LONGITUDINAL ASSOCIATIONS BETWEEN PARENTAL DAILY SLEEP,
MATERNAL DAILY MOOD, AND PARENTING

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by
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ABSTRACT

Parental mood disturbance and disrupted sleep are considered to be important predictors of parenting quality, particularly during the early postpartum period. Parents experience significant sleep loss and disturbances as they adapt to new demands of parenthood. In addition, mothers’ postpartum mood problems such as depression and anxiety, which have been known to be associated with postpartum sleep deprivation and disruptions, have been found to have negative influences on mothers’ early parenting quality. To date, few studies have examined longitudinal links between parental sleep, mood, and parenting in early infancy, and in particular studies that focus on both level and dynamics of parental daily mood in relation to sleep and parenting in early infancy are non-existent. Especially, mothers’ daily mood volatility may reflect an underlying self-regulatory capacity that may be predictive of parenting competence. This dissertation aimed to elucidate the daily associations between parental sleep and maternal mood (Study I), and the predictive linkages of maternal daily mood dynamics to early parenting quality, with particular attention on the emotional quality of parenting during infants’ bedtimes (Study II).

Data for both studies were drawn from a larger NIH-funded study of 167 families (Project SIESTA, R01HD052809). Study I used actigraphy assessments of parental sleep and daily diary data for maternal mood in multilevel modeling to examine how both mothers’ and fathers’ daily sleep and mothers’ daily mood were associated across 21 days of infants’ first six months. Fathers’ and mothers’ greater sleep efficiency, mothers’ longer sleep duration, and less sleep fragmentation during the previous night predicted better maternal mood the following day. Furthermore, mothers’ overall distress, in addition to its negative direct effect on their daily mood, moderated the daily link between parental sleep and maternal mood. More distressed mothers tended to report significantly worse mood than less distressed mothers, even on days
when they had less fragmented sleep and when fathers slept longer the night before. Study II used multilevel modeling to explore how dynamics of mothers’ daily mood, within-person variability as well as level of daily mood, were associated with maternal bedtime EA across infants’ first six months, after controlling for the effects of daily sleep dynamics. It was mothers’ day-to-day mood variability, but not the level of daily mood, that predicted mothers’ bedtime EA, indicating that mothers with higher daily mood variability showed lower bedtime EA.

Overall, this dissertation contributes to a growing body of literature addressing within-person associations between parental sleep and mood, and linking day-to-day variability of mothers’ mood with their bedtime parenting quality. Collectively, the two studies provide evidence for an underlying mechanism linking parental sleep, mood, and parenting during early infancy. The results also highlight the utility of daily diary approaches in studying parental well-being during the early postpartum period, and in particular in elucidating the dynamic linkages between parental sleep, mood, and parenting.
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General Introduction

Parenting quality is one of the most influential determinants of children’s socio-emotional and behavioral development (Chang, Schwartz, Dodge, & McBride-Chang, 2003; Dix, 1991; Kiang, Moreno, & Robinson, 2004). Parenting quality during infancy, particularly during early postpartum period, a time of laying a foundation for social and emotional interactions between prelinguistic infants and parents (Easterbrooks, Biesecker, & Lyons-Ruth, 2000), is especially important for infant development across a variety of domains, including infant sleep quality and attachment security (De Wolff & van Ijzendoorn, 1997; Sadeh, Tikotzky, & Scher, 2010; Teti, Kim, Mayer, & Counterine, 2010).

Parenting can be impacted by parent and infant factors, and predictors of early parenting quality include parental mood disturbance and disrupted sleep (Bayer, Hiscock, Hampton, & Wake, 2007; Grant et al., 2012; Meltzer & Mindell, 2007; Seymour, Giallo, Cooklin, & Dunning, 2014; Teti & Crosby, 2012). Mothers commonly experience significant sleep disturbances and deprivation as they adapt to new demands of motherhood (Matsumoto, Shinkoda, Kang, & Seo, 2003; Signal et al., 2007; Swain, O’Hara, Starr, & Gorman, 1997). Additionally, maternal postpartum mood disturbances such as depression and anxiety which are known to be associated with postpartum sleep disruptions (Dennis & Ross, 2005; Gay, Lee, & Lee, 2004; Goyal, Gay, & Lee, 2007, 2009) have been found to have negative impacts on mothers’ parental functioning and the mother-infant relationship (Conroy, Marks, Schacht, Davies, & Moran, 2010; Vliegen, Luyten, & Biringen, 2009). Examining the associations among parental sleep, mood and parenting during early postpartum period longitudinally, particularly with micro-bursts of data on sleep and mood, can shed light on the underlying mechanisms of how parental sleep and mood are related and how those factors predict parenting quality in early infancy.
The overall aim of the current dissertation was to elucidate the dynamic characteristics of parental daily sleep and mood and their linkages to early parenting quality. This study included daily diary data on parents’ sleep and mood during infants’ first 6 months and particularly focused on parenting in the context of mothers’ bedtime interactions with their infants. In this introduction, parental sleep, mood, and parenting during early infancy are first reviewed. Then, theory and empirical studies examining the links between parental sleep and mood as well as between parental mood and parenting are reviewed, followed by a discussion of how this dissertation contributes to the existing literature. Finally, an overview of the two studies conducted is provided.

Parental sleep, mood, and parenting in early infancy

Parental sleep

Postpartum mothers encounter a significant change in their sleep patterns that may lead to lack of sleep and sleep disturbances as they adjust to the new demands of motherhood (Dennis & Ross, 2005). Mothers have been found to sleep an average of 6.15 hours per night at 1 month postpartum (Quillin, 1997) and an average of 6.75 hours per night at 3 to 4 month postpartum (Cottrell & Karraker, 2002). In addition to the reduced amount of sleep time, mothers in the early postpartum period have consistently been shown to experience increased sleep disruptions including decreased sleep efficiency and circadian amplitude, increased wake after sleep onset (WASO) periods and sleep fragmentation, and more daytime napping (Goyal et al., 2009; Matsumoto et al., 2003; Swain et al., 1997). Even in cases of mothers reporting a higher average of nocturnal sleep time (7.2 hours) without significant changes across four postpartum months, their sleep was found to be highly fragmented and inefficient (Montgomery-Downs, 2010). The
most disturbed sleep patterns occurred during the first week of postpartum and seemed to improve over time, as newborns developed a circadian sleep-wake rhythm (Horiuchi & Nishihara, 1999; Nishihara & Horiuchi, 1998), although mothers’ sleep quality still was not the same as that of pregnancy (Signal et al., 2007; Swain et al., 1997).

Taking care of newborns has been found to be the most common and direct causes of parents’ postpartum sleep disturbances, specifically caring for infants’ sleep and feeding needs (Dennis & Ross, 2005; Hunter, Rychnovsky, & Yount, 2009). Intensive care of and interactions with newborns who need to be frequently fed and helped to go back to sleep at night may reduce the amount and continuity of parental sleep. Additionally, hormonal changes during the postpartum period have been reported as another reason for mothers’ postpartum sleep disruptions. A decreased level of progesterone right after delivery (Lee, Zaffke, & McEnany, 2000; Moline, Broch, Zak, & Gross, 2003) and changes in melatonin levels, which can influence circadian rhythms within the first 3 months (Parry et al., 2006), may have negative impacts on maternal postpartum sleep quality.

Sleep disturbances in postpartum mothers were reported to be different depending on parity, feeding methods, and type of birth (Hunter et al., 2009). Nulliparous mothers reported to have more disrupted sleep not only in subjective sleep but also in objective sleep based on polysomnography (Lee et al., 2000) and sleep efficiency assessed by actigraphy (Dørheim, Bondevik, Eberhard-Gran, & Bjorvatn, 2009b; Signal et al., 2007), although the sleep patterns of first time and multiparous mothers became more similar by 3 months postpartum. Also, mothers with Cesarean sections showed more disturbed sleep symptoms and those with breastfeeding had more nighttime awakenings and fragmented sleep (Quillin, 1997). However, the results of studies on the influence of feeding method on sleep still remain unclear considering findings that breast
feeding mothers reported longer sleep duration than formula feeding mothers (Doan, Gardiner, Gay, & Lee, 2007).

