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EARLY NIGHTTIME PARENTAL INTERVENTIONS AND INFANT SLEEP REGULATION ACROSS THE FIRST YEAR

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ABSTRACT

Sleep quality in infancy and early childhood can have serious implications for individual and family health and well-being (Lam, Hiscock & Wake, 2003). Parenting practices in the early months may be highly influential on infant sleep patterns and trajectories. This study used four-occasion observational and survey data to investigate how sleeping arrangement and two types of nighttime interventions at one and three months (non-distress-initiated and distress-initiated) are associated with infants' sleep development across the first 9 months. Distress-initiated interventions were identified as parents' verbal and tactile responses to infants' distress signals whereas non-distress initiated interventions were identified as parents' behaviors in response to non-distressed vocalizations or while infants were asleep. Analysis of data from 107 families revealed that infant night wakings decreased over time as expected. The link between early non-distress initiated interventions and rate of change in infant night wakings was significantly moderated by sleep arrangement such that solitary sleeping infants who experienced higher levels of non-distress-initiated interventions showed a less steep decline across time in infant night wakings compared to solitary infants who experienced low levels of non-distress-initiated interventions. Results also showed that higher levels of distress-initiated interventions at 1 and 3 months were associated with a steeper decrease in infant night wakings over time for both solitary and cosleeping infants. Importantly, these findings were not replicated when parental interventions as predictors of infant sleep were examined at later points in the first year. These results inform conceptualizations of parenting competence in infant sleep contexts during the first few months of life in terms of how best to promote infant sleep regulation across the first year.

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Introduction

An important task of parenting involves the socialization of self-regulated behavior in children. Parents' use of particular practices can contribute significantly to children's development, especially when they occur early in life and are repeated over time. One particularly important regulated activity, and perhaps one of the very first to develop, is sleep regulation, which appears to be sensitive both to constitutional factors, distal ecological influences (e.g., socioeconomic status), and aspects of the caregiving environment (Sadeh, Tikotzky, & Scher, 2010). During the perinatal period, family processes and practices that facilitate or hinder sleep are of particular interest to parents and researchers because infant sleep can have concurrent and long-term effects on family well-being and children's physical and cognitive development (Bernier et al., 2010; Martin et al., 2007; Bayer et al., 2007; Lam, Hiscock & Wake, 2003). Indeed, insufficient sleep has been linked empirically to compromised daytime functioning in children, exhibited by poor attention span and lack of concentration (Goodlin-Jones et al., 2009). Sleep duration has also been linked to socio-emotional and health outcomes, with shorter sleep duration early in life predicting problem behaviors in preschoolers (Scharf et al., 2013; Holley et al., 2011) and childhood obesity (Cespedes et al., 2014; Jong et al., 2012).

Importantly, much of the work to date on relations between parenting and infant/child sleep have been based on parent report (Hairston et al., 2016; Hughes et al., 2015; Bayer et al., 2007; DeLeon & Karraker, 2007; Hiscock & Wake, 2001). Although parent reports of what they do with their infants at night are important to assess, we would argue that objective empirical evidence is also needed about what constitutes parenting competence at nighttime, in particular through direct observation of early parenting practices that bear directly on infant sleep

development. Indeed, during early life, infant biological and emotional regulation has been found to be significantly predicted by observed parenting practices (Philbrook & Teti, 2016; Martinez-Torteya et al., 2014; Propper & Moore, 2006). Observations of parenting in infant sleep contexts may provide insights into how to best conceptualize competent parenting in infant sleep contexts and inform intervention efforts to promote self-regulated sleep infancy, both in terms of intervention content and timing. The present study makes use of observations of nighttime parenting and adds to the growing body of literature (see Sadeh et al., 2010; Teti, 2017, for reviews) identifying aspects of parenting in infant sleep contexts as playing a formative role in the development of infant sleep regulation. We pay particular attention to the manner in which parents intervene with their infants during the first three months of life and predictive linkages between these interventions and infant sleep regulation across the first year. We also examine whether these linkages are moderated by infant sleep arrangement patterns parents use with infants across the first year.

Infant Sleep Development

Despite differences in data collection methods, research is consistent in descriptions of sleep development across the first year (see Galland et al., 2012, and Henderson et al., 2011, reviews). The duration of uninterrupted infant nighttime sleep increases steadily across the first year with the most significant change occurring in the first 4 months. The majority of infants can sleep for up to 5.5 hours by 3 months as measured by longest sustained sleep period. The most significant changes occur across the first 4 months followed by a slower yet steady improvement in sleep duration throughout the first year. (Henderson et al., 2011). Reporting on infant night wakings, Galland et al., (2012) noted that frequency of night waking decreases over time, with the sharpest decline observed during the first 6 months and continuing at a slower pace until 24

months. Frequency of night waking, particularly those that disrupt parent sleep, may be among the more preferred indicators of infant sleep regulation because infants who wake frequently at night may exert a high physical and emotional toll on parents (Teti et al., 2016). The present study made use of parent reports of infant night waking along with actual observations of infant night waking from video in order to provide a more complete picture of infant nighttime behavior and how it is impacted by early nighttime parenting.

Parenting Interventions, Infant Sleep Arrangements, and Infant Sleep

Although infant sleep becomes increasingly consolidated and regulated over time, **(**Henderson et al., 2011; Galland, 2012), much between-infant variability in infant sleep trajectories is evident across the first year. These differences may be constitutionally based but may also be attributed to social ecological influences, and in particular, parenting (Teti, 2017).

Distress- and non-distress initiated parental interventions. In the present study, we examined two relatively understudied parenting behaviors that nevertheless may bear importantly on the development of infant sleep. In their study of linkages between infant sleep regulation and maternal presence and close contact with infants at night, Teti & Crosby (2012) paid particular attention to the manner in which mothers intervened with their infants at night. They reported from video observations across the night that mothers intervened with their infants in at least two distinct ways. Some interventions were "distress-initiated", in that they occurred in response to infant nighttime distress, whereas other interventions appeared to be "non-distress-initiated", in that they were not in response to infant distress but instead appeared to be in response to a parent's desire to spend time with the infant. Examples of non-distress-initiated interventions included parents visiting their sleeping infants at night, picking them up, and either feeding them or bringing their infants to the parents' bed. In other cases, some parents visited

their awake but non-distressed infants to socially interact. These non-distress-initiated were associated with increased infant night waking.

Differentiating between distress- vs. non-distress-initiated interventions with infants during the night may be helpful in informing conceptualizations about competent parenting of infants at night, assuming the desired outcome to be the development of infant self-regulated sleep. Such a distinction may be particularly relevant to sleep training and recommendations that directly address parents' nighttime interventions, which sometimes advocate graduated extinction or cry-it-out methods as effective practices to promote independent sleep development (Ramos & Youngclarke, 2006). However, as suggested by Teti and Crosby (2012), it may be the case that non-distress-initiated interventions, but not parent responses to infant distress, may be particularly disruptive of infants' ability to develop self-regulated sleep. This suggests that proactive efforts very early in an infant's life to minimize non-distress-initiated interventions may help reduce the frequency of distressed infant night awakenings and promote self-regulated sleep. Indeed, patterns of infant sleep may be well established at 12 months (Henderson et al., 2011), and efforts to prevent dysregulated infant sleep may be best implemented very early in life, while infant sleep is still rapidly consolidating. Although the present study is not an intervention study, it extends Teti and Crosby's (2012) findings by documenting the frequency and type of parental interventions with infants during the night when infants are 1-to-3 months of age and the extent to which they, in conjunction with sleep arrangements, are associated with differences in infant sleep development across the first year.

