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Maternal Executive Function and Sleep Interact in the Prediction of Negative Parenting

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Abstract

Objective/Background: Poorer executive function (EF) has been implicated in the etiology of negative parenting (e.g., harsh, reactive, intrusive). EF may be affected by good or poor quality sleep, and thus sleep may be involved in negative parenting. In the current exploratory study, we investigated the additive and interactive effects of maternal EF and sleep indicators in the statistical prediction of negative parenting.

Patients/Methods: A sample of 241 mothers of 2.5 yr-olds (51% girls) completed questionnaires, wore wrist actigraphs for one week, and completed several EF tasks during a laboratory visit.

Results/Conclusions: We found that sleep activity (e.g., nighttime waking and movements) interacted with EF in predicting negative parenting practices, such that poorer EF was linked with more negative parenting only in the context of higher levels of night waking. Sleep duration also interacted with EF, such that EF and parenting were no longer associated when sleep durations were short. The findings have implications for incorporating sleep into our understanding of maternal cognitive self-regulation and harsh parenting during early childhood development.

Keywords

sleep; nighttime waking; executive function; parenting; toddlers

Cognitive regulation includes capacities to plan, pay attention to stimuli, avoid distractions, hold relevant information in memory, and control impulses. Executive function (EF) is a key aspect of cognitive, emotion, and behavior regulation (Miyake & Friedman, 2012). EF can be impaired by fatigue arising from poor sleep quality (Wilkins, Woo, Kirk & Erikson, 2014). Both poorer sleep and EF deficits have been found to contribute to greater negativity in parenting behavior, such as verbosity, laxness, overreactivity, harshness, conflict, and low sensitivity (McQuillan, Bates, Staples, El-Mallah & Deater-Deckard, in press; Crandall, Deater-Deckard & Riley, 2015), but it is not known whether parental EF and sleep deficits are redundant, additive, or interactive in their associations with negative parenting behaviors. Thus, our goal was to conduct the first study to examine the potential additive and

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interactive statistical effects of poorer EF and sleep on negative parenting in a community sample of mothers with 30-month old toddlers.

EF and Negative Parenting

Negative parenting is commonly studied in relation to EF task performance deficits across one or several inter-correlated EF tasks spanning working memory, inhibitory control, attention/set shifting, and planning (Crandall et al., 2015; Friedman, Miyake, Young, DeFries, Corley & Hewitt, 2008). Several earlier studies established a key role for maternal working memory and general EF deficits in moderating the link between challenging child behavior problems and harsh reactive parenting behavior, such that mothers with poorer working memory exhibited harsher parenting when faced with challenging child behavior (Deater-Deckard, Sewell, Petrill & Thompson, 2010; Deater-Deckard, Wang, Chen & 2012). More recent work has replicated and extended those initial results, showing that maternal EF deficits are linked with biased social cognitions and child maltreatment (Azar, McGuier, Miller, Hernandez-Mekonnen & Johnson, 2017; Chico, Gonzalez, Ali, Steiner & Fleming, 2014), history of exposure to negative parenting in childhood and one's own negative parenting in adulthood (Bridgett, Kanya, Rutherford, & Mayes, 2017), and with harsher parenting among highly stressed sub-groups of mothers (Monn, Narayan, Kolstabakken, Schubert & Masten, 2017). Thus, the literature suggests that maternal cognitive regulation capacity plays an important role in the etiology of negative parenting behaviors and emotions.

Sleep, EF, and Parenting

Although most research on parental sleep after the postpartum and infancy periods has focused on children with chronic illness, some research suggests that poor parental sleep may play a role in parenting typically developing children, too. For instance, parents of young children frequently experience disrupted sleep due to their children's nighttime waking (Hunter, Rychnovsky & Yount, 2009; Kennedy, Gardiner, Gay & Lee, 2007; Gau & Merikangas, 2004; Bell & Belsky, 2008). Many caregivers are able to cope, but for some, the chronic sleep disruption due to child sleep problems, such as night wakings, is associated with negative affect and distress in parenting (Meltzer & Mindell, 2007; Mindell, Sadeh, Kwon & Goh, 2015). Mothers' own night wakings are correlated with their reports of child night wakings, and they are also linked with caregiving overload (Meltzer & Mindell, 2007). In terms of effects on parenting behavior, a longitudinal study of third graders found that high levels of child sleep problems were associated with adverse changes in mother sensitivity and conflict when the children were in sixth grade (Bell & Belsky, 2008). Studies have also shown that parental fatigue is associated with lower levels of warmth/sensitivity and higher levels of hostility and irritability in parenting (Chau & Giallo, 2015; Lesnoiwska, Gent & Watson, 2016), but they have not yet directly measured parent sleep. Furthermore, although there is some work on the effects of directly measured parental sleep on the perception of attachment relationships with their infants (Tikotzky, Chambers, Kent, Kaylor & Manber, 2012), community sample studies have not directly measured parents' sleep in relation their parenting *behaviors*, nor have they examined these processes in mothers of *toddlers*. The present study addresses these gaps.