Although most of studies on early postpartum have focused primarily on mothers (Hunter et al., 2009; Montgomery-Downs, 2010; Seymour et al., 2015), fathers also experience significant changes in their sleep and fatigue during early postpartum periods. Like mothers, fathers are also influenced by infants’ random sleep-wake patterns and often participate in their nighttime care during early postpartum period, resulting in the similar level of sleep disruption, deprivation and fatigue to that of mothers (Elek, Hudson, & Fleck, 1997, 2002). Their sleep patterns, however, were found to be more stable than mothers, who showed less sleep at night and more sleep during the day (Gay et al., 2004). In the study by Gay and colleagues (2004), fathers seemed to acquire even less amount of total sleep time than mothers within 24-hours period when both daytime and nighttime sleep included, probably due to mothers’ having more daytime naps. However, early postpartum mothers may have more sleep needs as well as nutritional needs, particularly if they are breastfeeding. In addition, they experience greater physiological and physical changes as well as more waking after sleep onset (WASO) than fathers. Fathers may have higher sleep continuity despite of the shorter total sleep time per day, and that may lead to comparable levels of sleep and fatigue for both mothers and fathers (Elek et al., 2002; Gay et al., 2004).

**Parental mood**

The transition to parenthood is a period of major changes including changes in physiological responses, intimate relationships, family and social roles, and adjustments to the parenting role (Grant et al., 2012). Parents in this transition period experience substantial levels
of emotional and psychological upheaval with increased vulnerability to mental health disturbances (Morse, Buist, & Durkin, 2000). Mood disturbances that parents can experience during the postpartum period include postpartum blues, postpartum depression and anxiety, and postpartum psychosis (Goyal et al., 2007). Postpartum blues is the most common and the least severe type of postpartum mood problems, and experienced by approximately 65% to 85% of postpartum mothers (Beck, Reynolds, & Rutowski, 1992). Postpartum blues are characterized by mild depressive mood, fatigue, tearfulness, anxiety, irritability, and headaches, which are mostly temporary with a peak within 4 to 5 days after delivery and alleviated by 10 to 15 days postpartum (Ugarriza, 2000). Postpartum psychosis, on the contrary, is the most uncommon, but most severe type of postpartum mood disturbances. This disorder included symptoms of agitation, pressured speech, auditory and visual hallucinations, delusions, inability to sleep, and poor appetite, which start suddenly within the first 48-72 hours after delivery or up to 4 weeks or longer during the postpartum period. Postpartum psychosis is classified as an emergency diagnosis, requiring immediate referral to a psychiatrist and hospitalization for treatment (Gale & Harlow, 2003).

Postpartum depression (PPD), another common postpartum mood disturbance, is a major depressive episode that occurs within the first 12 months postpartum and reported to be experienced by about 13% to 19% mothers over the first year postpartum (O’Hara & McCabe, 2013), although the estimates of its incidence and prevalence may differ by the sampling methods, the diagnosis criteria, and the types and the timing of assessments (Gavin et al., 2005). The risk factors of the development of postpartum depression include prior history of depressive disorder, depression during pregnancy, inadequate social support, and negative life events (Hatton et al., 2005) as well as low socioeconomic status such as low income and education, and
single marital status. Considerable prior research demonstrated that postpartum depression created risks to parental adjustments with their infants. For example, mothers who were depressed across infants’ first 3 months were found to be more irritable and hostile, to show less emotion and warmth and to have less play interactions with their infants (Lovejoy, Graczyk, O’Hare, & Neuman, 2000). Also, depressed mothers displayed less vocal and visual communication, and less smiling during interactions with infants compared to non-depressed mothers, which seemed to be universal across diverse cultures and socioeconomic backgrounds (Danaci, Dinc, Deverci, Sen, & Icelli, 2002; Eapen, Ghubash, Salem, & Sabri, 2005; Field, 2006; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Righetti-Veltema, Conne-Perreard, Bousquet, & Manzano, 2002). Furthermore, mothers with postpartum depressive symptoms were found to be less likely to bring infants in for routine health cares, to put infants in safe sleeping positions, and to give infants full immunizations (Zajicek-Farber, 2009). Even mild and unrecognized maternal depressive symptoms, if occurred during the first 4 months of infants’ life, have been found to have a substantial impact on mother-infant bonding (Moehler, Brunner, Wiebel, Reck, & Resch, 2006).

Although the literatures of postpartum depression to date have focused mainly on mothers, fathers also report increased risk of postpartum depression. According to the meta-analysis by Paulson and Bazemore (2010), a 10% prevalence rate of paternal depression within the first year postpartum was reported which is more than two times the12 month prevalence rate for men in the general population (Paulson & Bazemore, 2010). Several social risk factors for fathers’ postnatal depression were suggested including off-time entry into fatherhood, fathers’ living arrangements, and fathers’ race and ethnicity (Garfield, Clark-Kauffman, & Davis, 2006). Men becoming fathers outside the typical time frame for fatherhood, particularly during the
adolescent years (Lee, Fagan, & Chen, 2012), non-resident fathers (Huang & Warner, 2005; Jaffee, Caspi, Moffitt, Taylor, & Dickson, 2001), and non-Hispanic blacks and Hispanics, compared to non-Hispanic whites (Walesmann, Gee, & Geronimus, 2009), seem to be more likely to report depressive symptoms during postpartum periods. For example, a recent study by Garfield and colleagues (2014) found the evidence that nonresident fathers reported the highest mean levels of depressive symptom scores compared to groups of resident fathers and non-fathers (Garfield et al., 2014).

Finally, despite the fact that most studies of postpartum mood disturbances have focused on postpartum depression, there has been growing attention to another emotional postpartum disorder, postpartum anxiety (PPA), due to its significant prevalence rate of 12-20% (Farr, Dietz, O’Hara, Burley, & Ko, 2013). Postpartum anxiety is a distinct disorder from postpartum depression which has different risk factors and requires different treatment plans, although symptoms of depression and anxiety may co-occur (Bina & Harrington, 2017). Symptoms of anxiety include worry, restlessness, agitation, sleep disturbance, and apprehension (American Psychiatric Association, 1994). Although limited, research has found associated risk factors for postpartum anxiety including sociodemographic factors such as younger maternal age, being a first time mother (Chui-Yi, 2012; Swalm, Brooks, Doherty, Nathan, & Jacques, 2010), low education level (Britton, 2008; Chui-Yi, 2012), and psychosocial factors such as stressful life events (Britton, 2008; Chui-Yi, 2012; Yelland, Sutherland, & Brown, 2010), daily hassles (Swalm et al., 2010), a lack of family support (Bener, Gerber, & Sheikh, 2012; Britton, 2008), and finally a history of depression and anxiety (Britton, 2008; Swalm et al., 2010).
Parenting

Parenting quality has been consistently known to be a primary determinant of infant and child development across a wide spectrum, including attachment security, emotion regulation capacities, and internalizing and externalizing behaviors (Chang et al., 2003; De Wolff & van Ijzendoorn, 1997; Sroufe, 2005). Among various aspects of parenting, parental sensitivity, defined as the parental ability and readiness to perceive infants’ signals, to interpret these signals correctly, and to react to them promptly and adequately in a consistent manner (Ainsworth, Bell, & Stayton, 1974), is considered to play a major role in the development of secure infant attachment relationships. For example, one study that used a strict view of attachment, with the assumption that maternal sensitivity when the infant is ill, emotionally upset, or in physical danger may be the most relevant to the development of a secure attachment relationship, showed that greater maternal sensitivity to infants’ distress at 6 months postpartum was associated with increased odds of a secure infant-mother attachment relationship (McElwain & Booth-LaForce, 2006). This significant finding of the link between maternal sensitivity and infant secure attachment was replicated with other various ethnic and cultural groups such as Japanese (Vereijken, Riksen-Walraven, & Kondo-Ikemura, 1997), Colombian (Posada, Carbonell, Alzate, & Plata, 2004), and Ugandan mothers (Peterson, Drotar, Olness, Guay, & Kiziri-Mayengo, 2001).