Sleeping arrangements. In the present study, we also examined first-year infant sleep arrangement patterns as a potential moderator of relations between parental nighttime interventions with infants and trajectories of infant sleep regulation. With regard to infant and

parent sleep outcomes, co-sleeping has been associated with more frequent infant night wakings (DeLeon & Karraker, 2007; Ramos, Youngclarke, & Anderson, 2007). Better self-regulated sleep seems to be partially fostered through solitary sleeping with a greater ability for infants to fall asleep on their own (Keller & Goldberg, 2004). Infant sleep arrangements are quite fluid, however, particularly during the first six months of life (Teti et al., 2016), and changes in sleeping arrangements as children age or in response to sleep problems make it difficult to interpret findings. Thus, attempts to understand linkages between infant sleep arrangements and infant sleep need to take into account patterns of sleep arrangement use across the year, rather than through "snapshots" of sleep arrangements taken single points in time. As might be expected, sleep arrangements are closely linked to the degree to which parents spend time with and interact with their infants, with greater time spent and interaction with infants in co-sleeping arrangements vs. solitary sleeping arrangements (Teti, 2017), and cosleeping as well as greater parental presence and proximity to infants at bedtimes and nighttimes, have each been found to predict increased infant night awakenings (Philbrook & Teti, 2016; Ramos et al., 2007; Teti & Crosby, 2012). Thus, we examined first-year infant sleep arrangement patterns and parental interventions (distress- and non-distress-initiated) as predictors in the present study, and in addition used first-year infant sleep arrangements as a context for examining the linkages between parental interventions and first-year infant sleep trajectories.

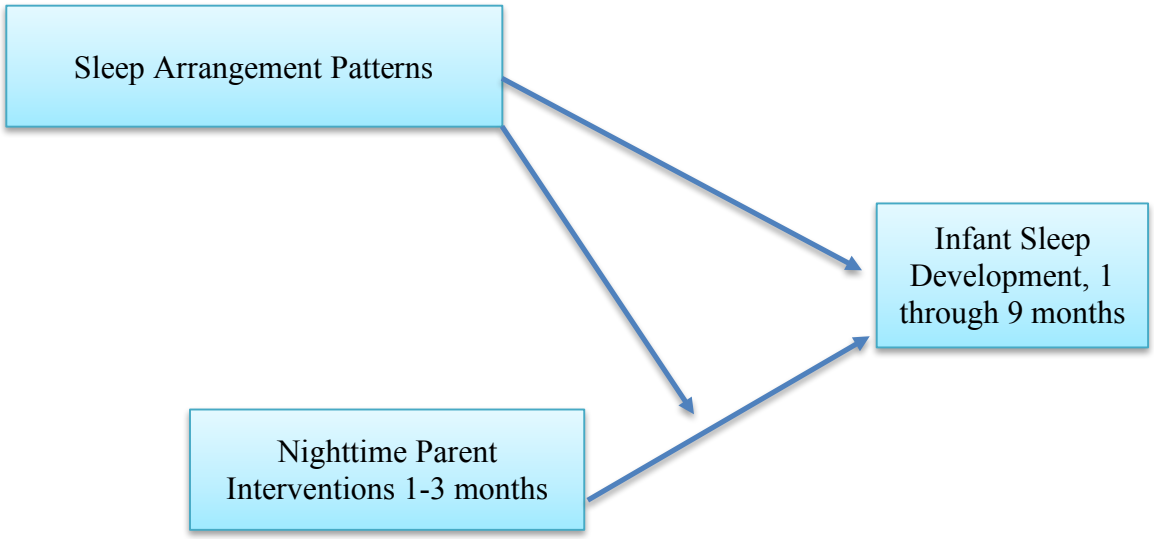

Figure 1. Nighttime parenting practices at 1 month of age, sleep arrangements across the first 9 months, and infant sleep development

Figure 1 depicts the specific relations to be examined in the present study.

Hypotheses

The following hypotheses were addressed:

1. It was hypothesized that non-distress-initiated interventions at 1 and 3 months would undermine infant sleep regulation across the first 9 months, by increasing initial levels and reducing rate of change of infant night wakings over time.
2. Less straightforward were expectations regarding linkages between distress-initiated parental interventions and infant sleep. On the one hand, infant sleep interventions involving graduated extinction (i.e., increasing and/or delaying latency to respond to infant nighttime distress for the purpose of promoting infants' ability to sooth themselves to sleep) (Blunden & Baills, 2013; Loutzenhiser, Hoffman, & Beatch, 2014) suggest that lower levels of distressed-initiated parental interventions would be associated with greater capacity for self-soothing and, in turn, stronger trajectories of self-regulated sleep.

Graduated extinction methods, however, are more likely to be used when infants are beyond 6 months of age and when a sleep problem, as identified by parents, is already apparent (Loutzenhiser et al., 2014). It is less clear whether reduced responsiveness to infant nighttime distress would or should have the same effects among very young infants (e.g., less than 6 months old), during which infant physiological regulation is at least partially dependent on the responsiveness of caregiving environment. We were informed by evidence linking early maternal responsiveness to infant distress in the first quarter of infants' first year and reduced infant crying in the fourth quarter (Bell & Ainsworth, 1972), more recent work linking maternal responsiveness to infant crying during the night and infant secure attachment (Higley & Dozier, 2009), and a host of studies linking infant physiological and sleep regulation to early maternal responsiveness and emotional availability (Philbrook et al., 2014) very early in life. Drawing from this body of work, we hypothesized that distress-initiated parent interventions would be predictive of stronger infant sleep trajectories over time, but particularly so by when such interventions took place during the infants' first three months of life. Thus, we hypothesized that infant sleep trajectories across the first year would be particularly sensitive to distress-initiated parental nighttime interventions that took place during the first three months of life.

3. More exploratory was the question of whether first-year infant sleep arrangement patterns moderated linkages between early parental interventions and infant sleep trajectories. As discussed above, Infant sleep arrangements have been found to predict infant sleep development, with cosleeping arrangements predictive of less well-regulated infant sleep than solitary sleeping arrangements. Both nondistress-initiated and distress-initiated

parental interventions may be more frequent in co-sleeping sleep arrangements simply because parents are in closer proximity to their infants during sleep than they are in solitary sleeping arrangements. Thus, it was of interest to determine whether linkages between parental interventions and infant sleep regulation were more vs less apparent in predominantly solitary vs. predominantly cosleeping first-year infant sleep arrangements.

Methods

Participants

This study makes use of data obtained in a larger study of parenting and infant sleep (SIESTA – Study of Infants' Emergent Sleep Trajectories; R01HD052809), which recruited 167 families from central Pennsylvania at 1 month of age. Mothers' average age was 30.2 years (SD = 5.2). The majority of mothers were married (84.7%) and employed (66%). The sample was predominantly Caucasian with 86.1% identified White, 3.5% African American, 2.1% Asian, 4.9% Latino, and 2.8% of other origin. Families earned on average $71,571 ranging from $5,000 to $350,000. This sample is largely representative of heterosexual families living in Central Pennsylvania. Of the 167 families recruited into the parent study, 155 families provided video data and nighttime parenting practices at 1 month. There were no socio-demographic differences between the families with coded nighttime practices and the larger sample ($t_{income}(11.364) = 0.59$; $t_{age}(12.02) = 1.04$, $t_{education}(11.62) = 1.20$, $X^2_{race}(4, N=166) = 2.75$; and $X^2_{marital}(4, N=167) = 4.18$; $ps > 0.05$).

Procedures

Observational data. Families were recruited from maternity wards shortly after giving birth. Those who expressed interest were later contacted with further information about the study

– participation in a series of longitudinal assessments when participant child is 1, 3, 6, 9, 12, 18 and 24 months old. The present study includes data from recorded observations and questionnaires up to 9 months. For one day at each assessment age, graduate students and/or project staff placed cameras in the home to continuously record parent child interactions during bedtime, and through the night until infant got out of bed in the morning. Families indicated their preferred locations for camera placement based on bedtime routines. For all families, at least one camera offered an overhead view of the infant sleeping surface allowing for continuous observation of sleep behaviors during the night.

