Rieker, Ekas, & Lickenbrock, 2012). The number of infant nighttime awakenings among infants with an insecure versus secure infant-father attachment relationship was not investigated as the number of infants with an insecure infant-father attachment relationship was too small to be included in the analysis (Zentall et al., 2012). To our knowledge, no other studies have examined infant sleep problems in relation to infant-father attachment security.

Yet, findings have indicated that fathers do provide nighttime caregiving to infants (Ball, Hooker, & Kelly, 1999; Goodlin-Jones et al., 2001; Tikotzky, Sadeh, & Glickman-Gavrieli, 2011). Importantly, paternal involvement in infant caregiving tasks can buffer against some of the negative effects of infant sleep problems (Millikovsky-Ayalon, Atzaba-Poria, & Meiri, 2015; Tikotzky et al., 2015). Furthermore, 18-month-old children exhibited more mature sleeping patterns earlier in development when their fathers showed more mind-mindedness (the tendency to see children as individuals with a mind of their own) (Tétreault, Bernier, & Matte-Gagné, 2021). Taken together, these findings suggest that fathers play an important role in their infants' sleeping behaviors. When examining relations between infant sleep problems and infant-parent attachment security, it is important to also incorporate the construct of infant dependency, as infants who show more sleep problems at night may be more irritable or dependent on their parents for nighttime reassurance, assistance, and support (Bélanger et al., 2015). Infant-parent attachment security can be differentiated from infant-parent dependency with use of the Attachment Q-sort procedure (AQS; Waters & Deane, 1985). The AQS has been developed as a naturalistic alternative for the Strange Situation Procedure (SSP; Ainsworth, Blehar, & Waters, 1978). In contrast to the SSP, the AQS does not require stressful separations in a lab setting and is usually administered in the child's home (Vaughn, Waters, & Teti, 2021). Furthermore, the AQS can be repeatedly used over a wide age range (12–48 months). The AQS compares behaviors of a particular infant with the behavioral profile of a prototypical secure and a prototypical dependent child. Accordingly, an infant-parent attachment security score and an infant-parent dependency score can be calculated by correlating the AQS as sorted by the observer with the prototypical AQS as sorted by a set of experts (Vaughn & Waters, 1990).

Currently, few studies have examined relations between infant sleep problems and infant-mother dependency. One study found that infant-mother dependency measured at 15 months old was related to fewer actigraphy-measured nighttime sleep minutes at 24 months old (Bélanger et al., 2015). Another study, which included 12-month-old infants, showed that parental reported infant sleep problems were related to infant-mother dependency but not to a night waking index, which comprised the number of interrupted nights, the number of awakenings per night, and the average time spent awake (Scher & Asher, 2004). These findings suggest that some aspects of infant sleep problems may be explained by the infant's greater dependency on the mother. To our knowledge, this is the first study examining the association between infant sleep problems and infant-father dependency. Given the predominantly genetic origin for the dependency profile of the infant (Bakermans-Kranenburg et al., 2004; Roisman & Fraley, 2008), it is plausible to suggest that associations between infant sleep problems and the infant's dependency level towards the mother and father would be similar, although this suggestion warrants further investigation.

### *1.3. The current study*

The first aim of the present study is to examine developmental trajectories of infant sleep problems as indexed by parental reports of number and duration of infant nighttime awakenings from 3 to 24 months old. In line with previous research (Mäkelä et al., 2018; Weinraub et al., 2012), we expect a non-linear decrease in infant sleep problems over time and individual differences in the developmental trajectories of infant sleep problems over time. The second aim of the present study is to examine whether developmental trajectories of infant sleep problems are associated with infant-parent attachment security and infant-parent dependency at 24 months. Based on meta-analytic evidence (Simard et al., 2017), we hypothesized that more infant sleep problems from 3 to 24 months are associated with lower attachment security with both mothers and fathers. Finally, based on the existing literature (Bélanger et al., 2015; Scher & Ascher, 2004), we expect that more infant sleep problems from 3 to 24 months are associated with higher dependency scores with both mothers and fathers.

## 2. Method

### 2.1. Participants

The present study included 107 co-living heterosexual couples expecting their first child (51.6 % male) at the time of inclusion. Participants were enrolled in the RIPPLE study, a longitudinal study examining parenting and early socio-emotional development. Couples were recruited using internet advertisements, flyers, and medical centers. Fathers mean age was 32.41 ($SD = 4.01$, range = 23–42). Mothers mean age was 30.82 years old ($SD = 3.63$, range = 23–42). All parents were fluent in writing and speaking Hebrew and living in central Israel. Fathers' mean years of education was 15.36 years ($SD = 2.41$), mothers' mean years of education was 16.3 years ($SD = 2.1$). All participants could be classified as Caucasian/Jewish, with varying levels of religiosity: 71.7 % secular, 16.2 % observant, and 12.1 % Orthodox Jewish. Approximately half of the sample (45.5 %) reported a salary being below the national mean income level, 12.7 % reported being at mean level, and 31.8 % reported being above the national mean income level. Parents were in good health without any neurological or psychological disorders and reported no substantial medication use or substance abuse. Parents did not report any significant pregnancy complications. All infants were single-born and in good health. At 3 months old, practice of feeding was: 49 % breast and bottle-feeding, 22.4 % breastfeeding, and 28.6 % bottle-feeding. Parental written informed consent was obtained at the start of the study. The study was approved by the institutional review board of the Interdisciplinary Center Herzliya. The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Families received a financial reimbursement and a token of appreciation for their participation in each study phase.