Disrupted sleep may adversely affect a parent's capacity for sensitive, responsive and engaged parenting in many ways. For example, it may be related to poorer parenting because of its effects on parents' cognitive regulation capacity, critical for responding in effective ways to child behavior challenges and other stressors. Studies of adults have shown that shorter sleep duration and a lower ratio of total sleep time to time in bed (i.e., poor sleep efficiency) are linked to poorer cognitive vigilance, memory, speed and attention (Miyata et al., 2013; Fernandez-Mendoza et al., 2010; Alhola & Polo-Kantola, 2007). This effect on poorer EF performance can be induced with just one night of sleep deprivation (Nilsson et al., 2005). In a study of experimentally induced sleep restriction in young adults, it was found that reaction times in verbal and arithmetic working memory tasks were impaired in the group that underwent multiple days of partial sleep deprivation (Jiang, Vandyke, Zhang, Li, Gozal & Chen, 2011). Other research shows that various aspects of cognitive performance, such as increased perseveration errors, difficulty incorporating new information, and poorer attention and working memory, are affected by short and long episodes of sleep deprivation (Alhola & Polo-Kantola, 2007).

To our knowledge, although there has been some work on sleep and its effects on basic cognitive functioning in mothers and children (Plessow, Kiesel, Petzold, Kirschbaum & 2011; Insana, Williams & Montgomery-Downs, 2013; Buckhalt, El-Sheik & Keller, 2007), there are no studies that have looked at the interaction of EF and night waking, timing of sleep, and night-to-night sleep variability in mothers of young toddlers. Studies have not examined these various aspects of maternal sleep alongside EF capacities or deficits, in explaining variability in maternal harsh, negative parenting behavior. Our aim was to fill these gaps in knowledge by examining maternal EF and four domains of poor sleep: short duration, later sleep timing, greater night-to-night sleep variability, and more frequent nighttime activity/waking. We also controlled for general cognitive ability as a covariate.

Based on the prior literature, it stands to reason that poorer EF performance and poorer sleep would covary, and that both would be associated with more negative parenting behavior (Crandall, Deater-Deckard & Riley, 2015; McQuillan et al., in press; Tu, Elmore-Staton, Buckhalt, & El-Sheik, 2018). However, we did not have a hypothesis regarding whether each (or only some) of the distinct sleep variables (i.e., night waking, duration, variability, and timing) and EF would independently and additively contribute to variance in parenting. Regarding the potential interaction between EF and each of the sleep components, we tested for these effects to explore whether such processes were present. Again, we did not have a hypothesis regarding the specific interactive effect that would be present. However, if a nonadditive effect was evident, it would likely conform to one of two competing processes. The first is one in which EF is most *strongly* linked with parenting, when sleep is poor. This pattern would fit with a cumulative stressor/risk model, in which nonadditive combinations of specific stressors or risks best account for variability in the outcome of interest (Evans, Li, & Whipple, 2013). Alternatively, a second possibility is that *EF is not linked* with parenting when sleep is poor, because in the face of poor sleep the parent's EF capacity no longer conveys a beneficial effect for parenting. This pattern would be consistent with the idea that stressors or risk factors (in this case, poor parental sleep) can override the potential beneficial effects of a salutary predictor (in this case, parental EF) (Deater-Deckard et al., 2012). For any statistically significant EF-by-sleep interaction terms

found in our exploratory analyses, we conducted post-hoc probing to test for these potential patterns.