The recordings were later coded independently for bedtime and nighttime parent child interactions among other things. For every 30 second interval, coders blind to all other family data scored infant location, parent presence, parent interventions and infant states (awake-non-distressed, distressed and asleep). Inter-coder reliabilities were high, with intraclass correlations (ICCs) ranging from .85 to 1.00 for nighttime parenting practices and infant states based on videos from 10 families on different occasions 1,3, 6, and 9 months.

For each video, the total number of intervals for which the infant was coded as "distressed" from the 1 and 3 months videos were also converted to the total number of minutes in order to create a *nighttime infant distress* variable ($distress_i$), which was used as a covariate in analyses to control for individual differences in infant distress during the night. ICCs for the "distressed" code ranged from .85 to .97. Table 1 includes the descriptive statistics for infant distress at 1 and 3 months showing that nighttime infant distress ranged from 0 to 130.5 minutes (M = 18.03 minutes, SD = 17.64 minutes).

Parent interventions were measured as the number of verbal and physical contact parents made at night in association with a specific infant state. These interventions were categorized as

distress-initiated if the infant was distressed in the 2 minutes prior to the parent responding, or *non-distress-initiated* if the infant was asleep or awake-non-distressed before the parent intervened. The present study focused on the total number of each type of early nighttime interventions (non-distress-initiated or distress-initiated) that occurred at 1 and 3 months. As shown in Table 1, early non-distress-initiated interventions ranged from 0 to 9 (*M* = 3.25 interventions, *SD* = 2.84 interventions). Early distress-initiated interventions ranged from 0 to 12 (*M* = 2.91 interventions, *SD* = 2.87 interventions). Inter coder reliability for each coder was high, based on between 8 - 10 randomly selected videos with ICCs ranging from .70 to .95.

Table 1. *Summary of Intercorrelations, Means and Standard Deviations for Nighttime Interventions and Infant Distress observed at 1 and 3 Months*

	Distress Initiated Interventions	Non-Distress Initiated Interventions	Infant Distress
Distress-Initiated Interventions	1		
Non-Distress Initiated Interventions	-0.09	1	
Infant Distress	0.54***	-0.12	1
M	3.25	2.91	18.03
SD	2.84	2.87	17.64
n	135	138	161

Note: * p<.05, ** p<.01, ***p<.0001

Parents were asked to report on their primary sleep arrangement at each occasion. The number of cosleepers and solitary sleepers differed with age as expected with more infants cosleeping at 1 month and more infants in solitary sleep at 9 months. Reports for 1, 3, 6, 9 and 12 months were used to later classify families as predominantly cosleepers (N=45) which includes families who were consistently cosleeping or cosleeping beyond 6 months and predominantly solitary sleepers (N=81) which includes families who were consistently solitary or had switched to solitary sleep by 6 months. Families who reported inconsistent patterns were excluded from

this categorization (N=14). The final variable ($sleeparr_{ti}$) was dummy coded (0=predominantly cosleep; 1=predominantly solitary sleep and *NA*= inconsistent group).

Parent-reported frequency of infant night wakings. Mothers were also asked to complete an infant sleep diary each day for a seven-day period, with one day coinciding with the video recordings. The total number of night wakings reported by mothers across the full week was used as a separate variable measuring nighttime sleep disruptions ($nightwakings_{ti}$).

Table 2 includes descriptive statistics for the mother report of infant night wakings. As infants got older, frequency of night wakings decreased steadily from Month 1 (*M*=15.26 night wakings, *SD*=6.44) to Month 9 (*M*=8.24 night wakings). Similarly, the variance of infant night wakings increased with age indicating gradually larger between-infant differences in infant night wakings from 1 to 9 months. Repeated measures of infant night wakings show strong intercorrelations ($.24 \leq r\text{s} \leq .61$), with high rank order stability with some noticeable individual fluctuations across occasions.

Table 2. *Summary of Intercorrelations, Means and Standard Deviations for Night Wakings by Occasion*

Age	1	3	6	9
1	1			
3	0.47***	1		
6	0.33***	0.45***	1	
9	0.24***	0.35***	0.61***	1
M	15.26	9.29	9.36	8.24
SD	6.44	6.16	7.42	7.01
n	155	147	148	144

Note: * p<.05, ** p<.01, ***p<.0001

Models to be tested

Growth curve modeling was used to test the interindividual differences (between-person) in infant sleep regulation (within-person) over time (Ram & Grimm; 2007). The first model to be

examined addressed the linkages between *non-distress-initiated* parental interventions and infant night waking from 1 to 9 months of age in addition to sleep arrangement and level of distress-initiated interventions. The second model addressed linkages between *distress-initiated* parental interventions and infant night wakings night wakings from 1 to 9 months in addition to sleep arrangement and non-distress-initiated interventions. These models address the first research question concerning the unique association between each type of nighttime interventions (non-distress-initiated versus distress-initiated) and infant night wakings. Moreover, both models included the interaction term for the total each intervention type observed at 1 and 3 months and sleep arrangement, testing for any moderation by sleep arrangement aligning with the second research question. The level of infant distress observed at 1 and 3 months was also included as a control variable in both models.

Conditional Growth Model 1 Equations:

Level 1

$$NightWakings_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti}) + \beta_{2i}(Age_{ti}^2) + \varepsilon_{ti}$$

Level 2

$$\begin{aligned}
\beta_{0i} = {} & \gamma_{00} + \gamma_{01}\, SleepArrangement_i \\
& + \gamma_{02}\,(NonDistressInitiatedInterventions_i) \\
& + \gamma_{03}(DistressInitiatedInterventions_i) + \gamma_{04}\, Distress_i \\
& + \gamma_{05}(NonDistressInitiatedInterventions_i \times SleepArrangement_i) + u_{0i} \\
\beta_{1i} = {} & \gamma_{10} + \gamma_{11}\, SleepArrangement_i + \gamma_{12}\,(NonDistressInitiatedInterventions_i) \\
& + \gamma_{13}(NonDistressInitiatedInterventions_i \times SleepArrangement_i) + u_{1i} \\
\beta_{2i} = {} & \gamma_{20}
\end{aligned}$$

The level 2 parameters *γs* represent differences in sleep trajectory based on categories of sleep arrangement (with "predominantly cosleep" as the reference group) and number of non-distress-initiated interactions observed at 1 and 3 months.

Conditional Growth Model 2 Equations:

Level 1

$$NightWakings_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti}) + \beta_{2i}(Age_{ti}^2) + \varepsilon_{ti}$$

Level 2

$$\begin{aligned}\beta_{0i} = {} & \gamma_{00} + \gamma_{01}\, SleepArrangement_i \\ & + \gamma_{02}\,(NonDistressInitiatedInterventions_i) \\ & + \gamma_{03}(DistressInitiatedInterventions_i) + \gamma_{04}\, Distress_i \\ & + \gamma_{05}(DistressInitiatedInterventions_i \times SleepArrangement_i) + u_{0i}\end{aligned}$$

$$\begin{aligned}\beta_{1i} = {} & \gamma_{10} + \gamma_{11}\, SleepArrangement_i + \gamma_{12}\,(DistressInitiatedInterventions_i) \\ & + \gamma_{13}(DistressInitiatedInterventions_i \times SleepArrangement_i) + u_{1i}\end{aligned}$$

$$\beta_{2i} = \gamma_{20}$$

The level 2 parameters *γs* represent differences in sleep trajectory based on categories of sleep arrangement (with "predominantly cosleep" as the reference group), number of distress-initiated interactions as observed from the video recordings at 1 and 3 months. All models were estimated using the nlme package in R (nmle;) under the assumption that incomplete data for the repeated measures are missing at random.