Additionally, maternal sensitivity has been found to be associated with infants’ social engagement, which consolidates during the first year of life to provide a basis for later social adaptation (Feldman, 2007). A longitudinal study by Feldman and Eidelman (2009) found that social engagement assessed yearly from birth to 5 years was predicted by maternal sensitivity of a previous point (Feldman & Eidelman, 2009). Also, child’s self-regulation has been predicted by parenting quality such as maternal sensitivity, scaffolding, and maternal interference (Bernier,
Carlson, & Whipple, 2010; Calkins & Johnson, 1998). It seemed that the quality of parenting played a role in transmitting the influences of the family structure, income, and psychosocial risks linked on self-regulation (Rhoades, Greenberg, Lanza, & Blair, 2011). A recent study by Frick and colleagues (2017) reported that infants of more sensitive mothers displayed more regulatory behaviors and a longer latency to distress (Frick et al., 2017).

Finally, parental influences have been associated with child internalizing and externalizing problems. Parents’ emotion dysregulation in the form of harsh or punitive parenting affects children’s emotion dysregulation, which, in turn, leads to an array of social problems in schools such as aggressive behaviors (Fabes, Eisenberg, & Miller, 1990). For instance, a study by Eisenberg and colleagues (2001) showed that children’s externalizing behavior problems in schools were predicted by maternal expressions of negative emotions mediated through the influence of children’s emotion regulation (Eisenberg et al., 2001). An intervention study by Moss and colleagues (2011) demonstrated that a positive intervention effect on responsive parenting and children’s internalizing problems. Children in the intervention group showed lower levels of internalizing and externalizing problems as well as more secure child attachment resulting from the positive intervention effect on parental sensitivity (Moss et al., 2011). Parental intrusiveness, another dimension of parenting, has also been linked to various patterns of child maladaptation (Egeland, Pianta, & O’Brien, 1993; Rubin, Burgess, Dwyer, & Hastings, 2003). One study by Ispa and colleagues (2004) found that maternal intrusiveness predicted increases in the toddlers’ negativity and decreases in their engagement with their mothers. They insisted that intrusive parents tend to be focused on their own agenda in mind during the interactions with their children, which may overwhelm the children with excessive stimulation or interrupt activities initiated by the child (Ispa et al., 2004).
Examining day-to-day associations between parental sleep and mood and daily mood dynamics as a predictor of parenting within infants’ bedtime context

Prior work has established persuasive evidence that parental sleep, mood, and parenting quality in the early postpartum period are closely related. A growing body of research directs attention to the dynamic nature of day-to-day associations between parental postpartum sleep and mood and the impact of daily mood dynamics on parenting. This dissertation sought to extend previous work by examining the intensive daily assessments of parental sleep and mood during early postpartum period. This allowed for investigating not only the dynamic processes between parental sleep and mood, but also how mood dynamics, particularly within-person variability of parental postpartum mood, were linked with parenting quality. Furthermore, parenting quality is examined within the infants’ bedtime context. Although parenting during the daytime contexts are more generally studied, bedtime contexts may be more stressful for both infants and parents, and therefore how mothers’ ability to regulate their emotions in the form of mood lability may be particularly relevant to their interactions with the infants during bedtimes. The following section provides an overview of the recent empirical evidence of the predictive relations between parental sleep and mood as well as between parental mood and parenting, followed by the explanation of how this dissertation contributes to this body of work.

Daily diary approach

Most of the previous research on parental sleep, mood, and parenting during early infancy has relied on cross-sectional data, which provides limited and inadequate understanding about developmental processes and interactions in families. However, ecological and family
systems perspectives bring attention to the dynamic and variable nature of within-person processes and family interactions occurring in daily life. For example, a mothers’ sleep one night may be better when her baby sleeps through the night, followed by the night with poor sleep due to intensive cares for infants or by the night with similar level of good sleep because of fathers’ help on nighttime care in spite of the infants’ frequent waking. A daily diary approach, which involves assessments of day-to-day experiences and interactions over a number of consecutive days, weeks, or sometimes months, can capture this dynamic character of parental postpartum sleep and mood. In addition to the benefit above, the daily diary approach can also solve the problem of retrospective recall biases by allowing family members to report experiences and interactions nearer to the time they occur (Almeida, Wethington, & Chandler, 1999). In cross-sectional designs, parents are asked to retrospect over weeks and months to provide summary accounts of their physical and psychological states and experiences. However, with the application of time-intensive diary methods, it became possible to create summary accounts without the biases caused by retrospection over relatively longer periods. For instance, Repetti and Wood (1997) reported that mothers showed low average ratings of interaction behaviors with their children such as attention, speaking, caring, and loving on days with relatively higher workload, whereas they showed higher average ratings of those behaviors on days with lower workload (R. L. Repetti & Wood, 1997).

Even though this primary finding is from aggregated diary data, because the data is from daily multiple time points, not from single reports in which participants try to recall their experiences, this finding may have more validity and reliability due to the reduction of systematic and random measurement errors (Bolger, Davis, & Rafaeli, 2003). Furthermore, this time-intensive repeated measurements allow researchers to address questions of within-person
associations, how much individuals change over time in variables or interests and how the changes in one family member relate to changes in other family member, beyond addressing the typically examined research questions on between-person associations (Bolger et al., 2003).

For example, Kouros and Elsheikh (2015) found a significant within-person association between children’s mood and sleep. On days when a child’s mood was worse than usual, the child reported poorer sleep quality those nights (Kouros & El-Sheikh, 2015). Finally, these within-person associations can exclude stable individual or contextual features by treating individuals as their own controls.

In this dissertation, we used a daily diary method to examine within-person associations between parental sleep and mood during the early postpartum period and to determine if predictive links exist between within-person variability of maternal mood and parenting quality over time. Previous studies have shown that disrupted sleep quality in parents predict parental mood during early infancy, mostly using single-point-in time measures such as questionnaires for overall sleep quality, postpartum depression and anxiety (Cooklin, Giallo, & Rose, 2012; Dørheim, Bondevik, Eberhard-Gran, & Bjorvatn, 2009a; Giallo, Rose, Cooklin, & McCormack, 2013; Seymour et al., 2015; Wolfson, Crowley, Anwer, & Bassett, 2003). However, intensive repeated measurements of parents’ daily sleep and mood in this dissertation allowed for investigation of both whether mothers were more likely to have better mood on days when mothers and fathers had better sleep the nights before and how fluctuations of maternal mood over postpartum days predicted mothers’ parenting quality over time. To our knowledge, this work represents the first study on the within-person associations between parental sleep, mood, and parenting during early postpartum period.
Parental sleep and mood

Parental sleep has been found to be strongly predictive of parental well-being and adjustments during the early postpartum periods. Particularly in relation to parental mental health and well-being, parents’ poor postpartum sleep may function as a cause as well as a marker of impending depression (Ross, Murray, & Steiner, 2005). Many studies suggest a bi-directional association between sleep difficulties and mood disturbances (Armitage, Flynn, Hoffmann, & Vazquez, 2009; Perlis, Giles, Buysse, Tu, & Kupfer, 1997), and more recently a growing literature on parents’ postpartum sleep and mood has been examining parental sleep disruptions as a contributing risk factor for the development of postpartum depression. Mothers’ self-reported sleep quality was strongly related to their postpartum depressive mood rating (Dørheim, Bondevik, Eberhard-Gran, & Bjorvatn, 2009a; Huang, Carter, & Guo, 2004; Wolfson, Crowley, Anwer, & Bassett, 2003). For example, Bei and colleagues (2010) found that postpartum mothers’ subjective perception of sleep including subjective nighttime sleep, sleep-related daytime dysfunction, and daytime naps were found to be significant predictors of postpartum depressive mood (Bei, Milgrom, Ericksen, & Trinder, 2010).