Method

Participants

The following sample was part of a longitudinal study on mother and toddler sleep that assessed objective and subjective measures of sleep in both parents and toddlers at 30 months, 36 months and 42 months. For the purposes of this paper, we focus on data obtained when children were 30 months of age, because data cleaning and preparation are still ongoing at the subsequent waves. We focused on 30-month-olds for the initial wave, because it is at this point in development when parenting stress levels are at their highest across early childhood (Williford, Calkins, & Keane, 2007). The total sample included 241 mother–child dyads with 84% having wrist actigraph data. Mothers were 21–50 years old, $M = 32.73$, $SD = 5.15$. Children were 30 months old, on average ($SD = 0.94$ months) (49% boys). Eighty percent of mothers were Caucasian, 3.7% were Hispanic, 1.9% were African American, 1.2% were Asian American, 0.4% were American Indian and 2% identified as mixed race. Eighty-four percent of the mothers were married, 4% were divorced, separated, or remarried, and the remaining 12% were single mothers. In 30 percent of the families, the study child was the only child, in 57% the child had one or two siblings, and 13% had 3 or more.

Participants were recruited using a variety of advertising methods in the two communities in which the study was conducted, including enrollment events, online and newspaper advertising, and placement of flyers in childcare centers and libraries, as well as through a departmental database. Mothers received honoraria, and toddlers received small gifts. The research was approved by the Institutional Review Boards of the two research sites.

Procedures—Following a consenting procedure that took place at the home, mothers were given an actigraph to wear on the nondominant wrist for 24 hours a day for seven days, a sleep diary to complete each day during the same week, and a questionnaire packet. The following week, mothers visited the laboratory to complete a battery of EF tasks and return the actigraph, sleep diary, and questionnaire packet.

Measures

Sleep.—The actigraph, the MicroMini Motionlogger from Ambulatory Monitoring, Inc. (AMI; Ardsley, NY), recorded minute-by-minute patterns of motor activity. The Cole-Kripke algorithm was used to extract estimates of sleep indices (Cole, Kripke, Gruen, Mullaney & Gillin, 1992). Mothers were also asked to complete a sleep diary recording the time they went to bed, the time they woke up, and any nap times. Both measures were used to determine amount of sleep per night and amount of nighttime activity. Night waking was scored when the activity count was above the activity threshold for at least five minutes. The amount of time asleep in bed and sleep onset time was based on actigraphy, whereas bed time was determined based on mother report. The actigraphic indexes included a wide range of the many measures taken from the minute-by-minute record of activity, which allows for psychometric refinement of often used constructs considered in sleep research.

Four sleep components were estimated from the many actigraph and sleep diary variables. Based on analyses with a separate sample (Hoyniak, Bates, Staples, Rudasill, Molfese & Molfese, 2018), a Principal Components Analysis (PCA) with oblique rotation (to allow for covariation between components) was used to extract four overarching sleep components: 1) Variability, 2) Timing, 3) Duration, and 4) Activity, that together explained 82% of the variance in indicators. These four components represent broad dimensions of actigraphy that are often examined in sleep research using single variables, without taking advantage of the benefits to reliability and validity of multi-variable aggregated composite scores (Meltzer, Montgomery-Downs, Insana, & Walsh, 2012). The sleep components have shown strong predictive validity in analyses regarding toddlers' cognitive development (Hoyniak et al., 2018) and mothers' stress and parenting (McQuillan, Bates, Staples, & Deater-Deckard, in press).

We chose to use composites when examining our actigraphy data for several reasons. First, a survey of the sleep literature observed wide differences across studies in the selection and use of actigraph variables (Meltzer et al., 2012). We sought to systematically examine multiple dimensions of sleep without re-running analyses for each of the numerous variables exported. Second, aggregate composite measures provide important measurement advantages over single variables, including better reliability and validity and a reduction in type 1 error through estimation of far fewer statistical parameters (Rushton, Brainerd, & Pressley, 1983). Using these composites allow us to parsimoniously examine important sleep features without having to run, and correct for, as many tests as we would in a comprehensive single variable analysis.

As described in detail next, the daily diary and actigraphic variables that compose each of the four sleep components were each averaged across the week of data collection. The weekly-averages of each variable were then standardized (z-scored) based on sample values. The standardized variables were then aggregated together to form the sleep component. *Sleep duration* captured 1) the amount of time the mother spent in bed each night, 2) the amount of time the mother spent in bed after sleep onset, and 3) the time the mother spent asleep each night (excluding night wakings). *Sleep variability* was represented by the night to night standard deviations of 1) time of mother's sleep onset, 2) time of mother's reported bedtime, 3) time at which the mid-point of sleep occurred, 4) duration of time spent in bed at night between diary reported bedtime and actigraph determined morning awakening, 5) duration of sleep period between sleep onset and sleep offset, and 6) total minutes asleep (excluding night wakings). *Sleep timing* was composed of 1) the average time of midsleep, 2) average time of sleep onset, and 3) the average bedtime reported in the sleep diary. Finally, *sleep activity* was measured as 1) the average amount of time awake after sleep onset, 2) average minute-to-minute activity level while asleep, 3) average number of night wakings lasting at least five minutes, 4) average duration of the longest wake episode after sleep onset, and 5) average percent of epochs marked as active after sleep onset. An active epoch occurs when the motor activity count is above 50. Sleep activity was therefore construed as the average amount of nighttime waking and activity across the week of data collection.