Results

Preliminary Analyses

Independent sample t-tests were used to determine whether the number of distress-initiated and non-distress-initiated interventions differed significantly between solitary sleepers and cosleepers. On average, cosleepers had significantly higher number of distress-initiated interventions at 1 and 3 months combined ($t(52) = 2.40$, $p = 0.02$) compared to solitary sleepers. Cosleepers also had significantly higher levels of non-distress-initiated interventions at 1 and 3 months compared to solitary sleepers ($t(67) = 2.72$, $p = 0.01$). Pearson correlations revealed that infant distress was positively correlated with frequency of night wakings at 1 month ($r = 0.19$, $p < 0.05$) but not with night wakings at 3, 6 and 9 months ($rs \leq 0.12$, $p > 0.05$). Total number of

distress-initiated interventions observed at 1 and 3 months was significantly and positively correlated with night wakings at 1 month ($r = 0.39$, $p < 0.01$) and 3 months ($r = 0.36$, $p < 0.01$). Total number of non-distress-initiated interventions observed at 1 and 3 months was also positively correlated with night wakings at 1 month ($r = 0.27$, $p < 0.01$) and 3 months ($r = 0.23$, $p < 0.01$). The two types of interventions (distress-initiated and non-distress-initiated) were not significantly correlated. Lastly, infant distress was moderately correlated with number of distress-initiated interventions ($r = 0.54$, $p < 0.001$). In sum, these correlations confirm the hypothesis that cosleepers tended to experience significantly higher levels of parental interventions (both distress- and non-distress-initiated). They also warrant the inclusion of infant distress as a covariate in the second model since early infant distress was correlated with infant night wakings and the number of distress initiated interventions.

Model Testing

The first step involved testing the unconditional means model with an intercept and no slope. As expected, the findings indicate that other predictors were needed in order to explain between person variance (29.3%) in infant night wakings. The next step involved the unconditional growth model with age as a predictor, using two potential models with a quadratic and cubic term for age respectively. The model with a quadratic term significantly improved the fit over the linear model. The cubic model was not a significant improvement in model fit. Consequently, all subsequent analyses modeled quadratic change of infant nighttime sleep duration. The effect of linear age was significant and positive, with an average increase in sleep duration over time. The effect of quadratic time was also significant indicating a deceleration in the rate of change. These results aligned with preliminary observations wherein infant night wakings appeared to decrease at a faster rate from Month 1 to Month 6 compared to the pattern

observed between Month 6 and Month 9. As shown in Figure 3, there is greater variability in infant night waking at Month1 and Month 3 (pink and green) compared to Month 6 and Month 9 when infant night wakings are fewer and less varied (blue and purple).

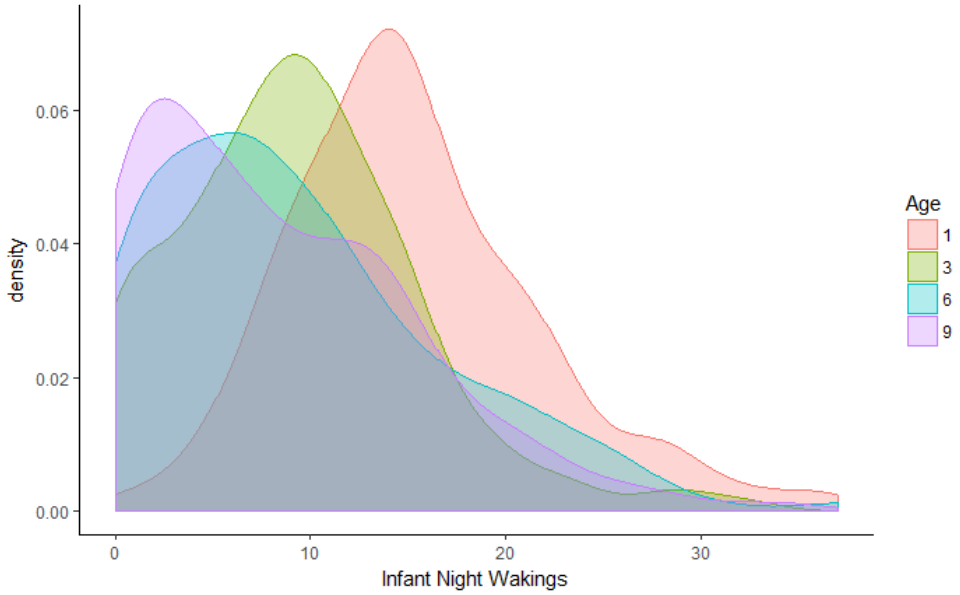

Figure 2. Density plot of Infant Night Wakings from Month 1 to Month 9

Next, sleep arrangement was added to the quadratic model as a predictor of infant night waking. Table 3 shows that the intercept (γ_{00} = 14.53) or average initial status of infant night wakings for predominantly cosleepers was over 14 night wakings per week at Month 1. Frequency of infant night wakings decreased with time (γ_{10} = -1.97). There were no associations between sleep arrangement patterns as coded (predominantly cosleeping and predominantly solitary) and either average initial level of infant night wakings or rate of change in infant night wakings across the first 9 months.

Adding the two types of parent interventions to the analyses (Model 1) showed that both types of parent interventions (non-distress-initiated or distress-initiated) in early infancy were significantly associated with initial levels of infant night wakings (γ_{02} = 0.55, $p<0.05$ for

nondistress initiated interventions; $\gamma_{03} = 0.86$, $p<0.001$ for distress initiated interventions). In order to test the moderation by sleeping arrangement, the interaction terms between sleeping arrangement and early non-distress-initiated interventions were added to the model. There was also a significant three-way interaction between age, sleep arrangement and number of non-distress initiated interventions in the first 3 months ($\gamma_{13} = 0.55$, $p<0.05$), indicating that sleep arrangement was a significant moderator of the association between frequency of non-distress initiated interventions and infant night wakings over time. For predominantly solitary sleepers, more non-distress initiated interventions in the first 3 months was linked to a less steep decline in infant night wakings across the first 9 months, compared to other solitary sleepers with low non-distress initiated interventions.

Table 3. *Results for Model 1 tests for Infant Night Wakings over time*

	Parameters	Estimates	95% CI
Fixed Effects			
Intercept	γ_{00}	**14.46* (0.92)**	**[12.73,16.33]**
Age	γ_{10}	**-1.97* (0.34)**	**[-2.64, -1.30]**
Age^2	γ_{20}	**0.18* (0.04)**	**[0.11,0.25]**
Sleep Arrangement (Predominantly Solitary)	γ_{01}	0.68 (1.13)	[-1.57,2.93]
Non-Distress initiated (NDI)	γ_{02}	**0.55* (0.26)**	**[0.03,1.08]**
Distress initiated (DI)	γ_{03}	**0.83* (0.19)**	**[0.57,1.30]**
Infant Distress	γ_{04}	-0.01 (0.01)	[-0.04,0.02]
Sol X NDI	γ_{05}	0.19 (0.37)	[-0.53,0.93]
Sol X Age	γ_{11}	-0.27 (0.23)	[-0.72,0.18]
NDI X Age	γ_{12}	**-0.13* (0.05)**	**[-0.23, -0.03]**
Sol X NDI X Age	γ_{13}	**0.15* (0.07)**	**[0.002,0.29]**
Random Effects			
Variance intercept		10.43	[4.79,22.66]
Variance age		0.45	[0.21,0.96]
Correlation intercept, age		-0.27	[-0.65,0.23]
Residual		24.1	
AIC		2664.11	

Note. Unstandardized coefficients and standard errors (between parentheses) are presented. N=107 families providing 409 observations. Covariates are group mean centered. Intercept centered at 1 Month. Higher parameter values indicate differences favoring families who are predominantly solitary sleepers, have more non-distress-

initiated interventions and have more distress-initiated interventions at 1 and 3 months. Bold font highlights significant findings, *p<.05, ** p<.01, ***p<.001.