### 2.2. Procedure

For the current study, we used data from four measurement points: 3 months postpartum (T1), 6 months postpartum (T2), 9 months postpartum (T3), and 24 months postpartum (T4). At T1, T2, T3 and T4, both parents reported separately on the sleep problems of their infant. At T4, home visits were conducted to assess infant-parent attachment security and infant-parent dependency, using the Attachment Q-sort procedure (AQS; Vaughn & Waters, 1990). A total of two home visits were conducted, one to assess infant-mother attachment security and dependency and one to assess infant-father attachment security and dependency, using a random order of assessment. Each visit lasted approximately 90 min. Infant-mother and infant-father attachment security and dependency were assessed separately by independent observers.

### 2.3. Measures

#### 2.3.1. Infant sleep problems

Sleep problems were measured using the Brief Sleep Questionnaire (BISQ; Sadeh, 2004). Both parents were instructed to report on their infants' sleep problems during the past week. The BISQ has demonstrated adequate validity and reliability, including test-retest reliability, and has been validated with actigraphy measures of sleep and sleep diaries (Sadeh, 2004). The BISQ includes 14 items; 4 items assessing demographic characteristics of the infant and 10 items assessing infant sleep behavior. For this study, we included used parental reports on two items that have been previously used as indicators of infant sleep problems (Simard et al., 2017): (1) average number of nighttime awakenings per night, and (2) duration of infant nighttime awakenings (from 10 PM to 6 AM) reported in hours. For validation purposes only, we examined associations between parental reports and actigraph sleep measures at T3, when infants were 9 months old. Actigraph measures were not collected at T1, T2 and T4. Parents were asked to attach the micro-mini actigraph (AMI, Ardsley, NY) to the infant's ankle for 7 consecutive nights. The data was scored in the Actigraphic Sleep Analysis (ASA) program, using a validated sleep–wake scoring algorithm for infants (Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995). Actigraph measures included: (1) number of awakenings longer than 5 min, and (2) duration of awakenings. Actigraph measures were averaged across the assessment period. For fathers, significant correlations were found between paternal reported and actigraph measured number of awakenings ($r = .33$, $p = .011$), and for paternal reported and actigraph measured duration of awakenings ($r = .33$, $p = .010$). No significant correlations were found between number of awakenings reported by the mother and registered by the actigraph ($r = .11$, $p = .41$), and the same was true for duration of awakenings ($r = .01$, $p = .93$).

#### 2.3.2. Attachment security and dependency

Infant-mother and infant-father attachment security and dependency were measured in counterbalanced order by independent observers based on a 90-minute home observation within a two-week period using the Attachment Q-Sort (AQS; Vaughn & Waters, 1990). The AQS measures infant-parent attachment security and dependency through naturalistic observations, lasting 90 min. The AQS includes 90 items with specific descriptions of infant behavior. Parents were instructed to behave as they usually would, and observers initiated some specific situations to prompt attachment behaviors. Examples include introducing a new and unfamiliar toy to the child and eliciting a surprising sound. An observer rated the typical attachment and dependency behaviors of the infant by sorting 90 cards into nine piles, each containing 10 items. The cards were sorted from "most descriptive of the child" to "least descriptive of the child". The attachment score was calculated by correlating the observers' Q-description with the criterion sort of the prototypical secure child (Waters & Deane, 1985). The dependency score was calculated by correlating the observers' Q-description with the criterion sort of the prototypical dependently behaving child. AQS items descriptive of secure attachment behavior are: '*Child keeps track of mother/father when playing around the house'* and '*If held in parent's arms, child stops crying and quickly recovers after being*

*frightened or upset'*. Examples of AQS items which describe dependent behavior are: '*Child wants to be the center of parent's attention. If parent is busy or talking to someone, child interrupts'* and '*At home, child gets upset or cries when parent walks out of the room'*. Scores range from -1.0 (highly insecure or highly independent) to 1 (highly secure or highly dependent). Meta-analytic evidence showed that the observer AQS is a valid measure of attachment, with satisfactory convergent, discriminant and predictive validity (Cadman, Diamond, & Fearon, 2018; Van IJzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004). The observer AQS has stronger predictive and discriminant validity as compared to the self-reported version of the AQS (Cadman et al., 2018). Observers were trained by experts for the assessment of infant-parent attachment and dependency using the AQS. In the current study, the Intraclass Correlation Coefficient (ICC) Interrater Reliability (IRR) using 20 % of the sample was .71 (see also Witte, Bakermans-Kranenburg, van IJzendoorn, Szepsenwol, & Shai, 2019).

### 2.4. Data analytic strategy

We estimated latent growth curve models and factor models in Mplus, using Full Information Maximum Likelihood (FIML) as the estimator (Muthén & Muthén, 2017). We fitted a 1-factor model with four indicators (maternal and paternal reports of number and duration of infant nighttime awakenings) for each time point. The fit indices of the 1-factor model were used to decide whether number and duration of infant nighttime awakenings could be included as indicators of a single latent variable of infant sleep problems or whether number and duration of infant nighttime awakening may reflect different aspects of infant sleep problems and should therefore be analyzed separately in the latent growth curve models. Next, latent growth curve models were fitted. Latent growth curve models allow for estimation of developmental trajectories of growth over time. Developmental trajectories of growth are represented by the intercept and the slope. In the present study, the intercept described the initial level of infant sleep problems (number and duration of infant nighttime awakenings) at T1 (3 months old), while the slope describes the rate of change in infant sleep problems from T1 (3 months old) to T4 (24 months old). For both the intercept and slope, the mean and variance are estimated, with the mean representing average initial and change levels, respectively, and the variance reflecting individual differences in these parameters.