In addition to the link between subjective sleep reports and mood disturbances, studies with objective sleep measures such as wrist actigraphy has also provided similar associations between postpartum sleep and mood. For instance, Goyal and colleagues (2009) found that mothers’ more wake time during the night and less daytime sleep assessed with actigraphy as well as higher subjective sleep disturbance served as significant predictors of maternal depressive symptoms at three months postpartum, even after controlling for prenatal depressive symptoms, infant temperament, and relationship satisfaction with the father of the baby (Goyal et al., 2009). Another recent study by Park and colleagues (2013) also found that actigraphic
assessments of sleep maintenance, such as sleep fragmentation, efficiency, and wake time after sleep onset, were significantly associated with postpartum depressive mood scores (Park, Meltzer-Brody, & Stickgold, 2013). More recent work on postpartum sleep problems and depression also suggested consistent and strong support for the link between sleep disruption and mood disorder risk in the postpartum period (Bhati & Richard, 2015; A. Lawson, Murphy, Sloan, Uleryk, & Dalfen, 2015).

Although fathers also experience sleep disruption in early transition to parenthood (Gay et al., 2004) and increased risk of postpartum depression (Paulson & Bazemore, 2010), very few studies have examined the link between fathers’ sleep and mood during postpartum period. Only one recent study by Saxbe and colleagues (2016) included both mothers and fathers in examining the link between sleep and postpartum depression longitudinally, reporting that fathers’ sleep quality at 6 months postpartum predicted depressive symptoms at both 6 and 12 months postpartum. Additionally, the study found that mothers’ sleep quality predicted fathers’ depressive symptoms both at 6 and at 12 months, suggesting the potential mechanism of transmission of depressive symptoms within couples (Saxbe et al., 2016). Despite the evidence of the potential influence of fathers’ sleep on mothers’ mood, previous studies have not yet examined fathers’ sleep as a predictor of mothers’ mood, especially in a daily level.

This dissertation examined how parental sleep the night before was predictive of mothers’ next day mood across infants’ first 6 months. Parents’ daily sleep and mood may be particularly variable during early postpartum period because of substantial demands to adjust to new roles and responsibilities and to reorganize daily routines. In addition, sleep in fathers who share a bed or a room with mothers and thus are influenced by mothers’ activity during nighttime (such as caring for a newborn) may be closely related with mothers’ daily mood. Unlike most prior
evidence focused on the link between maternal sleep and mood, our study examined fathers’ sleep as well as mothers’ sleep in relation to mothers’ mood at a daily level.

**Parental mood and parenting**

Parental mood disturbances during the postpartum period have been found to interfere with parents’ capacity to provide good quality care for their infants (Serretti, 2006), which in turn leads to negative consequences for child development during infancy, childhood, even up to adolescence (Beck, 1998; L. Murray et al., 1996; Weinberg & Tronick, 1998). Among the several kinds of parental mood problems during postpartum period, a considerable body of research has studied the adverse impacts of parents’ postpartum depression on parenting (Field, 2010). Much research has shown that mothers with postpartum depression are less capable of providing an environment that can promote healthy growth for their infants. Depressed mothers have been characterized as showing less consistent interactive behaviors, providing not only minimal warmth and positive emotion, but also less frequent physical contacts, and being unable to establish affective synchrony with their infants (Feldman, 2007; Field, 1992; Murray & Cooper, 1997; Weinberg & Tronick, 1998). Mothers with postpartum depression were also found to differ from non-depressed mothers in their vocal responses, such that they used longer utterances, less repetition, fewer explanations, suggestions, and questions, and fewer references to their infants’ behaviors (Herrera, Reissland, & Shepherd, 2004).

In addition to the immediate influence of postpartum depression on their parenting behaviors during the postnatal period, long term effects of postpartum depression on later parenting quality have also been found. For example, depressed mothers when their children were one year old on average showed lower level of sensitivity when their children became age 4
Another study by Vliegen and colleagues (2009) also found similar results in demonstrating a link between postnatal depression and emotional availability. They found that mothers with postpartum depression were less sensitive, more intrusive, and less able to structure the interactions with their infants. Depressed mothers also perceived their interactions with infants as less attuned, less joyful, and their infants to be less involved with them, compared to non-depressed mothers. Interestingly, more than half of the depressed mothers in this study asked to stop the play interaction earlier, resulting in significantly shorter average play time compared to that of non-depressed mothers. This suggests that depressed mothers may perceive the interactions as less joyful or be unable to develop the capacity for play with their infants, probably due to the substantial preoccupation with their own thoughts and feelings (Vliegen et al., 2009).

Although significantly less studied than postpartum depression and parenting, research on the link between mothers’ anxiety and parenting reports differences in parenting between anxious mothers and control groups. Anxious mothers have been reported to overstimulate their infants, show intrusive or inconsistent behaviors to their infants, and display insensitive reactions to infants’ signals (Feldman, 2007; Feldman et al., 2009; Lynne Murray, Cooper, Creswell, Schofield, & Sack, 2007). Compared to depressed mothers who exhibit flat and withdrawn emotion and rarely engage in genuine social interactions with their infants, anxious mothers tend to show intrusive behaviors that are not suited to infants’ states and cues (Feldman et al., 2009). In addition to parenting behaviors, high maternal anxiety has been related to low parental self-efficacy which is defined as parents’ beliefs about their parenting abilities and satisfaction in their parenting role (Johnston & Mash, 1989). For example, Porter and Hsu (2003) reported that mothers’ high anxiety was linked with decreased parental self-efficacy, particularly for first-time
mothers at 1 month postpartum, but not at 3 months postpartum, suggesting that postpartum parents’ anxiety symptoms may reduce over time as parents adapt to new roles and responsibilities, with increased feelings of confidence and competence developing over time (Porter & Hsu, 2003). Overall, previous evidence has indicated that poorer and problematic maternal mood is predictive of lower quality parenting.

In addition to the focus on the average level of mothers’ mood like prior evidence suggests above, mothers’ emotion varies and fluctuates more dynamically over time, particularly during the transition to parenthood, and parental ability to regulate emotion is directly relevant to parenting quality (Dix, 1991; Teti & Cole, 2011). Indeed, prior research proved that parents with unstable and dysregulated mood tended to react unpredictably and insensitively to their children (Gottman, Katz, & Hooven, 1996; Marziali, Damianakis, & Trocmé, 2003). Thus, this dissertation examined how mothers’ mood volatility across days in the early postpartum period, as well as the overall level of mood, was predictive of their parenting quality.

Unique to this dissertation was its study of links between maternal mood and mothers’ parenting quality, specifically maternal EA, in the bedtime context. Unlike free play contexts in which parents and infants usually share a same goal, bedtime contexts may pose more challenges and stress for both infants and parents due to the fact that the task of parenting, in this context, is to help the infant separate, both psychologically and physically, from the parent and settle to sleep. In this stressful context, emotionally available parenting (Biringen, 2000) may be particularly important because it may promote feelings of safety and security in infants, thus making the transition from daytime to nighttime easier by fostering feelings of trust in the infants (Dahl & El-Sheikh, 2007; Teti, Kim, Mayer, & Countermine, 2010). Mothers with higher mood lability may not be able to provide reliable and consistent sleeping environments for infants,
making it more challenging for infants to feel safe and secure, compared to mothers with stable mood. This dissertation also examined how within-person deviations in maternal mood variability, as well as in mood level, were associated with maternal EA. In other words, it tested whether mothers showed poorer emotionally available parenting than usual during bedtime interactions with their infants on days their mood fluctuated more than usual.

**Main research questions**

The purpose of this dissertation was to make use of micro-bursts of daily data within a large longitudinal dataset in order to examine how parental sleep, maternal mood and maternal bedtime parenting were associated. Day-to-day associations between parental sleep and maternal mood (Study I) and the predictive link between maternal mood variability and their bedtime parenting (Study II) were examined in two separate papers. The data were drawn from Project SIESTA (Study of Infants’ Emergent Sleep Trajectories, Douglas Teti, PI).