Figure 3, using high and low levels of non-distress initiated interventions (+1SD, -1SD) showed a difference in slopes for solitary sleepers with low levels of non-distress initiated interventions compared to all remaining groups (Solitary Sleep/High NDI, Cosleep/Low NDI and Cosleep/High NDI). Solitary sleepers with low levels of non-distress initiated interventions at 1 and 3 months (black dotted line) had a steeper decline in infant night wakings or better sleep regulation than solitary sleepers who experienced high levels of non-distress initiated interventions at 1 and 3 months (black dashed line). In addition, solitary sleepers with low non-distress initiated interventions showed better sleep regulation than cosleeping infants who showed a less steep decline in infant night wakings at both high levels of non-distress initiated interventions (grey dashed line) and low levels of non-distress-initiated interventions (grey solid line).

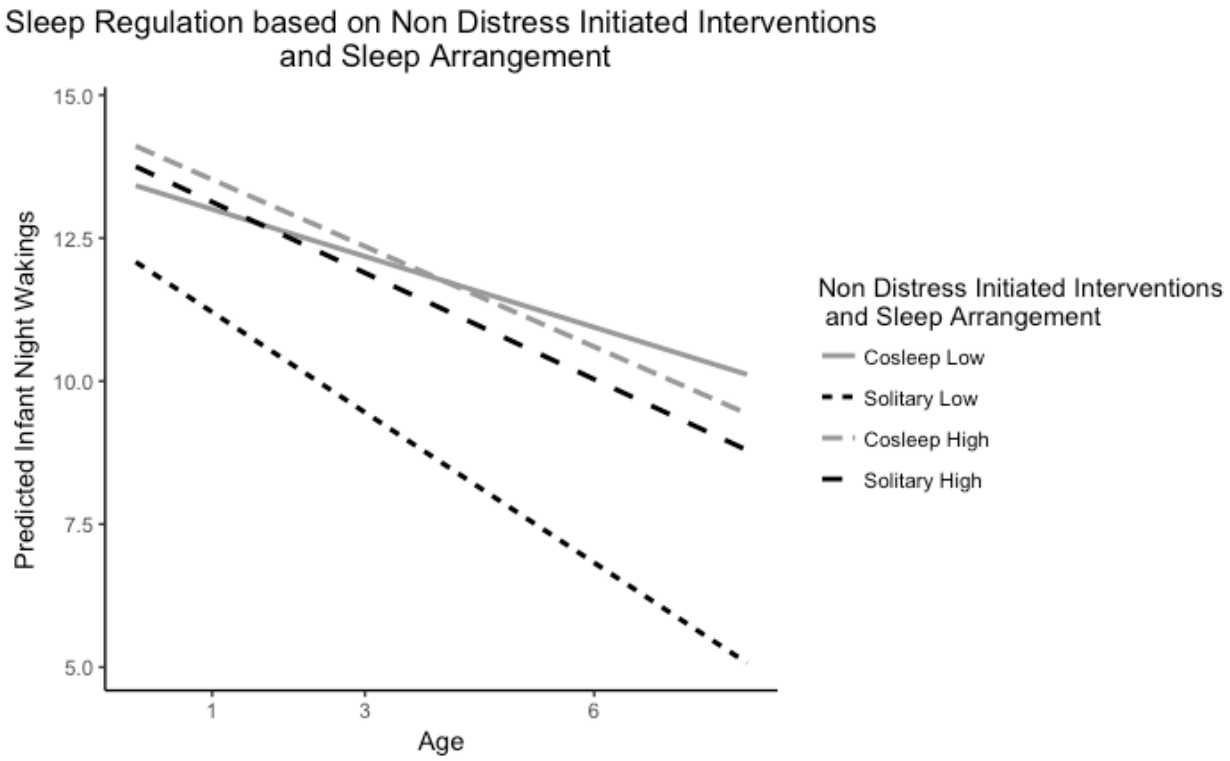

Figure 3. Infant sleep regulation by levels of non-distress-initiated interventions and sleep arrangement.

Model 2 included sleep arrangement group, the number of distress-initiated interventions, the number of non-distress-initiated interventions and the number of distress intervals observed at 1 and 3 months. The total number of distress intervals observed at 1 and 3 months was included in order to account for the significant correlation between infant distress and infant night wakings (r= 0.36, p<0.01). There was also, as expected, a significant correlation between infant distress and the number of distress-initiated interventions (r = 0.54, p < 0.001). The results again indicated a decline in infant night wakings over time (γ_{10} = -2.02, p<0.05). There was no significant association between sleep arrangement and number of infant night wakings at one month. Non-distress-initiated and distress-initiated interventions were both significantly linked to initial levels of infant night wakings even after accounting for infant distress. Distress-initiated interventions were significantly associated with the rate of change in infant night wakings over

time such that higher levels of distress-initiated interventions at 1 and 3 months were linked to a steeper decline in infant night wakings across the first 9 months (γ_{10} = -0.11, p<0.05). This association was not moderated by sleep arrangement.

Table 4. *Results for Model 2 tests for Infant Night Wakings over time*

	Parameters	Estimates	95% CI
Fixed Effects			
Intercept	γ_{00}	**14.34* (0.89)**	**[12.59,16.09]**
Age	γ_{10}	**-2.02* (0.35)**	**[-2.68, -1.36]**
Age^2	γ_{20}	**0.18* (0.04)**	**[0.11,0.25]**
Predominantly Solitary (Sol)	γ_{01}	1.01 (1.10)	[-1.17,3.20]
NonDistress-Initiated (NDI)	γ_{02}	**0.48*** (0.15)**	**[0.17,0.78]**
Distress-initiated (DI)	γ_{03}	**1.18*** (0.24)**	**[0.69,1.66]**
Infant Distress	γ_{04}	-0.02 (0.02)	[-0.05,0.01]
Sol X DI	γ_{05}	-0.32 (0.22)	[-0.26,1.33]
Sol X Age	γ_{11}	-0.27 (0.23)	[-0.76,0.11]
DI X Age	γ_{12}	**-0.11* (0.05)**	**[-0.21, -0.01]**
Sol X DI X Age	γ_{13}	-0.06 (0.08)	[-0.23,010]
Random Effects			
Variance intercept		9.42	[3.96,22.28]
Variance time		0.42	[0.18,.96]
Correlation intercept, time		-0.108	[-0.64,0.49]
Residual		24.01	
AIC		2699.64	

Note. Unstandardized coefficients and standard errors (between parentheses) are presented. N=107 families providing 409 observations. Covariates are group mean centered. Intercept centered at 1 month. Higher parameter values indicate differences favoring families who are predominantly solitary sleepers and have more non distress-initiated interventions and more distress-initiated interventions at 1 and 3 months. Bold font highlights significant findings, *p<.05, ** p<.01, ***p<.001.