To examine developmental trajectories of infant sleep problems over time, we chose a statistical model that could capture different patterns of growth. In the present study, both number and duration of infant nighttime awakenings suggested non-linear patterns of growth (see Figs. 1 and 2). We therefore fitted latent growth curve models with estimated time scores, in which the pattern of growth is not pre-specified but is allowed to be estimated by the data (McArdle, 2009; Muthén & Muthén, 2017). Moreover, the latent growth curve model with estimated time scores fitted the data better as compared with other growth curve models (e.g., quadratic growth curve model and piecewise growth curve model). The latent growth curve model with estimated time scores is a less restrictive type of model than the linear latent growth curve model, because it does not assume linear growth. For model identification, the latent growth curve model with estimated time scores was specified as follows: the slope factor loading of T1 was fixed to 0 and the slope factor loading of T4 was fixed to 21, representing the time between T1 (3 months) and T4 (24 months). The slope factor loadings of T2 and T3 were freely estimated, allowing non-linear growth between T1 and T4. The intercept was identified by restricting all factor loadings to 1. After good model fit was established, the four infant-parent attachment and dependency variables were added as outcome variables to the growth model for infant sleep problems, to examine whether initial levels and developmental trajectories of infant sleep problems were predictive of infant-mother attachment security, infant-father attachment security, dependency towards the mother, and dependency towards the father. We provide the unstandardized estimates of all models. The effect sizes of the association between infant sleep problems and attachment security and dependency varies between studies and can possibly be explained by methodological differences (Simard et al., 2017). With a sample size of $N = 107$, an alpha set at .05 and a power of .80, the study was able to detect medium-sized associations ($r = .27$) between infant sleep variables and infant-parent attachment security and dependency (G*Power, Faul, Erdfelder, Lang, & Buchner, 2007).

To evaluate the goodness of model fit, we interpreted the following fit indices: The Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis index (TLI), and the Standardized Root Mean Square Residual (SRMR). For the RMSEA, values below .05 indicate a good fit and values between .05 and .08 indicate an acceptable fit. The CFI and TLI indicate a good fit when values are above .95, while values above .90 suggest an acceptable fit. The SRMR indicates a good fit when values are below

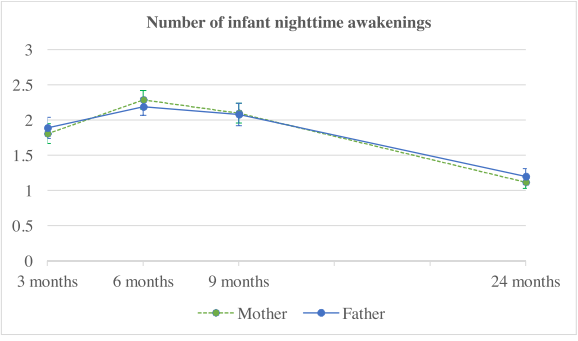


**Fig. 1.** Temporal trend of number of infant nighttime awakenings reported by mothers and fathers.
Note. Error bars display standard errors.

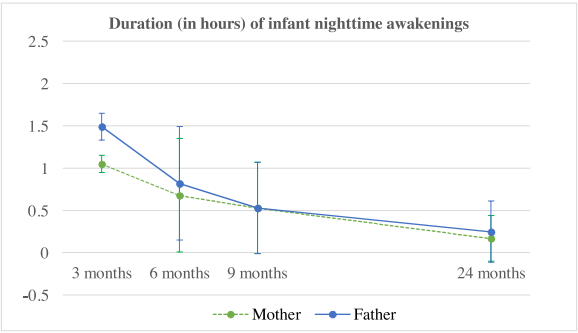


**Fig. 2.** Temporal trend of duration of infant nighttime awakenings reported by mothers and fathers.
Note. Error bars display standard errors.

.08 (Kline, 2011). A good model fit is further indicated by a non-significant $\chi^2$ statistic, although it should be noted that the $\chi^2$ statistic is influenced by sample size (Raykov & Marcoulides, 2006).

## 3. Results

### 3.1. Preliminary analyses

Preliminary analyses were performed to examine variable distributions and to identify potential outliers. All variables met the assumption of normality, using the rule of thumb of absolute skewness values below 3.0 and absolute kurtosis values below 8.0 (Kline, 2005). One impossible value (e.g., 12 waking hours per night) was treated as a missing data point. Univariate outliers were defined as having an absolute standard score above 3.28 (most extreme 0.1 % of a normal distribution). These values (12 values out of 968 values) were winsorized to reduce their impact on the results (Tabachnick, Fidell, & Ullman, 2007). To examine patterns of missing data, a missing value analysis was conducted in IBM SPSS statistics version 26. The rate of missing data ranged from 10 % to 35.5 %. The Little's MCAR test was non-significant, $\chi^2$ (525) = 553.62, $p$ = .187, indicating that the data was missing completely at random (MCAR), justifying the use of FIML as an estimator in the growth models.