Of the total sample, 84% had at least five nights of usable data, but we retained all cases with any actigraphy data for maximum data retention: 16% of mothers were missing some actigraphy data due to refusal to wear actigraphs ($n=6$), actigraphic equipment failure ($n=42$), or lost actigraphs ($n=2$). For the 84% of the total sample with actigraphic data, mothers provided, on average, 6.76 days of data ($SD=1.46$ days), which was in accordance with guidelines to collect at least five days of actigraphy data for reliable estimates (Acebo et al., 1999; Sadeh, 2015).

Executive Function (EF).—Our measurement of EF included aspects of attention/set shifting, inhibitory control, and working memory (Miyake & Friedman, 2012). We chose to assess an overall EF score instead of specific components of EF since it would give us a comprehensive measure of higher order cognitive regulation without requiring the administration of many tasks (i.e., a minimum of three tasks per theorized EF construct, for adequate measurement testing using confirmatory factor analysis techniques). Task “impurity” makes it difficult to parse out which EF tasks correspond to which theorized dimensions of EF; all task scores correlate with one another because they tap into the general EF ability variance (Miyake & Friedman, 2000). Mothers completed three standard EF tasks on a computer: Tower of Hanoi (Davis & Klebe, 2001), Wisconsin Card Sort (Heaton & PAR Staff, 2003), and Stroop Color-Word (Stroop, 1935). They also completed a backward digit span task while face to face with a research assistant who recorded their responses on a score sheet. Tower of Hanoi involved using a mouse to move three disks of different sizes to a target peg, keeping the original order and following two rules: only one disk could be moved each turn, and larger disks could not be placed on smaller disks. Time to completion was used as the score for the task, $M=33.17$ sec, $SD=16.89$ sec. This was reverse scored for analyses, so that a higher score corresponded with better performance. For the Wisconsin Card Sort task, mothers were presented with computer images of four stimulus cards with different colors, quantities, and shapes and were asked to match a stack of cards to the original stimulus cards according to a matching rule (i.e., either by color, quantity or shape). The matching rule changed without warning, and the participant had to infer the new rule based on feedback from the computer regarding correct and incorrect responses. We used total number of correct trials (reflexed, log transformed, and again reflexed to transform to reduce skew), $M=51.90$ trials, $SD=7.32$ trials. For the Stroop task, mothers selected a keyboard key representing various colors. The task involved four blocks of 20 trials each: select color key corresponding to the name of the color written in black ink; select color key corresponding to the ink color of the matching color word (i.e., congruent condition); select color key corresponding to ink color of a nonmatching color word (i.e., incongruent condition); and finally, select color key based on the ink color of a matching or nonmatching color word (i.e., mixed congruent and incongruent condition). We used the percent of correct responses during the mixed congruent and incongruent trial block, $M=96.52\%$, $SD=10.21\%$. For backward digit span, an experimenter directly faced the participant and read a random sequence of single-digit numbers (0–9) at the rate of one digit/second, which the participant attempted to reproduce in reverse. Each participant was given two chances to correctly reproduce the sequence in reverse, and the task ended when the participant got two consecutive sequences wrong. We used the highest sequence length correctly completed, $M=5.86$ digits, $SD=1.36$ digits.

Since our goal was to assess an overall EF score, we standardized all four task scores and examined them as a set using principal components analysis—a procedure used in prior studies of parenting and adult EF (e.g., Cuevas et al., 2014; Deater-Deckard et al., 2012). The first principal component accounted for 40% of the variance, and absolute values of loadings ranged from 0.49 to 0.72. All four task scores were averaged to yield a composite EF z-score that was widely and normally distributed. Mothers with two or more of the four task scores were included ($n = 233$); those with only one completed task did not receive a composite EF z-score ($n = 8$).