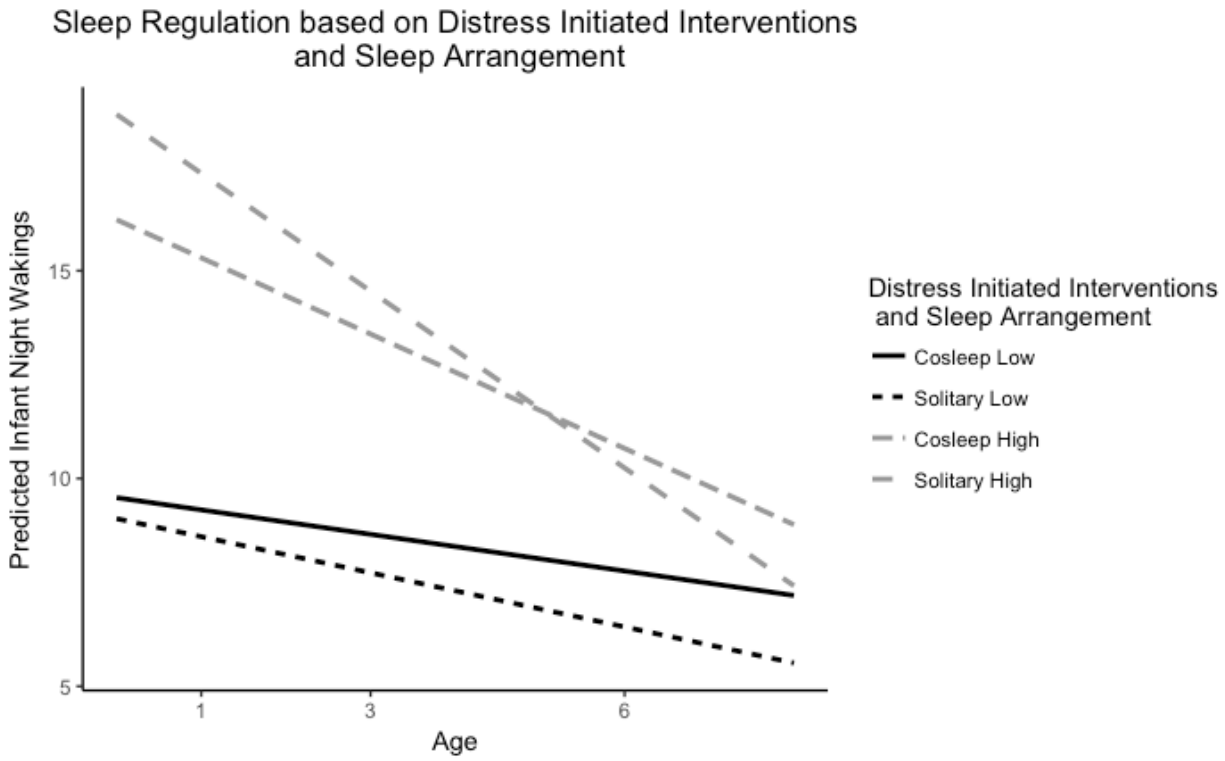

Figure 4. Infant sleep regulation based on levels of distress-initiated interventions and infant distress at 1 and 3 months.

Figure 4, using high and low levels of distress-initiated interventions at 1 and 3 months (+1SD, -1SD) depicted the slopes for infant sleep regulation. Infants with low levels of distress-initiated interventions in the early months (black lines) had a flatter decline in infant night wakings or worse sleep regulation than infants who experienced high levels of distress-initiated interventions in the early months (grey dashed lines). There was no significant moderation by sleep arrangement. Cosleepers and solitary sleepers with similar levels of distress-initiated interventions also show similar slopes for sleep regulation. In other words, high levels of distress initiated interventions is associated with better sleep regulation for both cosleepers and solitary sleepers (grey dashed lines).

Discussion

The overall patterns of infant night wakings matched findings highlighted in the literature showing a decline in infant night wakings over time (Henderson et al., 2011; Galland et al., 2012). Based on the models tested, first-year sleeping arrangements were not associated with initial levels of infant night wakings or rate of change in infant night wakings. Non-Distressed initiated interventions in early infancy contributed to explaining trajectories of infant night wakings. However, this association was moderated by sleep arrangement. Only for infants who were classified as predominantly solitary sleepers, higher levels of non-distress-initiated interventions in early life was linked to a flatter decline in infant night wakings across the first 9 months whereas low levels of non-distress-initiated interventions was linked to a steeper decline in infant night wakings.

These results indicate that solitary sleepers who experienced high level of sleep disruptions through unnecessary or inappropriate nighttime interventions (non-distress-initiated) at 1 and 3 months showed a slower rate of sleep regulation over time as opposed to solitary sleepers who experienced fewer disruptions. Since non-distress-initiated interventions encompass a wide variety of behaviors, these results also corroborate findings indicating the role of specific parenting practices such as feeding, proximity and physical contact in negatively predicting sleep regulation (Philbrook & Teti, 2016; Teti & Crosby, 2012; Sadeh et al., 2010).

Moreover, the number of distress-initiated interventions in the first 3 months was significantly associated with the trajectory of infant night wakings, such that higher levels of distress-initiated interventions were associated with steeper decline in infant night waking over time compared to lower levels. This link was significant even after accounting for the amount of infant distress coded from nighttime videos at 1 and 3 months. These results suggest that infant

sleep regulation may benefit from appropriate or warranted nighttime interventions that occur early in a child's life and may be delayed if appropriate interventions are withheld during the early months.

These findings align with findings from Bell and Ainsworth (1972) who concluded that maternal responsiveness during the first few months of life was associated with lower levels of infant distress toward the end of the first year. Higley and Dozier (2009) also found advantages to sensitive and responsive parenting at night in promoting secure attachment. In the current study using the context of sleep and nighttime parenting practices, parents' responsiveness to infant nighttime distress early in the first year was similarly conducive to fewer night wakings or better sleep regulation over time. It is important to note that models based on parent nighttime interventions observed at 6 or 9 months (non-distress- and distress-initiated) did not show a significant association between those interventions and infant sleep trajectories at later points. Furthermore, these results contradict the recommendations commonly endorsed by popular books on parenting to let infants "cry it out" without consideration to infants' developmental needs, under the assumption that early nighttime interventions (appropriate or not) may encourage subsequent infant night wakings. Such an assumption could not be substantiated in this study because high distress-initiated interventions observed in the first 3 months were not associated with a slower decline in sleep regulation regardless of levels of infant distress. In fact, the opposite pattern was observed such that slower sleep regulation was associated with a low level of distress-initiated interventions.

Collectively, the present findings contribute to a clearer understanding of what constitutes competent parenting in infant sleep contexts during the first few months of life by demonstrating the specific influences of early parenting interventions on infant sleep patterns across the first

year. Focusing on early parenting practices in addition to sleeping arrangement as well as possible interactions between them provides a better understanding of infant sleep development and parent's experiences. It appears that very early in the infant's first year, parents can influence their infants' sleep development based on whether or not their nighttime interactions with their infants are appropriate and/or needed. Infant self-regulated sleep across the first year appears to be promoted when parents respond to infant night distress but withhold interacting with their infants when their infants are not distressed. Nighttime parenting competence can be improved through interventions and recommendations that address parents' ability to detect and respond appropriately to infant distress signals but to withhold intervention during the night when infants are not distressed.

Moreover, these results significantly contribute to the literature on infant sleep and parenting by including observational measures of parenting practices and by using longitudinal assessments that effectively capture changes in infant sleep due not only to age but also to family and environmental influences. It is important to consider the implications of different sleep measures in both the investigation of research questions and the implications of research findings. On one hand, observational data offers a more complete and objective assessment of total nighttime sleep duration. On the other hand, parent reports are based on sleep and wake patterns that parents can detect and remember which may be more salient to their own physical and mental health in the short and long term.

Limitations

This study has some limitations. The first one concerns the coding of sleeping arrangement. Using mother's reports, infants were coded as predominantly solitary sleepers if they consistently slept in a separate room from their parents or switched to solitary sleeping by

six months. Results might differ if different subcategories were considered based on the timing and direction of change in sleep arrangement. Additionally, this categorization did not account for the presence of siblings and other relatives who could potentially influence infant night wakings at any occasion. These results are only generalizable to a very limited population of infants and families according to the sample of the current study. Due to the number of occasions (4), models were limited to a quadratic exponent and shape. Furthermore, since these results were based on correlation models, no causal inference can be made.

Future Directions

Future research should attempt to answer these questions using a more diverse sample as well as a clearer sense of directionality. The measurement occasions should also be extended in order to improve knowledge on sleep regulation. It will also be interesting to include a broader definition and categorization of nighttime interventions. Perhaps information about timing and length of nighttime parent interventions would offer a clearer picture of parenting competence at night as well as possible interactions with other family level characteristics and measures of parenting quality such as emotional availability.