Table 1 displays the descriptive statistics and cross-parent correlations for number and duration of infant nighttime awakenings. Cross-parent correlations for number and duration of infant nighttime awakenings were moderate to strong, with cross-parent correlations for number of infant nighttime awakenings ranging from $r$ = .57 to $r$ = .75, and cross-parent correlations for duration of infant nighttime awakenings ranging from $r$ = .39 to $r$ = .55.

Correlations between parental reports of number and duration of infant nighttime awakenings were moderate to strong (range for mothers: $r$ = .44–.49, range for fathers: $r$ = .44–.59) (see Table 2). Only for mothers, one weak correlation between number and duration of infant nighttime awakenings was found at 6 months ($r$= .16). Regarding the dependent variables, infant-mother attachment security was correlated with infant-father attachment security ($r$ = .46, $p$ < .001) (see also Witte et al., 2019), while infant-mother dependency was correlated with infant-father dependency ($r$ = .27, $p$ = .026). Non-significant correlations were found between attachment security and dependency for both mothers ($r$ = -.17, $p$ = .118) and fathers ($r$ = -.05, $p$= .699). Practice of feeding at 3-months-old (breast and bottle-feeding, breastfeeding, or bottle-feeding) was not related to any of the sleep variables.

### 3.2. Measure of infant sleep problems

To assess whether parental reports of number of infant nighttime awakenings and duration of infant nighttime awakenings were indicative of a single latent variable of infant sleep problems, we fitted a 1-factor model with four indicators at each time point. Fit indices showed a poor fit: $\chi^2$ (98) = 254.50, p < .001; RMSEA = 0.125, CFI = 0.677, TLI = 0.604, SRMR = 0.116. This could be due to

**Table 1**
Means, standard deviations and cross-parent correlations between sleep variables.

| | | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| Number of infant awakenings | Mother | 1.81 (1.30) | 2.29 (1.27) | 2.10 (1.33) | 1.12 (.84) |
| | Father | 1.89 (1.32) | 2.19 (1.14) | 2.08 (1.38) | 1.20 (.96) |
| | *r* | .75** | .67** | .62** | .57** |
| Duration of infant awakenings[1] | Mother | 1.05 (0.94) | 0.68 (0.67) | 0.53 (0.50) | 0.17 (.25) |
| | Father | 1.49 (1.43) | 0.82 (0.67) | 0.53 (0.47) | 0.25 (.32) |
| | *r* | .39** | .47** | .55** | .45** |
| Cronbach's $\alpha$ | | .77 | .67 | .73 | .60 |

*Note.* Standard deviations appear in parentheses. *r*s indicate the correlations between maternal and paternal reports on the same variable. ** $p$ < .001. Duration of infant night awakenings is reported in hours.

**Table 2**
Correlations between parent-reported number and duration of infant nighttime awakenings.

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|---|
| **Mother** | | | | | | | |
| 1. Number of awakenings T1 | – | | | | | | |
| 2. Number of awakenings T2 | .53** | – | | | | | |
| 3. Number of awakenings T3 | .18 | .43** | – | | | | |
| 4. Number of awakenings T4 | .25 * | .39** | .36** | – | | | |
| 5. Duration of awakenings T1 | .48** | .41 | .13 | .11 | – | | |
| 6. Duration of awakenings T2 | .30** | .16 | .23* | .26* | .45** | – | |
| 7. Duration of awakenings T3 | .22 | .11 | .44** | .29* | .41** | .48** | – |
| 8. Duration of awakenings T4 | −.02 | .01 | .19 | .49** | .28* | .36** | .35** |
| **Father** | | | | | | | |
| 1. Number of awakenings T1 | – | | | | | | |
| 2. Number of awakenings T2 | .53** | – | | | | | |
| 3. Number of awakenings T3 | .30** | .49** | – | | | | |
| 4. Number of awakenings T4 | .21 | .27* | .13 | – | | | |
| 5. Duration of awakenings T1 | .45** | .12 | −.04 | .13 | – | | |
| 6. Duration of awakenings T2 | .34** | .44** | .13 | .17 | .37** | – | |
| 7. Duration of awakenings T3 | .16 | .14 | .59** | .21 | .13 | .21 | |
| 8. Duration of awakenings T4 | .16 | .19 | .28* | .52** | .27 | .41** | .28* |

* $p < .05$, ** $p < .001$.

a pattern of relatively low correlations between reported number of infant nighttime awakenings and duration of infant nighttime awakenings in mother report as well as in father report, and relatively higher correlations among father and mother report on the same sleep variable. These findings suggest that number of infant nighttime awakenings and duration of infant nighttime awakenings reflect different dimensions of infant sleep problems. In the next step, number of infant nighttime awakenings and duration of infant nighttime awakening were therefore analyzed separately by creating composite scores for each time point by averaging maternal and paternal reports on the respective variables. All composite scores met the assumption of normality. At each time point, the composite score for infant nighttime awakenings was moderately correlated with the composite score for duration of infant nighttime awakenings (T1, $r = .50$, $p < .001$), (T2, $r = .31$, $p = .002$), (T3,$r = .55$, $p < .001$), (T4, $r = .51$, $p < .001$). Growth curve models were then fitted separately for number of infant nighttime awakenings and duration of infant nighttime awakenings.