Negative Parenting.—Mothers completed the Parenting Scale (Arnold, O’Leary, Wolff, & Acker, 1993) to rate their discipline behaviors on 30 seven-point Likert scaled items, which were used to create three composite scores: laxness, overreactivity, and verbosity in parenting, and a higher order composite scale, referred to as negative parenting, which was the average of all items ($\alpha = .70$). For each item, mothers were asked to fill in the circle that best described their parenting between two statements such as “When my child behaves, I do something about it right away” to “I do something about it later”. Examples of the items measuring laxness were “I threaten to do things that I am sure to carry out” to “I know I won’t actually do”, and “When I want my child to stop doing something, I firmly tell my child to stop” to “I coax or beg my child to stop.” Example of items measuring overreactivity were “When my child misbehaves, I handle it without getting upset” to “I get so frustrated or angry that my child can see I’m upset”, and “When I’m upset or under stress, I am picky and on my child’s back” to “I am no more picky than usual”. Examples of items measuring verbosity were “If saying no doesn’t work right away, I take some other kind of action” to “I keep talking and try to get through to my child”, and “If my child talks back or complains when I handle a problem, I ignore the complaining and stick to what I said” to “I give my child a talk about not complaining.”

General Cognitive Ability.—General cognitive ability was included as a covariate in the analyses. We administered the Shipley (1940) as a measure of general cognitive functioning. The vocabulary task (40 items) required participants to underline the word (out of four choices) which was most similar in meaning to the target word. The abstract reasoning task (20 items) involved the participants completing a blank space in a complex pattern of numbers or letters. The total raw score was obtained by summing the raw scores on both the tasks, and this was compared to age-norms to derive the IQ scale score (Zachary & Shipley, 1986).

Results

All variables were widely and normally distributed, except for Shipley IQ scores which were negatively skewed (skewness = -1.63). Descriptive statistics and correlations between study variables are shown in Table 1a and 1b. For the all the sleep composite z-scores, all mean scores represent averages across the week, average amount of nighttime waking, average duration of sleep, average variability in sleep and average timing of sleep. Mean composite z-scores for EF also represented each mother’s average EF score across tasks relative to others in the sample. For negative parenting, the mean was just below three on the 7-point scale, suggesting that overall, mothers reported levels of negative parenting in the lower end

of the potential score distribution for the instrument. However, the distribution of scores was normal, and there was ample variability. The IQ score mean was 6 IQ points above the normative average of 100. There was ample variability ($range = 67-125$), though the distribution showed some range restriction in variance when compared to the normative SD of 15.

As shown in Table 1b, lower EF and IQ scores covaried as expected, and both were associated with more sleep activity and more negative parenting. More sleep variability, later timing of sleep, and shorter sleep durations all covaried with each other, but among these, only greater sleep variability was significantly correlated with more negative parenting. Shorter sleep duration and more sleep activity also covaried, but were not significantly correlated with parenting.

To explore all potential additive and interactive effects, we estimated a hierarchical multiple regression equation predicting negative parenting with IQ score and EF, as well as the main effects of all four sleep variables (step 1), followed by entry of the four two-way interactions between each of the sleep variables with EF. The full equation was significant, $F(10, 208) = 3.45, p < .001$. The only main effect was Shipley IQ score, and there were two significant two-way interaction effects: sleep activity by EF and sleep duration by EF.

To interpret the two-way interaction between sleep activity and EF, we conducted post-hoc probing using estimation of simple slopes at the mean, and at 2 SD and 1 SD above and below the sample mean, of sleep activity. We chose these multiple levels of the moderator to fully explore the overall pattern of the moderation effect across the range of the moderator variable. Poorer EF was most strongly predictive of more negative parenting, at high levels of sleep activity (2 SD above: $\beta = -.43, p = .001$; 1 SD above: $\beta = -.26, p = .002$). In contrast, the association between EF and negative parenting was modest and nonsignificant at mean and low levels of sleep activity (e.g., mean: $\beta = .09, p = .181$; 1 SD below: $\beta = .07, p = .512$; 2 SD below: $\beta = .24, p = .152$). Since Shipley scores were correlated with EF, we included them in the post-hoc simple slopes probing to see if the results changed. The pattern of the simple slopes remained the same (see Figure 1); however, the effect sizes of the slopes at 1 SD and 2 SD above mean sleep activity were reduced somewhat (2 SD above: $\beta = -.25, p = .083$; 1 SD above: $\beta = -.13, p = .185$; mean: $\beta = -.004, p = .962$; 1 SD below: $\beta = .12, p = .298$ and 2 SD below: $\beta = .24, p = .153$).