Conclusion

In sum, this study contributes to the literature on infant sleep development and its relation to early parenting behaviors. The results confirm the influence of parenting practices, especially as they occur in early life, on infant sleep regulation. Higher levels of distress-initiated parental interventions were linked to better infant sleep regulation across the first year. Non-distress initiated interventions were also linked to the rate of change in infant night wakings over time. However, this association was moderated by sleep arrangement such that solitary sleeping infants with low levels of non-distress-initiated interventions had better sleep regulation

compared to other solitary sleepers with high levels of non-distress interventions as well as cosleeping infants with either high or low levels of non-distress-initiated interventions. Infant self-regulated sleep appears to be reinforced by appropriate (distress-initiated) parental interventions and weakened by unwarranted (non-distress-initiated) parental interventions observed in the first 3 months. Future research addressing early parenting quality in addition to parenting practices may be extremely useful in understanding nighttime parenting competence and its association with infant sleep regulation over time.

APPENDIX A
TABLES 1-4

Table 1. *Summary of Intercorrelations, Means and Standard Deviations for Nighttime Interventions and Infant Distress observed at 1 and 3 Months*

	Distress Initiated Interventions	Non-Distress Initiated Interventions	Infant Distress
Distress-Initiated Interventions	1		
Non-Distress Initiated Interventions	-0.09	1	
Infant Distress	0.54***	-0.12	1
M	3.25	2.91	18.03
SD	2.84	2.87	17.64
n	135	138	161

Note * p<.05, ** p<.01, ***p<.0001

Table 2. *Summary of Intercorrelations, Means and Standard Deviations for Night Wakings by Occasion*

Age	1	3	6	9
1	1			
3	0.47***	1		
6	0.33***	0.45***	1	
9	0.24***	0.35***	0.61***	1
M	15.26	9.29	9.36	8.24
SD	6.44	6.16	7.42	7.01
n	155	147	148	144

Note * p<.05, ** p<.01, ***p<.0001

Table 3. *Results for Model 1 tests for Infant Night Wakings over time*

	Parameters	Estimates	95% CI
Fixed Effects			
Intercept	γ_{00}	**14.46* (0.92)**	**[12.73,16.33]**
Age	γ_{10}	**-1.97* (0.34)**	**[-2.64, -1.30]**
Age^2	γ_{20}	**0.18* (0.04)**	**[0.11,0.25]**
Sleep Arrangement (Predominantly Solitary)	γ_{01}	0.68 (1.13)	[-1.57,2.93]
Non-Distress initiated (NDI)	γ_{02}	**0.55* (0.26)**	**[0.03,1.08]**
Distress initiated (DI)	γ_{03}	**0.83* (0.19)**	**[0.57,1.30]**
Infant Distress	γ_{04}	-0.01 (0.01)	[-0.04,0.02]
Sol X NDI	γ_{05}	0.19 (0.37)	[-0.53,0.93]
Sol X Age	γ_{11}	-0.27 (0.23)	[-0.72,0.18]
NDI X Age	γ_{12}	**-0.13* (0.05)**	**[-0.23, -0.03]**
Sol X NDI X Age	γ_{13}	**0.15* (0.07)**	**[0.002,0.29]**
Random Effects			
Variance intercept		10.43	[4.79,22.66]
Variance age		0.45	[0.21,0.96]
Correlation intercept, age		-0.27	[-0.65,0.23]
Residual		24.1	
AIC		2664.11	

Note. Unstandardized coefficients and standard errors (between parentheses) are presented. N=107 families providing 409 observations. Covariates are group mean centered. Intercept centered at 1 Month. Higher parameter values indicate differences favoring families who are predominantly solitary sleepers, have more non-distress-initiated interventions and have more distress-initiated interventions at 1 and 3 months. Bold font highlights significant findings, *p<.05, ** p<.01, ***p<.001.

Table 4. *Results for Model 2 tests for Infant Night Wakings over time*

	Parameters	Estimates	95% CI
Fixed Effects			
Intercept	γ_{00}	**14.34* (0.89)**	**[12.59,16.09]**
Age	γ_{10}	**-2.02* (0.35)**	**[-2.68, -1.36]**
Age^2	γ_{20}	**0.18* (0.04)**	**[0.11,0.25]**
Predominantly Solitary (Sol)	γ_{01}	1.01 (1.10)	[-1.17,3.20]
NonDistress-Initiated (NDI)	γ_{02}	**0.48*** (0.15)**	**[0.17,0.78]**
Distress-initiated (DI)	γ_{03}	**1.18*** (0.24)**	**[0.69,1.66]**
Infant Distress	γ_{04}	-0.02 (0.02)	[-0.05,0.01]
Sol X DI	γ_{05}	-0.32 (0.22)	[-0.26,1.33]
Sol X Age	γ_{11}	-0.27 (0.23)	[-0.76,0.11]
DI X Age	γ_{12}	**-0.11* (0.05)**	**[-0.21, -0.01]**
Sol X DI X Age	γ_{13}	-0.06 (0.08)	[-0.23,010]
Random Effects			
Variance intercept		9.42	[3.96,22.28]
Variance time		0.42	[0.18,.96]
Correlation intercept, time		-0.108	[-0.64,0.49]
Residual		24.01	
AIC		2699.64	

Note. Unstandardized coefficients and standard errors (between parentheses) are presented. N=107 families providing 409 observations. Covariates are group mean centered. Intercept centered at 1 month. Higher parameter values indicate differences favoring families who are predominantly solitary sleepers and have more non distress-initiated interventions and more distress-initiated interventions at 1 and 3 months. Bold font highlights significant findings, *p<.05, ** p<.01, ***p<.001.

APPENDIX B
FIGURES 1-4

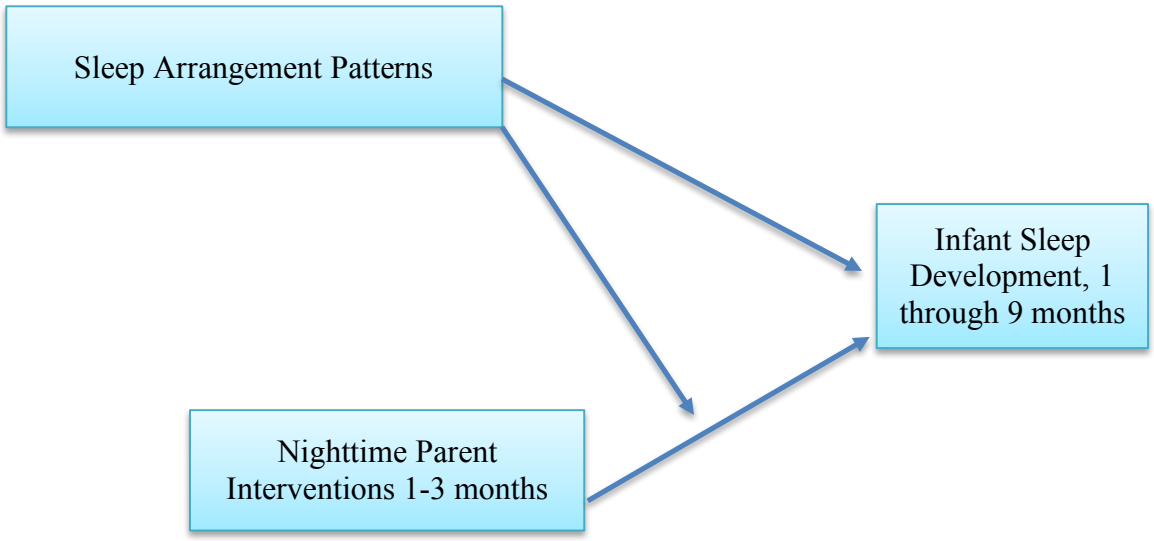

Figure 1. Nighttime parenting practices at 1 month of age, sleep arrangements across the first 9 months, and infant sleep development