### 3.3. Developmental trajectories for number of infant nighttime awakenings

The growth model for number of infant nighttime awakenings showed excellent fit: $\chi^2$ (3) = 2.832, $p = .418$; RMSEA = 0.000, CFI = 1.00 TLI = 1.00, SRMR = 0.07. The estimated mean value of the intercept was 1.931 ($SE = .129$, $p < .001$), indicating that 3-month-old infants woke on average two times per night. There was also significant variability in the initial number of infant nighttime awakenings (variance $I = .568$, $SE = .136$, $p < .001$), indicating that infants differed in the number of nighttime awakenings at 3 months. The estimated mean of the slope was negative and significant ($S$ = -.035, $SE = .006$, $p < .001$), indicating a decline in the number of infant nighttime awakenings across time. The estimated slope factor loadings confirmed the presence of a non-linear decline in number of infant nighttime awakenings over time, with first an increase in number of awakenings from 3 to 6 months, after which a decrease up to 24 months was present (see Fig. 1). The variance of the slope was non-significant (variance $S = .000$, $SE = .001$, $p = .370$), indicating no significant individual differences in the rate of change over time. The covariance between the intercept and slope was significant with an estimated value of -.012, ($SE = .006$, $p = .042$), suggesting that infants who started with more nighttime awakenings at 3 months old showed a greater decrease in the number of nighttime awakenings as compared to infants who started with a lower number of nighttime awakenings at 3 months old.

### 3.4. Developmental trajectories for duration of infant nighttime awakenings

The model for duration of infant nighttime awakenings also showed an excellent fit: $\chi^2$ (3) = 1.229, $p = .746$; RMSEA = 0.000, CFI = 1.00 TLI = 1.00, SRMR = 0.04. The estimated mean value of the intercept was $I = 1.282$ ($SE = .105$, $p < .001$), indicating that the average duration of infant nighttime awakenings was approximately 1.3 h for 3-month-old infants. There was also significant variability in the initial duration of nighttime awakenings (variance $I = .348$, $SE = .113$, $p = .002$), indicating that infants differed in their duration of infant nighttime awakenings at 3 months. Results further showed a significant decline in duration of infant nighttime awakenings across time (estimated mean $S$ = -.051, $SE = .005$, $p < .001$). The estimated slope factor loadings confirmed the presence of a non-linear decline in duration of infant nighttime awakenings, with the largest decline being present between 3 and 9 months, after which the decline became less steep (see Fig. 2). Infants did not significantly differ in their individual developmental trajectories over time (variance $S = .000$, $SE$ =.000, $p = .079$). However, the covariance between the intercept and slope was significant with an estimated value of -.012 ($SE = .005$ $p = .017$), suggesting that infants with longer nighttime awakenings at 3 months showed more decrease in the duration of nighttime awakenings as compared to infants with shorter nighttime awakenings at 3 months.

### 3.5. Associations with infant-parent attachment security and dependency

In the next step, we added the outcome variables to the model to examine whether initial levels and developmental trajectories of number and duration of infant nighttime awakenings were predictive of infant-mother attachment security, infant-father attachment security, infant-mother dependency, and infant-father dependency (see Fig. 3 for the latent growth curve model with estimated time scores for number of infant nighttime awakenings). Note that in the previous analyses, the variances of the slopes for both number and duration of infant nighttime awakenings were non-significant, while there was a significant covariance between the intercept and slope