**Study I: Day-to-Day Associations between Parental Sleep, Maternal Mood, and Maternal Distress across the Infants’ First Six Months**

Study I used daily data to investigate the association between parental sleep and maternal mood across infants’ 1, 3, and 6 months. Parents’ sleep has known to be disrupted during the early postpartum period due to the new demands of parenthood (Cooklin et al., 2012; Giallo, Rose, & Vittorino, 2011; Signal et al., 2007; Swain et al., 1997) and previous work has demonstrated that disrupted parental sleep was predictive of parental postpartum mood disturbances such as depression and anxiety (Dørheim, Bondevik, Eberhard-Gran, & Bjorvatn, 2009a; Huang, Carter, & Guo, 2004; Seymour, Giallo, Cooklin, & Dunning, 2014a; Wolfson,
Crowley, Anwer, & Bassett, 2003). There is also theory and research about the cross-over effect of daily experiences between mothers and fathers, which suggests fathers’ sleep, in addition to mothers’ own sleep, may affect maternal mood (Insana, Costello, & Montgomery-Downs, 2011; Larson & Almeida, 1999; Saxbe et al., 2016).

With the increasing use of daily diary research designs, it has become possible to capture dynamic characteristics of the link between sleep and mood in a daily level (Kouros & El-Sheikh, 2015; Li, Romans, De Souza, Murray, & Einstein, 2015; McCrae et al., 2016). Thus, this study used multilevel modeling to explore the day-to-day relations between parental sleep, including not only mothers’ but also fathers’ sleep, and mothers’ mood during early postpartum period. Additionally, mothers’ overall distress was examined as a moderator of the daily link between parental sleep and maternal mood. Both mothers’ and fathers’ better sleep the night before were hypothesized to predict mothers’ better mood next day. Higher maternal overall distress was also hypothesized to predict lower maternal daily mood, and further predict worse maternal mood next day even with better sleep the night before. No specific direction of the moderating effect of maternal distress on the daily link between fathers’ sleep and mothers’ mood was hypothesized due to the lack of supporting evidence for the directions of possible negative influences.
Study II: Maternal Daily Mood Dynamics and Bedtime Emotional Availability during Infants’ First Six Months

Study II investigated the association between within-person variability of maternal mood and mothers’ bedtime EA across infants’ 1, 3, and 6 months. Beyond the attention on the effects of overall level of mothers’ postpartum mood on parenting (Gelfand & Teti, 1990; Lovejoy et al., 2000; Martin, Clements, & Crnic, 2002; Weisman et al., 2010), a growing body of research suggest that maternal mood volatility may have significant influences on parenting quality (Litz, Orsillo, Kaloupek, & Weathers, 2000; Lorber & Slep, 2005; Marziali et al., 2003; Pearlman & Courtois, 2005). Greater daily fluctuations in maternal mood reflect the underlying capacity for self-and emotion regulation as an essential pre-requisite to competent parenting (Lorber, 2012; Teti & Cole, 2011), which may be especially important during early postpartum period, during which a foundation for mother-infant relationships and infant development is being established. Thus, this dissertation examined how mothers’ day-to-day mood variability in addition to the overall level of mood was associated with maternal emotional availability during bedtime interactions with their infants, using multilevel modeling. Higher maternal daily mood level was hypothesized to predict higher maternal bedtime EA, and higher maternal daily mood variability was hypothesized to predict lower maternal bedtime EA. Mothers’ daily sleep level and variability were included as covariates in order to control the possible effects of maternal sleep dynamics on mood and parenting.
Study I

Day-to-Day Associations between Parental Sleep, Maternal Mood, and Maternal Distress across Infants’ First Six Months

Introduction

Parents’ sleep quality during the postpartum period is known to be disrupted (Giallo, Rose, et al., 2013; Montgomery-Downs, 2010; Seymour & Dunning, 2013) and these changes in parents’ sleep quality have been associated with their mood during postpartum period (Cooklin et al., 2012; Dørheim et al., 2009b; Giallo, Rose, et al., 2013; Huang et al., 2004; Seymour et al., 2015; Wolfson et al., 2003). To date, most previous studies have focused on the relationship between parents’ overall level of sleep and overall mood such as depression and anxiety. For example, mothers’ higher sleep disturbance assessed both subjectively and objectively was strongly predictive of depressive symptoms at three months postpartum (Goyal et al., 2009). However, most of these existing studies examined the relations between sleep and mood assessed with single-point-in-time measures and very few studies have examined dynamic linkages between parental postpartum sleep and mood.

With the use of daily diary study designs, it has become possible to provide information on the temporal association between sleep and mood (Kouros & El-Sheikh, 2015). To our knowledge, no study has yet addressed the day-to-day relationship between maternal sleep and mood during the early postpartum period, and no study has included fathers’ sleep as an influential factor on the link between mothers’ sleep and mood. Moreover, very few studies looked at how mothers’ overall psychological well-being affects their daily mood. The current study tried to build upon previous work by examining day-to-day associations between mothers’
and fathers’ sleep and maternal mood using objective measures of parental sleep quality, as well as examining the direct and moderating impact of mothers’ overall distress on links between parental daily sleep and maternal daily mood across the first six months of infant’s life.

**Day to day associations between maternal sleep and mood**

There has been a considerable amount of research on the link between mothers’ sleep loss and their mood, suggesting that sleep deficits have been found to be a significant predictor of parental mood (Goyal et al., 2009; Park et al., 2013). However, one limitation about the most existing studies is that they have used average levels of sleep and mood in mothers, ignoring their day-to-day variation of sleep and mood, which is the key feature of parental sleep and mood during the early postpartum period.

With the increased use of daily diary study design and multilevel modeling, it has become possible to examine the day-to-day relationship between sleep quality and mood in the ecologically valid context of the home (Kouros & El-Sheikh, 2015). For instance, Bromberg and colleagues (2012) examined daily relationships between sleep, mood and pain in children with polyarticular juvenile arthritis over a 2 month period using actigraphs and daily mood ratings (Bromberg, Gil, & Schanberg, 2012). They found significant daily links between poor sleep quality and higher pain ratings with mood moderating the relationship. Kouros and El-Sheikh (2015) also found the significant within-person association between children’s mood and sleep, suggesting a child’s worse mood than usual during the day was predictive of poorer sleep quality that night (Kouros & El-Sheikh, 2015). Li and colleagues (2015) reported the significant daily relations between sleep, mood, and ovarian hormones among a small sample of non-help-seeking women over the 42 days (Li et al., 2015). Finally, a recent study by McCrae and her colleagues (2016) used both subjective and objective daily sleep measures to predict positive and negative
affect in older caregivers of patients with Alzheimer’s dementia (McCrae et al., 2016). They found that nights with less subjective wake time and better sleep quality were followed by days with lower negative affect for older caregivers.

Despite the increased number of findings of daily links between sleep and mood in diverse populations, however, no study has yet investigated the daily association between maternal sleep and mood, especially during the early postpartum period when mothers’ physical and emotional conditions change dynamically due to the changes in their routines and responsibilities (Goyal et al., 2009). Therefore, this study will take a closer look at the day-to-day relationship between mothers’ sleep quality and mood during early postpartum period across infants’ first 6 months.