To interpret the two-way interaction term between sleep duration and EF, we conducted post-hoc probing using simple slopes at 2 SD and 1 SD above and below the sample mean of sleep duration. EF capacity was significantly predictive of lower levels of negative parenting at high and average levels of sleep duration (2 SD above: $\beta = -.40, p = .028$; 1 SD above: $\beta = -.29, p = .012$; mean: $\beta = -.19, p = .007$). In contrast, EF was not related to negative parenting at low levels of sleep duration (1 SD below: $\beta = -.09, p = .275$; 2 SD below: $\beta = .01, p = .938$). We re-ran the simple slopes analyses including Shipley score as a covariate. The pattern of results remained the same (see Figure 2): 2 SD above: $\beta = -.39, p = .032$; 1 SD above: $\beta = -.24, p = .049$, mean: $\beta = -.09, p = .283$; 1 SD below: $\beta = .06, p = .492$; 2 SD below: $\beta = .21, p = .137$.

Finally, we conducted two additional sets of post-hoc analyses, to address some remaining questions. First, we considered the possibility that EF was the moderator rather than sleep being the moderator, in the two significant interactive effects. To test this possibility, we estimated simple slopes between sleep activity and duration in prediction of variance in negative parenting, across levels of EF. None of the simple slopes was significant, indicating that the sleep variables were the functional moderators in the statistical models reported above. Second, we considered whether effects varied across the three subscales of negative parenting (i.e., laxness, verbosity and overreactivity). To examine this, we estimated the simple slope equations again, separately for each of the three parenting subscales. For laxness and verbosity, the slope estimates were very similar to those reported for the overall parenting scale; in contrast, none of the simple slopes was significant for overreactivity.

Discussion

There is rapidly mounting evidence that poor maternal EF and its related features (e.g., attention problems, physiological dysregulation) are risk factors for harsher parenting, as described in recent journal special sections on this topic (*Journal of Family Psychology*, 2017, volume 31, issues 1 and 2; *Journal of Abnormal Child Psychology*, 2017, volume 45, issue 3). The emerging interpretation is that mothers with cognitive regulation deficits are more emotionally and behaviorally reactive and engage in harsher parenting practices as a result (Crandall, Deater-Deckard & Riley, 2015). In a separate literature, research on parental fatigue implicates it as a risk factor for negative parenting practices such as higher levels of hostility, and lower levels of warmth (Chau & Giallo, 2015; Cooklin, Giallo & Rose, 2012; Lesniowska, Gent & Watson, 2016; McQuillan et al., in press; Tu et al., 2018). Child night waking has been shown to covary with mother night waking, and it has been identified as a risk factor for higher distress in parenting (Meltzer & Mindell, 2007; Mindell, Sadeh, Kwon & Goh, 2015). Child sleep problems over time have been shown to be predictive of higher levels of conflict and lower levels of closeness and sensitivity in the mother child relationship (Bell & Belsky, 2008).

No prior studies of parenting, EF, and sleep have directly tested objective measures of maternal sleep and its potential additive and interactive effects with EF deficits, in the etiology of harsh parenting. This is a noteworthy gap, given the ample evidence showing that poorer sleep degrades cognitive regulation among adults (Nilsson et al., 2015; Plessow et al., 2011). To our knowledge, the current study is the first to look at the links between objective measures of sleep and EF with parenting, of typically developing toddlers.

We analyzed four multivariate sleep indexes derived from actigraphy and diary data—sleep duration, timing, variability, and night activity. As part of the investigation, we explored interactive effects because the role of EF in parenting behavior may depend on other parental factors, such as sleep quality, that can affect cognitive process in mothers (Plessow et al., 2011). We explored two competing possibilities—that the link between EF and parenting would be particularly strong in the context of poor sleep (reflecting a nonlinear cumulative risk effect of the combination of poor sleep and poor EF; Evans et al., 2013), versus the link between EF and parenting being negligible in the context of poor sleep (reflecting an

overriding effect of low-quality sleep; e.g., Deater-Deckard et al., 2012, for an example of an overriding effect of family environment stressors).