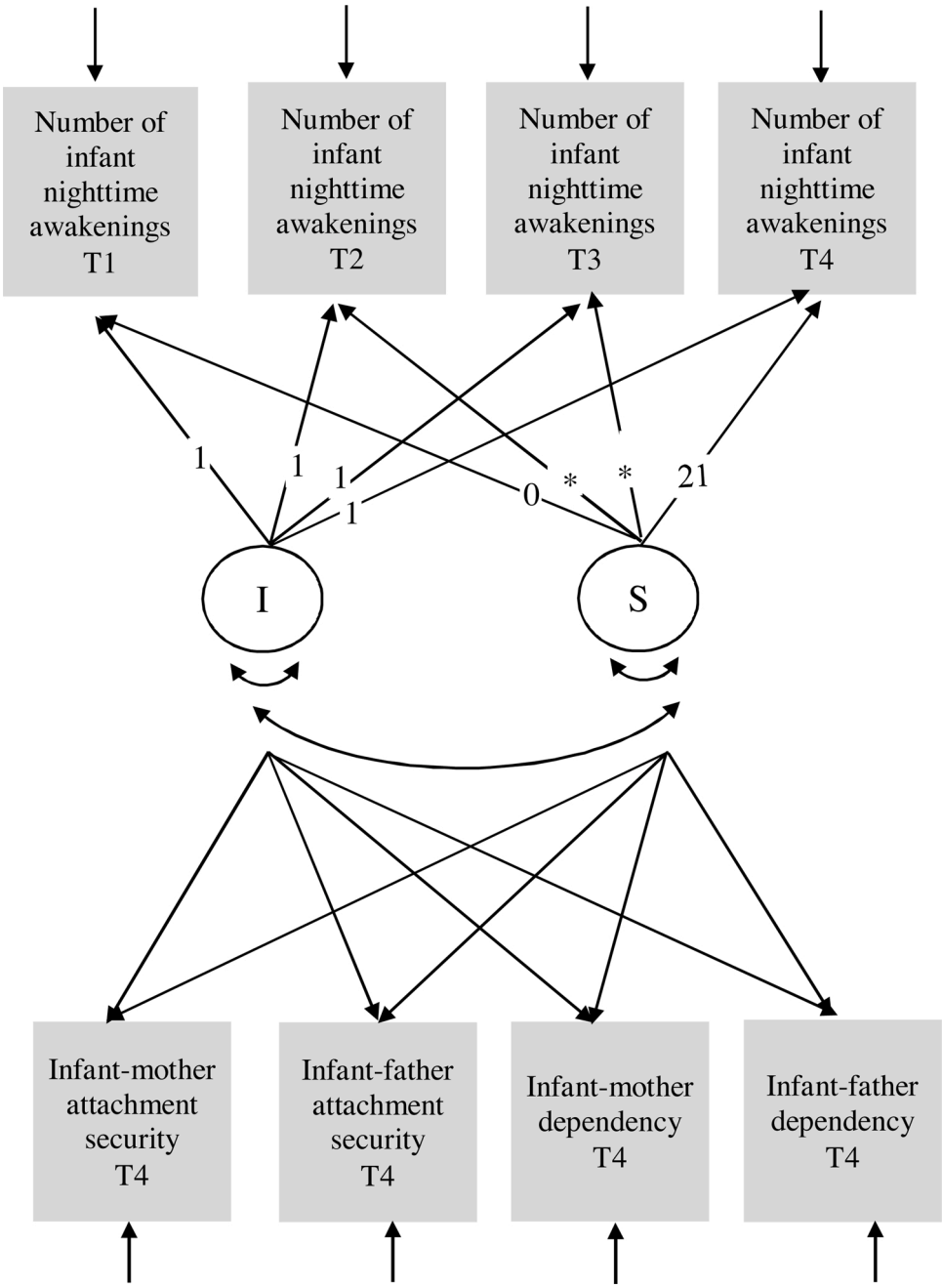


**Fig. 3.** Latent growth curve model with estimated time scores for number of infant nighttime awakenings.
*Note.* I refers to the intercept and represents the initial number of infant nighttime awakenings at T1. S refers to the slope and represents the rate of change in number of infant nighttime awakenings across time. To identify the model, the factor loadings of the intercept are specified at 1. The first factor loading of the slope is specified at 0, the second and third factor loadings of the slope are freely estimated, the last factor loading is specified at 21, representing the time between the assessments of T1 and T4.

in both models. In the final models, we initially restricted the variances of the slopes to 0. However, this parametrization resulted in a misfit of the model. We therefore assigned no restrictions to the slope variances. Correlations between the residuals of all outcome variables were included in the final models.

The model for number of infant nighttime awakenings indicated an excellent fit: $\chi^2$ (11) = 9.650, $p$ = .562; RMSEA = 0.000, CFI = 1.00, TLI = 1.00, SRMR = 0.061. The intercept of number of infant nighttime awakenings showed a positive significant path coefficient to infant-father attachment security, with an estimated value of 1.619 ($SE$ = .510, $p$ = .001), indicating that a larger number of infant nighttime awakenings at 3 months old was predictive of greater infant-father attachment security at 24 months old. The intercept showed non-significant path coefficients with infant-mother attachment security ($p$ = .794), infant-mother dependency ($p$ = .492), and infant-father dependency ($p$ = .630). Non-significant path coefficients were found between the slope and infant-mother attachment security ($p$ = .744), infant-father attachment security ($p$ = .086), infant-mother dependency ($p$ = .169), and infant-father dependency ($p$ = .393).

The model for duration of infant nighttime awakenings also showed an excellent fit: $\chi^2$ (11) = 10.649, $p$ = .473; RMSEA = 0.000, CFI = 1.00, TLI = 1.00, SRMR = 0.053. The intercept of duration of infant sleep problems showed a positive significant path coefficient to infant-father attachment security, with an estimated value of 1.470 ($SE$ = .483, $p$ = .002), indicating that longer durations of infant nighttime awakenings at 3 months old were predictive of a more secure infant-father attachment relationship at 24 months old. The intercept also showed a significant negative path coefficient with infant-mother attachment security, with an estimated value of -1.424 ($SE$ = .504, $p$ = .005), indicating that longer nighttime awakenings at 3 months predicted lower infant-mother attachment security at 24 months. The intercept further showed non-significant path coefficients with infant-mother dependency ($p$ = .711), and infant-father dependency (p = .254). The slope showed a significant negative path coefficient to infant-father attachment security, with an estimated value of -.06 ($SE$ = .02, $p$ = .003), indicating that a larger decrease in duration of infant nighttime awakenings between 3 and 24 months was associated with a more secure infant-father attachment relationship at 24 months old. For mothers, these findings were reversed: a greater decrease in duration of infant nighttime awakenings was associated with lower infant-mother attachment security at 24 months old ($B$= .061, $SE$ = .023, $p$ = .007). We used latent growth curve models to explore post-hoc the role of paternal involvement in the unexpected finding of a positive rather than a negative association between number and duration of infant nighttime awakenings and infant-father attachment security. It was speculated that frequent and long infant nighttime awakenings could lead to maternal burden and stress, thereby affecting the development of a secure infant-mother attachment relationship. We hypothesized post-hoc that when fathers increase their involvement in nighttime caregiving to reduce maternal burden and stress, infant-father interaction may be stimulated, and thus consequently supporting the development of a secure infant-father attachment relationship. With regard to developmental trajectories of paternal involvement, fathers showed an increase in their involvement in putting the infant to sleep from 3 to 24 months old ($S_{2\_}$ .016, $SE$ = .005, $p$ = .001). Moreover, fathers showed an increase in tending to the infant during nighttime awakenings from 3 to 24 months (estimated mean $S$ = .033, $SE$ = .000, $p$ = .001). However, paternal involvement at night did not seem to be involved in the association between number and duration of infant nighttime awakenings and infant-father attachment security, since initial levels and developmental trajectories of paternal involvement in putting the infant to sleep and tending to the infant at night were not associated with infant-father attachment security (see Supplementary Material for a detailed description of the measures).