**Role of fathers’ sleep on mothers’ sleep and mood**

Most studies on parental sleep and mood during postpartum period have focused primarily on mothers (Calcagni, Bei, Milgrom, & Trinder, 2012; Goyal et al., 2007, 2009; Park et al., 2013; Seymour et al., 2015). However, recent studies have begun emphasizing that fathers are also at risk for sleep disturbance and fatigue during perinatal period, even from the late pregnancy period (Elek et al., 2002; Gay et al., 2004; Gjerdingen & Center, 2003). Like mothers, fathers are also influenced by their newborns’ random sleep and wake patterns and often involved in their nighttime care. Consequently, fathers may be going through sleep disruption and deprivation similar to that of mothers. No difference was found between mothers’ and fathers’ self-reported length of nighttime sleep during pregnancy (Elek et al., 1997) and fathers’ postpartum ratings of fatigue were not different from that of mothers (Elek et al., 2002). According to Gay and colleagues (2004), fathers acquired even less amount of total sleep minutes including both nighttime and daytime sleep than mothers when sleep was objectively
According to the emotional transmission model by Larson and Almeida (1999), one family members’ daily events and emotions may be predictive of subsequent emotions or behaviors in another family member (Larson & Almeida, 1999). In fact, negative experiences of one family member such as stress, anxiety, burnout, and work-family conflict have been found to cross over between spouses (Bolger, DeLongis, Kessler, & Wethington, 1989; Crouter & McHale, 1993; R. L. Repetti, 1989). One study by Westman (2001) found the direct crossover effect of job insecurity and burnout from husbands to wives (Westman, Etzion, & Danon, 2001). Based on this evidence, the effects of fathers’ sleep quality during early postpartum period, often disturbed as mothers by various reasons such as frequent infant waking, fathers’ own psychological distress including postpartum worried and anxiety (Clinton, 1987; Fawcett & York, 1986), and involvement with nighttime caregiving, may cross over from fathers to mothers. Furthermore, according to Insana and colleagues (2011), fathers’ greater objectively measured sleep time has been found to be associated with more positive couples’ postpartum relationship satisfaction (Insana et al., 2011). The result of one recent study showed that mothers’ sleep at 6 month postpartum was related to fathers’ depression at both 6 and 12 month (Saxbe et al., 2016). Based on these studies, although there has been no direct evidence linking between paternal sleep and maternal mood, it is reasonable to suggest that paternal sleep quality may be predictive of maternal postpartum mood. There is yet no study which examined the direct link between paternal sleep quality and maternal mood directly, especially focusing on day-to-day relationship between them. Thus, the current study investigated how fathers’ sleep quality predicted mothers’ daily mood during the early postpartum period.
Mothers’ overall distress as a moderator of the daily association between sleep and mood

There have been a number of studies of the associations between psychological distress and daily mood (Costello, Benjamin, Angold, & Silver, 1991; Cowdry, Gardner, O’Leary, Leibenluft, & Rubinow, 1991). However, those studies have mostly treated daily mood dynamics as one of critical symptoms or characteristics of mood disorders with clinical samples. For example, it has been found that frequent ups and downs of mood were exclusively reported in mood disorder patients and this mood variability has been studied in patients with schizophrenia, panic, depression, bipolar disorder, borderline personality disorder, and anxiety disorder (Benedetti et al., 1996; Bowen et al., 2004; MacKinnon et al., 2003; Peeters et al., 2006). According to Peeters and colleagues (2006), people with clinical depression reported greater moment-to-moment variance of negative mood with higher overall levels of negative mood, as well as lower overall levels of positive daily mood with reduced variability, compared to healthy controls (Peeters et al., 2006). Patients with anxiety disorders also showed more fluctuating daily mood than their control subjects (Bowen, Baetz, Hawkes, & Bowen, 2006).

However, there is very little information about how overall psychological distress such as depression and anxiety may influence the dynamics of mood states in everyday life for non-clinical samples and no study has investigated the moderating effects of parents’ overall psychological distress on the association between their daily sleep and mood, particularly during early post-partum period. One recent study by Buttner and colleagues (2015) found that women who are diagnosed with PPD showed higher levels of negative mood and lower levels of positive mood across ten days right after deliveries (Buttner, Brock, & O’Hara, 2015). Considering that the exposure to constant feelings of distress is generally related to a wide range of negative outcomes including decrease of everyday well-being and increase of disease incidence (García-
Villamisar & Armentia, 2014), it is reasonable to expect that mothers’ overall psychological distress would have negative impacts on their daily mood both in direct and indirect ways, particularly during the early post-partum period, a dynamic period when parental roles, duties and moods are in great perturbation.

**Current Study**

The current study examined how both mothers’ and fathers’ sleep qualities were associated with daily maternal mood and how maternal overall psychological distress moderated the relationship between maternal daily sleep and mood as well as directly predicted maternal daily mood. This study adds to the existing literature in several ways. First, parents’ sleep was assessed objectively using actigraphy, rather than self-report. This study used three aspects of objective sleep from actigraphy, including sleep efficiency, sleep fragmentation, and sleep minutes. Secondly, fathers’ sleep was included as an influential factor of maternal mood, unlike previous studies mostly focusing on mothers’ sleep only. Thirdly, this study used micro-bursts of data on parental sleep and maternal mood that were imbedded within a larger longitudinal study from infants 1,3, and 6 months, which allowed for the investigation of mothers’ early postpartum mood changes over time and the within-person associations between parents’ sleep and mood across early postpartum period. Finally, this study examined the moderating role of mothers’ overall distress on links between parental sleep and maternal mood, which, to our knowledge, have not been tested yet by the previous studies.
Hypotheses

The following hypotheses were proposed:

Hypothesis 1: Mothers’ better sleep (higher sleep efficiency, lower sleep fragmentation, and longer sleep minutes) the night before will be associated with mothers’ better mood next day across 21 days of infants’ 1, 3, and 6 month.

Hypothesis 2: Fathers’ better sleep (higher sleep efficiency, lower sleep fragmentation, and longer sleep minutes) the night before will be associated with mothers’ better mood next day across 21 days of infants’ 1, 3, and 6 month.

Hypothesis 3: Higher mothers’ overall distress level will predict lower maternal daily mood across 21 days of infants’ 1, 3, and 6 month.

Hypothesis 4: Mothers’ overall distress will moderate the associations between mothers’ sleep the night before and their next day mood change across 21 days of infants’ 1, 3, and 6 months. Mothers with higher level of overall distress will show worse mood next day even with better sleep the night before (higher sleep efficiency, lower sleep fragmentation, and longer sleep minutes), compared to those with lower levels of overall distress.

Hypothesis 5: The role of mothers’ overall distress in moderating associations between fathers’ sleep the night before and mothers’ next day mood across 21 days of infants’ 1, 3, and 6 months was also examined. No specific direction of influence was hypothesized, however, because there was not enough literature to support the specific directions of effects.
Methods

Participants

Participants were part of Project SIESTA, a larger NIH-funded longitudinal study of parenting, infant sleep, and infant development across infants’ first two years (NIH R01HD052809). A total of 167 parents and infants were recruited within 1 or 2 days after delivery from the obstetric floors of two local hospitals in central Pennsylvania, the Mt. Nittany Medical Center and the Milton S. Hershey Medical Center. In order to be recruited to the study, mothers had to be 18 years or older and to speak English fluently.

One hundred sixty seven families participated in the study when their infants were 1 month old. Mother’s average age was 29.4 years old (SD=5.3) ranging in age from 18 to 43 and fathers’ average age was 32.1 years old (SD=5.9) ranging in age from 21 to 49. 138 (83%) of mothers and 133 (86.4%) of fathers were married and living with a partner. A total of 84% of mothers identified themselves as White, 3.6% as African American, 3.6% as Asian American, 5.5% as Latino and 3.6% as Other. Eighty-four percent of fathers reported themselves as White, 3.3% as African American, 4% as Asian American, 4.6% as Latino, and 4% as Other. A total of 30% of mothers were high-school graduates without any post-high school education, 38.6% attended or graduated from college, and 30.1% received graduate or professional degrees, and a remaining 1.3% did not complete high-school education. Thirty percent of fathers were high-school graduates, 43.5% attended or graduated from college, and 24.7% received graduate or professional degrees. A total of 62.1% of mothers and 94.8% of fathers were employed and the average family income was $69,503.59 ranging from $0 up to $300,000 from mothers’ reports.