Overall, we found no evidence of simple additive effects for any of the sleep variables or EF; zero-order correlations with parenting were modest and mostly nonsignificant; in the regression model (see Table 2), none of the main effects was significant. However, for two of the four sleep variables, we found significant interactive effects with EF. First, for sleep activity (i.e., night waking and restlessness), there was a significant negative interaction with EF in the prediction of self-reported negative parenting. The interactive effect for sleep activity was consistent with a nonlinear cumulative stressor/risk effect: poorer EF was most strongly predictive of more negative parenting, for mothers who also had average to high levels of sleep activity (i.e., poor sleep). In contrast, for those mothers with low sleep activity (i.e., good sleep quality), the association between EF and self-reported parenting was negligible and not statistically significant.

Various studies on mother and child sleep have found that child nighttime waking is a risk factor for higher parental stress and negative mood (Meltzer & Mindell, 2007; Mindell, Sadeh, Kwon & Goh, 2015). Night activity in children has been shown to have associations with coercive parenting (Zaidman-Zait & Hall, 2015). These studies have used mother reports regarding child and self sleep variables. We expanded on these findings by using objective measures of sleep. The findings from the current study suggest a similarly important role for maternal nighttime motor activity, or fragmentation of sleep, at least in interaction with mothers' EF deficits, in explaining individual differences in negative parenting practices.

Second, for sleep duration, we also found a significant negative interaction effect with EF. Our interpretation of this interaction pattern was distinct from that of sleep activity, because it was consistent with an "overriding" effect of poor sleep. Stronger EF capacity was linked with less negative parenting as found in prior research, but only at moderate to long sleep durations—in contrast, there was no association with parenting when sleep durations were short (i.e., poor sleep). Although there are some studies on children with illnesses showing that mothers of young children report shorter amounts of total sleep (McBean & Schlosnagle, 2016; McCann, Bull, & Winzenberg, 2015), there is no literature on the intersection of sleep duration and parenting behaviors that we could use to interpret this "overriding" interactive effect. However, it is clear from the broader sleep literature that shorter sleep duration is indicative of not only poorer quality sleep but also of acute and chronic stress, as well as poorer sleep hygiene in youth and adults (Brown, Buboltz, & Soper, 2002; Olds, Maher, & Matricciani, 2011; Otsuka et al., 2017). Our findings suggest that poor sleep, when indicated by short duration, overrides any potential effect of better cognitive self-regulation in minimizing negative parenting for mothers of toddlers. This effect is consistent with a prior study (Deater-Deckard et al., 2012) which reported that at higher levels of chronic stress exposure, maternal EF no longer played a role in explaining differences in maternal harsh parenting.

It is important to note that unlike sleep activity (i.e., fragmentation, which is considered to be indicative of poor sleep), the interpretation of longer sleep durations is more complicated.

Although it seems intuitive to interpret “longer sleep is better”, there is some literature suggesting otherwise. For instance, there are detrimental causes and consequences of longer sleep durations, for both mental health concerns such as depression (Zhai, Zhang & Zhang, 2015) and physical health concerns such as type-2 diabetes and cardiovascular disease (Shan et al., 2015). It is possible that this is true for mothers in this study as well, i.e., mothers with poorer cognitive regulation and longer sleep duration were suffering from poorer sleep quality. However, we were not able to address this in our study.

Several limitations must be considered when interpreting our results. First, the study design was correlational and cross-sectional, so causal mechanisms cannot be established. Second, mothers reported their negative parenting behavior, so the association between their EF task performance and sleep activity/duration may not generalize to observed parenting behavior. Third, although there are distinct advantages to objective measurement of body movement via actigraphy to operationalize various components of sleep, the findings may not generalize to subjective self-reported indicators of sleep experiences and qualities. In addition, actigraphy has been shown to be highly sensitive to movements, thus resulting in both underestimation and overestimation of night activity/wakings relative to polysomnographic measures (Sadeh, 2011; Meltzer, Montgomery-Downs, Insana & Walsh, 2012a). Fourth, although our study sample was diverse in terms of maternal age and socioeconomic indicators, the sample was not representative of the full population, and the results may not generalize to other ethnically and culturally distinct groups of families.

With these caveats aside, our findings suggest the usefulness of incorporating parental sleep into theoretical and empirical models of parental cognitive self-regulation and negative parenting. Taken together, the findings indicate that for mothers of toddlers, night waking and duration of sleep may play unique roles that qualitatively alter the role of maternal cognitive self-regulation in the etiology of harsh, negative versus positive parenting behaviors. If replicated, the results point to multiple sleep factors as well as EF all playing distinct interactive roles in explaining individual differences in parenting behavior. These processes may differ substantially depending on the specific aspect of sleep (e.g., sleep duration versus nighttime activity) in question.