## 4. Discussion

The present study examined initial levels and developmental trajectories of infant nighttime awakenings from 3 to 24 months old and their associations with infant-parent attachment security and dependency at 24 months. Contrary to our hypothesis, results of the present study showed that more frequent and longer infant nighttime awakenings at 3 months were associated with greater infant-father attachment security at 24 months. In addition, a larger decrease in duration of infant nighttime awakenings was associated with greater infant-father attachment security but with lower infant-mother attachment security at 24 months. The hypothesis of a negative association between infant sleep problems and infant-mother attachment security was partly confirmed. As hypothesized, duration of infant nighttime awakenings at 3 months was negatively associated with infant-mother attachment security at 24 months. Contrary to our expectations, number of infant nighttime awakenings at 3 months was not associated with infant-mother attachment security at 24 months.

To explore the unexpected finding of a positive rather than negative association between number and duration of infant nighttime awakenings and infant-father attachment security, we examined the role of paternal involvement. We hypothesized post-hoc that frequent and long infant nighttime awakenings may lead to maternal burden and stress, thereby affecting the development of a secure infant-mother attachment relationship. When, at the same time, fathers increase their involvement in nighttime caregiving to reduce maternal burden and stress, infant-father interaction may be stimulated, consequently supporting the development of a secure infant-father attachment relationship.

Although caution is necessary when interpreting the results of post-hoc analyses, findings indicated that initial levels and developmental trajectories of paternal involvement in putting the infant to sleep and tending to the infant at night were not associated with infant-father attachment security. We recommend future research to include a more comprehensive measure of paternal involvement in nighttime caregiving, as the limited number of items included in the present study may be insufficient to reliably assess fathers' involvement in nighttime caregiving.

It should be noted that our findings indicated that longer infant nighttime awakenings at 3 months old were associated with lower infant-mother attachment security. Potential differences in the extent to which mothers and fathers show sensitive parenting at night may be an important area for further research. Paternal sensitivity is one of the main predictors of infant-father attachment security

(De Wolff & Van IJzendoorn, 1997; Lucassen et al., 2011; Verhage et al., 2016). Moreover, a previous study has shown that sensitive and responsive maternal nighttime interactions were related to infant-mother attachment security at 12 months old (Higley & Dozier, 2009). The use of video recordings has been shown to be a valuable method to assess parenting behaviors at night (Anders, Halpern, & Hua, 1992; Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Higley & Dozier, 2009), and could be implemented in future research to assess maternal and paternal sensitivity at night. Another direction for future research is to examine whether infant sleep arrangements (where and with whom the infant sleeps) impacts the relation between infant sleep problems and the infant-mother and infant-father attachment relationship. Associations between infant sleep arrangements and sleep problems are not consistent, and few studies have examined the association between bed-sharing and the quality of the infant-parent attachment relationship (Mileva-Seitz, Bakermans-Kranenburg, Battaini, & Luijk, 2017). Also, research has shown that fathers are more likely to support a limit-setting approach (e.g., resisting excessive demands of the infant to promote self-soothing abilities) in response to hypothetical case descriptions of infants with sleep problems (Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007). Hence, associations between infant sleep problems, parental limit setting, and infant-father attachment security may be examined in future research. Furthermore, there are many other parent, child, family, and environmental characteristics, which may be involved in the relation between infant sleep problems and infant-father attachment security, which warrant examination in future research.

As previously described, longer infant nighttime awakenings at 3 months were associated with lower infant-mother attachment security at 24 months, while the number of infant nighttime awakenings at 3 months was not associated with infant-mother attachment security at 24 months. Studies examining the association between infant sleep problems and infant-mother attachment security have so far provided inconsistent results (Bilgin & Wolke, 2019; McNamara et al., 2003; Morrell & Steele, 2003; Scher, 2001; Scher & Asher, 2004; Simard et al., 2017; Weinraub et al., 2012). These inconsistent findings may be attributed to the different measures used to assess infant sleep problems. Some studies have combined various aspects of infant sleep problems in an overall measure representing infant sleep problems (Bilgin & Wolke, 2019; Morrell & Steele, 2003; Scher & Asher, 2004), while other studies focused on distinct sleep outcomes (McNamara et al., 2003; Scher, 2001). In contrast to our findings, meta-analytic evidence showed no association between the measurement of awakenings and infant-mother attachment security (Simard et al., 2017). However, it is important to note that awakenings in this meta-analysis was indexed by both the number and duration of awakenings, which prohibited the separate examination of these sleep variables in relation to infant-mother attachment security (Simard et al., 2017).