Of the 167 families, due to the intensiveness of daily longitudinal data, 151 families who had both mothers and fathers and provided data for at least 1 day matched between mothers and
fathers across 21 days were included in the final sample of the study. Of those 16 missing families, 5 families were of single mothers, 8 families had fathers who were not willing to participate, and 3 families had too little data that did not match between mothers and fathers. Mothers in the final sample were significantly different from the mothers who dropped in several aspects of socio-demographic characteristic, including age, yearly income, and marital status: mothers in the final sample were more likely to be older, \( t (164) = 18.83, p < .05 \) and living with partner regardless of being single or married, \( \chi^2 (4, 167) = 68.81, p < .001 \), and had higher yearly income, \( t (152)=17.87, p < .01 \). Fathers in the final sample were different from the fathers who dropped in race and marital status: fathers in the final sample were more likely to be White, \( \chi^2 (4, 151) = 51.02, p < .001 \), and living with partner regardless of being single or married, \( \chi^2 (2, 155) = 28.94, p < .001 \).

**Procedure**

Families were visited by a designated home visitor across 7 days of data collection period when infants were 1, 3, and 6 months old. At the first visit of each data collection week (Day 1), parents were provided with a packet of various questionnaires including measures for depressive and anxiety symptoms to complete by the end of the data collection week as well as with Actigraph watches. Parents were asked to wear the Actigraph watches for 7 continuous days of each data collection period and to press the “event marker” on the device at bedtimes and rise times for nighttime sleep and daytime naps. During every day between Day 1 and Day 7, parents received phone calls from the home visitor during their convenient times to answer daily interviews regarding their moods of the day. At the final visit (Day 7), the home visitor visited families again to collect completed questionnaires and Actigraph watches.
Self-report Measures

Daily Mood. Maternal daily mood was assessed from daily phone interviews which are conducted with mothers respectively on their convenient times for the seven consecutive days of the data collection week at 1, 3 and 6 month. During these interviews, mothers were asked to rate how energetic they felt during the day on a 5-point Likert scale (1 = feeling low and tired, 5 = feeling positive and energetic). Since the interview item specifically asked mothers for their overall energy level of the day, mothers’ daily mood was operationalized as mothers’ daily vitality in this study.

Overall Distress. Maternal overall distress was assessed by sum of their depressive symptom score and anxiety score, using depressive and anxiety symptom subscales of Symptom Checklist-90-R (Derogatis, 1977) at 1, 3, and 6 months. Each subscale consists of 13-item and 10-item self-report measures for depressive and anxiety symptoms. Mothers reported on the degree of which they experienced a variety of depressive symptoms (e.g., loneliness, crying, feeling blue, hopelessness, worthlessness and loss of sexual interest) and anxiety symptoms (e.g., feeling tense and keyed up, nervousness or shakiness inside, and Feeling so restless you couldn’t sit still) during the past 7 days with 5-point Likert-scale (0 = Not at all; 4 = Extremely). Items for depression and anxiety were averaged respectively at each time point and higher scores indicate higher levels of depressive and anxiety symptoms (Depression: 1 month \( \alpha = .91 \), 3 month \( \alpha = .90 \), 6 month \( \alpha = .88 \) / Anxiety: 1 month \( \alpha = .86 \), 3 month \( \alpha = .76 \), 6 month \( \alpha = .87 \)). For this study, since depression and anxiety scores were highly inter-correlated with each other (1 month \( \gamma = .64 \), 3 month \( \gamma = .70 \), 6 month \( \gamma = .72 \)), they were summed together to yield one final score for mothers’ overall distress at infants’ 1, 3, and 6 month.
Objective Measure

**Parental Sleep.** Parental sleep was measured across seven consecutive days of the data collection week at each age point (1, 3, and 6 month) using Mini-Mitter Actigraphy wristwatches (Model AW-64). Actigraph watches have been validated as a reliable method to assess objective sleep with the consistency between actigraphy and polysomnographically measured sleep parameters reported by previous studies (Ancoli-Israel et al., 2003; Kushida et al., 2001; Tryon, 2004). In the current study, we particularly examined the following nighttime sleep variables as possible predictors of maternal mood, generated using the accompanying software, Actiware (Version 5.0), which used an algorithm to determine an individual’s sleep and wake states data from the accelerometer assessing the individual’s activity level: a) sleep efficiency, b) sleep fragmentation, and c) sleep minutes. The sleep efficiency refers to a percentage of time spent asleep between the sleep onset and final awakening (De Souza et al., 2003) and the sleep fragmentation provides an overall measure of restless sleep which is generated by calculating both the individual’s activity level during sleep and the frequency of sleep activity being interrupted by bouts of activity. Finally, the sleep minutes represent the amount of sleep time in minutes. Also, it must be noted that parental daily sleep was always measured precedent to the daily mood assessment. During the 7 days of each data collection week, parental sleep was measured from the night of Day 1 and mothers’ mood was measured from Day 2, which indicates the parental daily sleep always preceded mothers’ daily mood.
Results

Preliminary analyses

Descriptive information for the parental daily sleep, maternal daily mood, and maternal overall distress across 1, 3, and 6 month is provided in Table 1-1 and Table 1-2. Since there were seven days of data collection for each age point for 167 parents, a total number of observations for each age point was 1169 days.

Table 1-1. Descriptive information for mothers’ daily mood and overall distress across infants’ 1, 3, and 6 month.

<table>
<thead>
<tr>
<th>Month</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
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<td></td>
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<tr>
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<td></td>
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<tr>
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<td>8.68</td>
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Note. N=Number of observation, M=Mean, SD=Standard Deviation, Min=Minimum, Max=Maximum.
Table 1-2. Descriptive information for parents’ daily sleep across infants’ 1, 3, and 6 month.

<table>
<thead>
<tr>
<th></th>
<th>Month</th>
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<th>M</th>
<th>SD</th>
<th>Min</th>
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<td>53.37</td>
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<tr>
<td></td>
<td>3</td>
<td>826</td>
<td>85.66</td>
<td>6.52</td>
<td>49.03</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>791</td>
<td>86.06</td>
<td>6.09</td>
<td>33.33</td>
<td>98.15</td>
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<tr>
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<tr>
<td></td>
<td>3</td>
<td>826</td>
<td>33.96</td>
<td>14.56</td>
<td>0.82</td>
<td>109.08</td>
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<tr>
<td></td>
<td>6</td>
<td>790</td>
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<td>13.23</td>
<td>3.69</td>
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<tr>
<td>Fathers’ Sleep Minutes</td>
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<td>921</td>
<td>367.93</td>
<td>76.71</td>
<td>92.00</td>
<td>666.00</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>826</td>
<td>370.78</td>
<td>76.69</td>
<td>68.00</td>
<td>838.25</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>791</td>
<td>370.33</td>
<td>71.49</td>
<td>124.00</td>
<td>585.00</td>
</tr>
</tbody>
</table>

Primary analyses

All analyses were conducted in SAS 9.4 using Proc Mixed. One set of two-level models was run. These models predicted mothers’ next day mood from both mothers’ and fathers’ sleep of the previous night across 21 days during infants’ first 6 months of life. The models included time and parents’ sleep quality at level 1 and mothers’ overall distress level at level 2. All analyses used maximum likelihood estimation to account for missing data in the dependent variables.

Models predicting mothers’ daily mood from parents’ daily sleep and mothers’ overall distress across 21 days during infants’ first 6 month

The nested character of this longitudinal data required to separate within-person associations from between-person associations. Estimates of within-person associations represented how deviations in parents’ day-to-day sleep from their averaged sleep score collapsed across 21 days were associated with mothers’ day-to-day mood across 21 days (for example, whether a mothers’ mood tended to be higher next day when her and her partner’s sleep quality were higher than their average). Estimates of between-person associations indicated how the parents’ sleep was associated with mothers’ mood on average across the 3 time points (for example, whether parents who had better sleep on average across 1, 3, and 6 month tended to report better mood on average). In order to separate these associations, person-mean variables for parents’ sleep (sleep efficiency, sleep fragmentation, and sleep minutes) were first created by calculating the average of each sleep variable across 21 days for each parent, which could be represented as the between-person effects. Then, person-mean centered variables were created by subtracting the person-mean of each parent from his or her raw scores for each sleep variable at each of the 21 days, which indicated the within-person effects. In the first set of analyses, only
the within-person effects of parents’ sleep estimates were examined on how parental sleep the night before was associated with mothers’ next day mood. Between-person associations were tested for mothers’ overall distress in order to examine whether mothers’ overall distress on average across the 3 time points predicted mothers’ daily mood. Grand-mean centered variables were created for mothers’ overall distress by subtracting the grand mean (which is the mean of person mean) from each mother’s person mean of overall distress. Interaction terms were created by multiplying mothers’ person-mean centered sleep and fathers’ person-mean centered sleep by the grand-mean centered maternal overall distress respectively in order to test whether the associations between parental daily sleep and maternal daily mood differed by maternal overall distress level.