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Figure 1:
Maternal EF and Negative Parenting As A Function of Sleep Activity
Standardized slopes between mother EF performance and self-reported negative parenting as function of sleep activity controlling for Shipley scores. Effect sizes of varying levels of sleep activity levels (Std Dev = standard deviations above [+] or below [-] mean).

Figure 2:

Maternal EF and Negative Parenting As A Function of Sleep Duration

Standardized slopes between mother EF performance and self-reported negative parenting as function of sleep duration controlling for Shipley scores. Effect sizes of varying levels of sleep duration levels (Std Dev = standard deviations above [+] or below [-] mean).

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Table 1a.

Descriptive Statistics	Mean SD	
	Mean	SD
1.Stroop	96.52	10.22
2.WCSt	1.08	.17
3.ToH	33.23	16.90
4.Digit	5.86	1.36
5.EF	-.02	.64
6.Ship.	106.47	9.48
7.Slp V.	.06	.85
8.Slp T.	.01	.96
9.Slp D.	-.05	.87
10.Slp A	-.06	.86
11.Lax.	2.56	.74
12.Verb.	3.34	.82
13.Overr.	2.37	.59
14.Neg P.	2.76	.52

Table 1b.

Correlations

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1.Stroop	1												
2.WCSt	-.27 ^{***}	1	ToH										
3.ToH	-.06	.13	1	Digit									
4.Digit	.2 ^{**}	-.29 ^{***}	.24 ^{***}	1	EF								
5.EF	.27 ^{***}	.67 ^{***}	.57 ^{***}	.69 ^{***}	1	Ship							
6.Ship	.35 ^{***}	-.35 ^{***}	-.24 ^{***}	.36 ^{***}	.5 ^{***}	1	Slp V						
7.Slp V	-.04	.13	.03	-.11	-.13 [*]	-.12	1	Slp T					
8.Slp T	.03	.04	-.01	-.01	-.03	-.04	.36 ^{**}	1	Slp D				
9.Slp D	-.07	-.19 ^{**}	.05	.01	.10	.13	-.31 ^{***}	-.55 ^{***}	1	Slp A			
10.Slp A	-.17 [*]	.09	.16 [*]	-.05	-.18 ^{***}	-.22 ^{***}	.12	.03	-.16 ^{**}	1	Lax		
11.Lax	-.09	.02	.15 [*]	-.03	-.12	-.24 ^{***}	.07	-.03	.01	.14 [*]	1	Verb	
12.Verb	-.17 [*]	.11	.11	-.07	-.18 ^{***}	-.27 ^{***}	.1	.08	-.12	.11	.57 ^{***}	1	Overr
13.Overr	-.08	.10	.09	-.02	-.12	-.12	.18 ^{***}	.12	-.15	.00	.28 ^{***}	.41 ^{***}	1
14.Neg P	-.14 [*]	.09	.16 [*]	.05	-.17 ^{***}	-.29 ^{***}	.16 [*]	.07	-.11	.10	.83 ^{***}	.65 ^{***}	.8

* $p < .05$ *** $p < .01$ (all two-tailed tests).

WCSt = Wisconsin Card Sort; ToH = Tower of Hanoi; Digit = Digit span; EF = Executive function composite; Ship = Shipley IQ; Slp V = sleep variability (composite); Slp T = sleep timing (composite); Slp D = sleep duration (composite); Slp A = sleep activity (composite); Lax = Laxness; Verb = Verbosity; Overr = Overreactivity; Neg P = Negative parenting (composite)

Table 2

Hierarchical Multiple Regression Analysis Predicting Negative Parenting

	<i>B</i>	<i>S.E.</i>	β	<i>t</i>	<i>p</i>
Step 1:					
Executive Function (z)	-.02	.04	-.04	-.51	.613
Shipley IQ (z)	-.12	.04	-.24	-3.06	.003
Sleep Variability (z)	.05	.04	.10	1.37	.171
Sleep Timing (z)	-.003	.04	-.01	-.07	.943
Sleep Duration (z)	-.01	.04	-.02	-.28	.782
Sleep Activity (z)	-.002	.04	-.004	-.06	.952
Step 2:					
Sleep Variability X EF	.36	.03	.07	-1.07	.287
Sleep Timing X EF	-.02	.04	-.03	-.36	.723
Sleep Duration X EF	-.09	.04	-.18	-2.16	.032
Sleep Activity X EF	-.09	.04	-.20	-2.56	.011