Interestingly, findings of the present study suggested that number and duration of infant nighttime awakenings may not be indicative of a single construct of infant sleep problems. Some infants may show many but short awakenings per night, while other infants may show few but lengthy awakenings per night. Therefore, number and duration of infant nighttime awakenings may underlie different dimensions of infant sleep problems. A meta-analysis shows that the strength of the association between infant sleep and infant-mother attachment security varies according to the sleep dimension being assessed (i.e. sleep problems, nighttime awakenings, sleep duration) (Simard et al., 2017). Therefore, it may be useful for future studies to consider and examine different sleep variables to generate a more comprehensive and specific understanding of relations between infant sleep problems and infant-parent attachment security. Similarly, the association between temperamental dependency and different sleep variables could be addressed in future studies.

To date, few studies have examined associations between infant sleep problems and infant-mother dependency (Bélanger et al., 2015; Scher & Asher, 2004), and studies examining the association between infant sleep problems and infant-father dependency have been absent. The present study did not reveal significant associations between number and duration of infant nighttime awakenings at 3 months and the infants' dependency level towards either their mother or their father at 24 months. In line with previous research (Bakermans-Kranenburg et al., 2004; Scher & Ascher, 2004; Waters & Deane, 1985), our findings indicated that attachment security and dependency are unrelated constructs, and are differently associated with infant sleep problems.

The present study has several important strengths, including a longitudinal design with multiple time points to assess developmental trajectories of infant sleep, using both mothers' and fathers' reports on infant sleep, and observations of attachment security and dependency with both parents. Nevertheless, we also point to some limitations which are important to consider when interpreting the results. First, given the correlational design of the study, longitudinal associations between number and duration of infant nighttime awakenings and infant-parent attachment security and dependency cannot be interpreted in terms of causality. Second, the sample consisted mainly of highly educated families with a Jewish/Caucasian classification. As such, the results of the present study may be limited in their generalizability to families with different educational and cultural backgrounds. Third, the present study focused on dyadic associations between infant sleep problems and infant-parent attachment security and dependency. Future research may integrate a family system approach to examine infant sleep problems in relation to patterns of infant-mother and infant-father attachment security within the family. Fourth, the AQS provides an infant-parent attachment security score as well as a dependency score but does not allow for distinguishing between insecure attachment classifications (insecure-avoidant, insecure-ambivalent, and insecure-disorganized).

Finally, we included only parent-reported measures of infant sleep problems, which may not be free of reporting bias (see also Scher & Asher, 2004; Simard, Bernier, Bélanger, & Carrier, 2013; Tikotzky & Volkovich, 2019). In the present study mother reports and father reports showed high interrater reliability at each time point. Yet, maternal reports of infant sleep were not significantly correlated with actigraph sleep measures collected at 9 months postpartum. Paternal reports and actigraph sleep measures were only moderately correlated. The discrepancy between parental reports and actigraph measures may possibly be explained by limited parental awareness of infant nighttime awakenings, which may become even more apparent over time, when infants have developed self-soothing abilities (Tikotzky & Volkovich, 2019). Nevertheless, parental perception of infant sleep problems was related to the quality of the infant-parent attachment relationship. Therefore, it may be particularly important to target the way parents perceive their infants' sleep, in addition to focusing on the improvement of actual infant sleep.

### 4.1. Conclusion

This longitudinal study showed that infant nighttime awakenings decrease over time, which might be reassuring for parents struggling with their infants' sleep-wake patterns in the first few months after birth. Our study found that more frequent and longer infant nighttime awakenings at 3 months were associated with greater infant-father attachment security at 24 months, while longer infant nighttime awakenings at 3 months were related to lower infant-mother attachment security at 24 months. The mechanisms explaining these findings remain speculative. Future studies could examine the role of paternal involvement in nighttime caregiving in a more comprehensive manner, while the assessment of parental sensitivity and parental limit-setting is also recommended. The present study revealed that infant sleep problems are differentially associated with infant-mother and infant-father attachment security, emphasizing the importance of including both parents in research on infant sleep problems and infant-parent attachment security. Future longitudinal research is needed to examine which factors are involved in the relation between more frequent and longer infant nighttime awakenings and greater infant-father attachment security, as well as which factors explain the relation between longer infant nighttime awakenings and lower infant-mother attachment security.

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## Author statement

Annemieke M Witte; Conceptualization; Methodology; Formal Analysis; Data Curation; Writing Original Draft; Visualization
Marleen H.M de Moor; Conceptualization; Methodology; Formal Analysis; Validation; Writing- Review and Editing; Supervision
Ohad Szepsenwol; Conceptualization; Methodology; Data Curation; Writing – Review & Editing
Marinus H van IJzendoorn; Conceptualization; Methodology; Writing- Review and Editing; Funding Acquisition
Marian J Bakermans-Kranenburg; Conceptualization; Methodology; Writing- Review and Editing; Supervision; Funding Aquisition
Dana Shai; Conceptualization; Investigation; Methodology; Writing – Review and Editing; Funding Acquisition
Conceptualization: Ideas; formulation or evolution of overarching research and aims
Methodology: Development or design of methodology; creation of models
Software: Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components
Validation: Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs
Formal Analysis: Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data
Investigation: Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection
Resources: Provision of study materials, reagents, materials, laboratory samples, animals, instrumentation, computing resources, or other analysis tools
Data Curation: Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse
Writing – Original Draft: Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)
Writing – Review & Editing: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post- publication stages
Visualization: Preparation, creation and/or presentation of the published work, specifically visualization/data presentation
Supervision: Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team
Project administration: Management and coordination responsibility for the research activity planning and execution
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## Declaration of Competing Interest

None.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.infbeh.2021.101653.

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