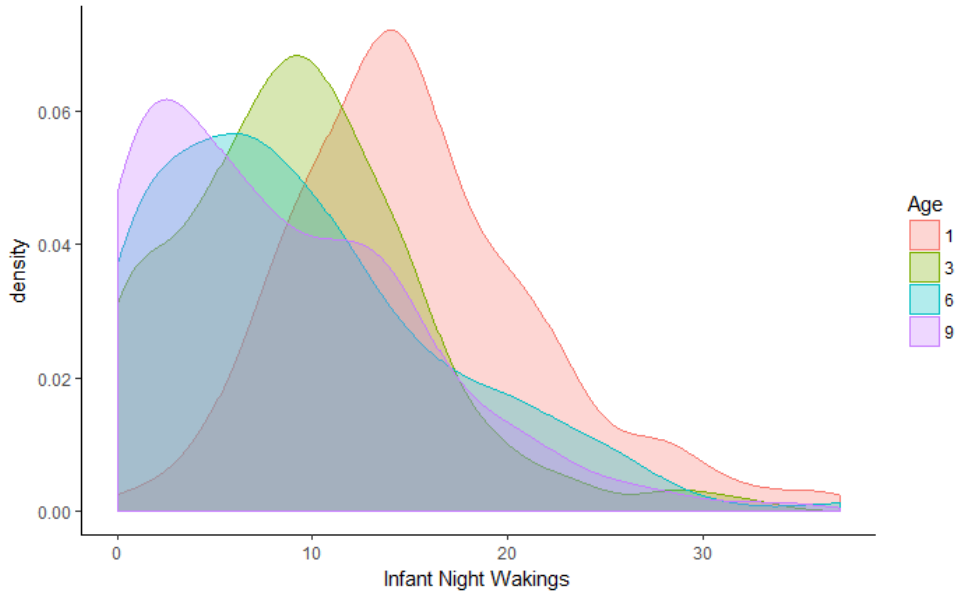

Figure 2. Density plot of Infant Night Wakings from Month 1 to Month 9

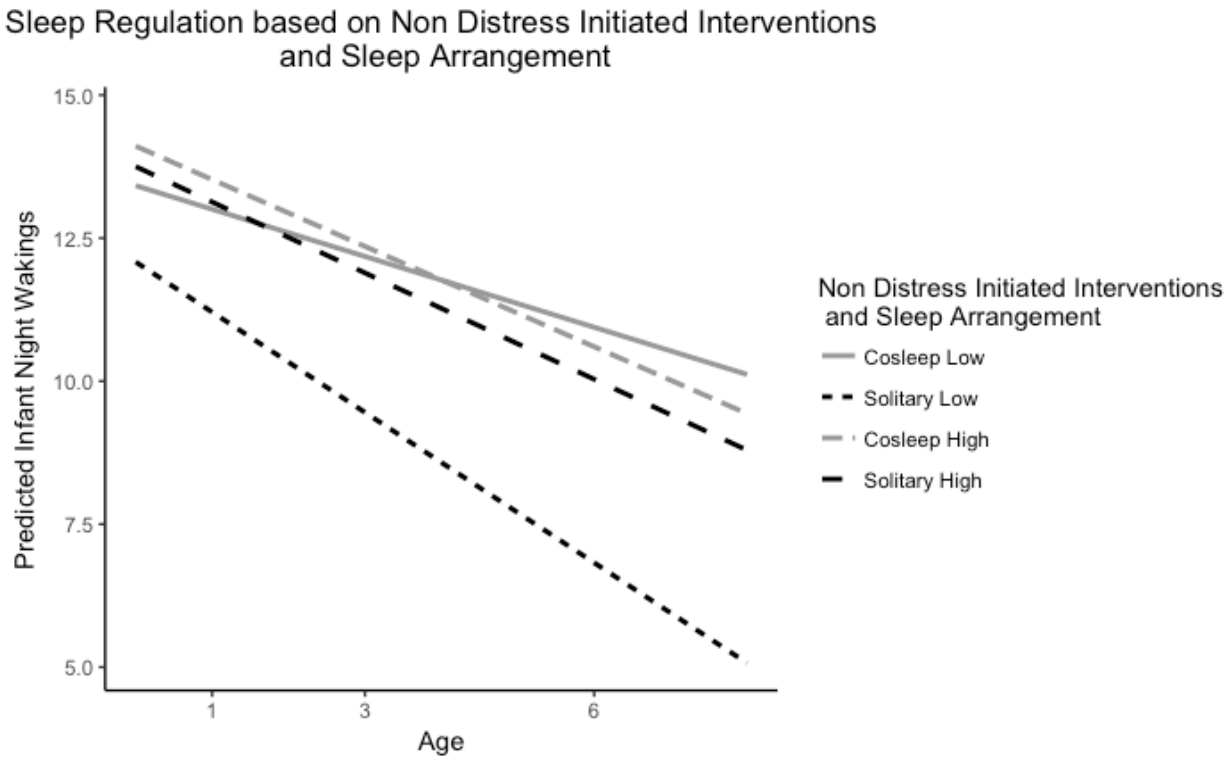

Figure 3. Infant sleep regulation by levels of non-distress-initiated interventions and sleep arrangement.

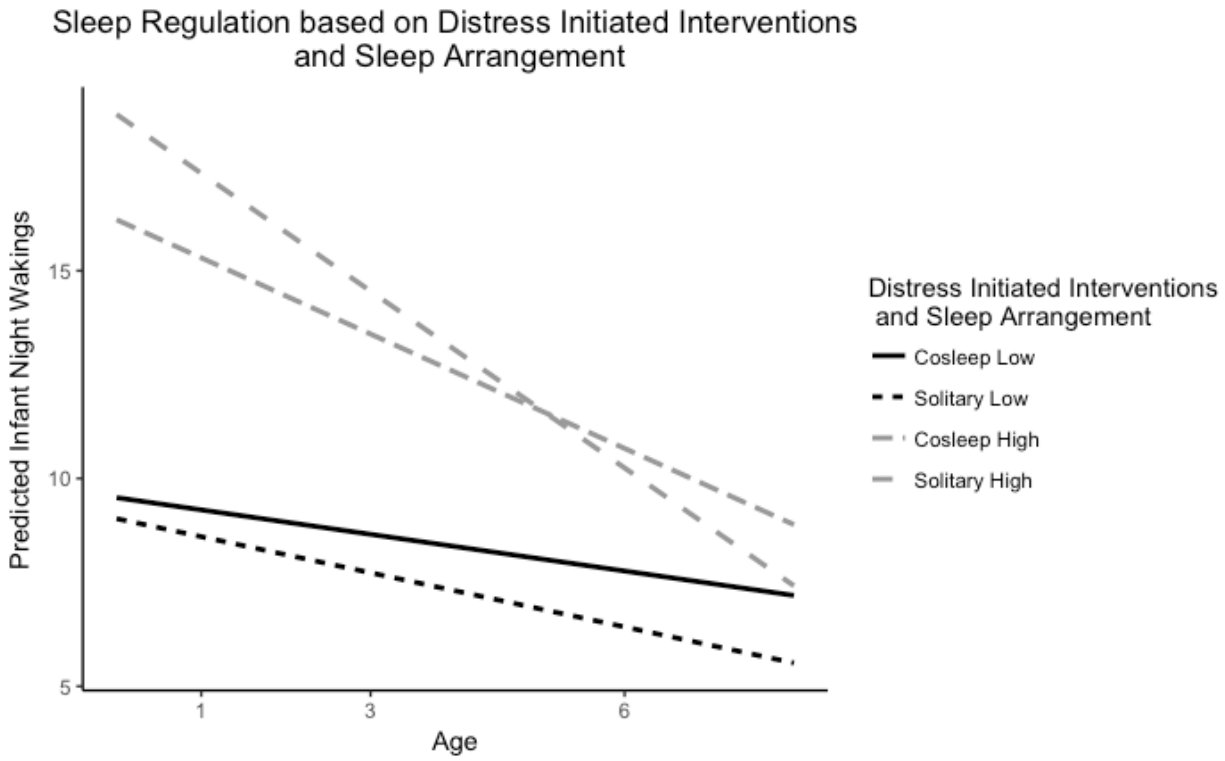

Figure 4. Infant sleep regulation based on levels of distress-initiated interventions and infant distress at 1 and 3 months.

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