The equations for the model predicting maternal daily mood were depicted below:

Level 1:

\[ \text{Mom Mood}_{iti} = \beta_{0i} + \beta_{1i}Month_{iti} + \beta_{2i}MomSleep_{iti} + \beta_{3i}DadSleep_{iti} + e_{iti} \]

Level 1 equation represented that mothers’ mood at time \( t \) was a function of the intercept specific to each mother \( i \) as well as slopes indicating linear change in mood with time (month), person-mean centered mothers’ and fathers’ sleep variables.

Level 2:

\[ \beta_{0i} = \gamma_{00} + \gamma_{01}\text{MomDistress}_i + \mu_{0i} \]
\[ \beta_{1i} = \gamma_{10} + \mu_{1i} \]
\[ \beta_{2i} = \gamma_{20} + \gamma_{21}\text{MomDistress}_i + \mu_{2i} \]
\[ \beta_{3i} = \gamma_{30} + \gamma_{31}\text{MomDistress}_i + \mu_{3i} \]

Level 2 equations allowed the estimates of the intercept and slopes for mothers’ and fathers’ sleep to vary as a function of grand-mean centered mothers’ overall distress level.
Between-person variation in the intercept was a function of the overall intercept, grand-mean centered mothers’ distress and a residual specific to each mother. Between-person variation in the linear slope for mothers’ mood was a function of the overall slope and a residual specific to each mother. Maternal distress was not added as a predictor of the linear trend because the time trend in the influence of maternal overall distress on mothers’ daily mood was not of interest in this study. Between-person variations in the slopes for mothers’ and fathers’ sleep variables were a function of overall slopes of each parent’s sleep, interactions between parents’ sleep and maternal overall distress, and a residual specific to each mother.

First, an unconditional means model was tested to examine the percent of the variance in mother’s mood accounted for by each level of analysis. Intraclass correlation (ICC) evaluating the relative magnitude of within-person and between-person variance component indicated that a smaller portion of the variance (37%) was attributable to between-person factors, but the larger portion (63%) was due to within-person factors. Individual trajectory for maternal daily mood across 21 days was displayed graphically in Figure 1-1. The equations for this model are:

Level 1: \( \text{Mom Mood}_{ti} = \beta_{0i} + e_{ti} \)

Level 2: \( \beta_{0i} = \gamma_{00} + \mu_{0i} \)
Then, an unconditional linear growth model was tested to examine a change in the level of mothers’ mood over time. The results showed that mothers’ mood did not change significantly over 1, 3, and 6 month, which suggested that it would be possible to consider the 21 days collapsed across the three time points, rather than separately at each time point. The equations for this model are:

**Level 1:**  \( Mom\ Mood_{ti} = \beta_{0i} + \beta_{1i}Month_{ti} + e_{ti} \)

**Level 2:**
\[
\begin{align*}
\beta_{0i} &= \gamma_{00} + \mu_{0i} \\
\beta_{1i} &= \gamma_{10} + \mu_{1i} 
\end{align*}
\]

Next, a conditional model including time-varying predictors, parents’ sleep variables (sleep efficiency, sleep fragmentation, and sleep minutes), was fit to the data. Each set of sleep variables were entered separately in order to see its respective effects on mothers’ daily mood. The equations for this model are:
Level 1:
\[ Mom\ Mood_{ti} = \beta_{0i} + \beta_{1i}Month_{ti} + \beta_{2i}MomSleep_{ti} + \beta_{3i}DadSleep_{ti} + e_{ti} \]

Level 2:
\[ \beta_{0i} = \gamma_{00} + \mu_{0i} \]
\[ \beta_{1i} = \gamma_{10} + \mu_{1i} \]
\[ \beta_{2i} = \gamma_{20} + \mu_{2i} \]
\[ \beta_{3i} = \gamma_{30} + \mu_{3i} \]

Among the three sleep variables, the model with parents’ sleep efficiency variables was fit to the data first. The results indicated that both mothers’ and fathers’ sleep efficiency significantly predicted mothers’ mood over 21 days. When mothers showed more efficient sleep than usual the night before, they reported better mood next day, \( B= 0.029 \) (\( SE=0.004 \)), \( t =6.89 \), \( p < .001 \). As in the mothers’ results, fathers who showed higher sleep efficiency than usual the night before also reported better mood next day, \( B= 0.008 \) (\( SE=0.004 \)), \( t =2.32 \), \( p < .05 \). This represented that not only mothers’ own efficient sleep but also fathers’ efficient sleep can lead to their partners’ more energized and positive mood next day, which may eventually affect maternal parental functioning during the day. Next, the model with parents’ sleep fragmentation was fit to the data. The results showed that only mothers’ sleep fragmentation significantly predicted mothers’ mood over 21 days. When mothers had more fragmented sleep than usual the night before, they reported worse mood next day, \( B= -0.009 \) (\( SE=0.002 \)), \( t =-5.22 \), \( p < .001 \). Unlike sleep efficiency, fathers’ fragmented sleep did not have any significant predictive relation to maternal mood. Lastly, the model with parents’ sleep minutes was fit to the data. The results showed that only mothers’ sleep minutes significantly predicted mothers’ mood over 21 days. When mothers had longer sleep duration than usual the night before, they reported better mood the next day, \( B= 0.003 \) (\( SE=0.0004 \)), \( t =8.66 \), \( p < .001 \). Like the results of sleep fragmentation
model, fathers’ sleep minutes did not predict mothers’ next day mood.

Finally, we tested whether there was any between-person variability across the sample in the within-person associations relating person mean centered parental sleep to maternal mood.

The equations for this model are:

Level 1:
\[ \text{Mom Mood}_{ti} = \beta_0 + \beta_{1i} \text{Month}_{ti} + \beta_{2i} \text{MomSleep}_{ti} + \beta_{3i} \text{DadSleep}_{ti} + e_{ti} \]

Level 2:
\[ \beta_{0i} = \gamma_{00} + \gamma_{01} \text{MomDistress}_i + \mu_{0i} \]
\[ \beta_{1i} = \gamma_{10} + \mu_{1i} \]
\[ \beta_{2i} = \gamma_{20} + \gamma_{21} \text{MomDistress}_i + \mu_{2i} \]
\[ \beta_{3i} = \gamma_{30} + \gamma_{31} \text{MomDistress}_i + \mu_{3i} \]

The results showed that mothers’ overall distress significantly predicted maternal mood and had meaningful interaction effects with parental sleep on maternal mood. For the sleep efficiency model, maternal overall distress negatively predicted maternal mood, \( B = -0.024 (SE=0.006), t = -4.30, p < .001 \), which indicated that when mothers had higher distress level overall, they reported worse daily mood. For both sleep fragmentation and sleep minutes models, besides the main effects of maternal distress on maternal mood, \( B = -0.009 (SE=0.002), t = -5.21, p < .001 \) and \( B = -0.025 (SE=0.006), t = -4.33, p < .001 \), there were significant interaction effects between maternal distress and parental sleep variables. In the sleep fragmentation model, maternal overall distress had a significant interaction effect with mothers’ sleep fragmentation on maternal mood over 21 days, \( B = 0.0005 (SE=0.0002), t = 2.29, p < .05 \) (Figure 1-2). This demonstrated that more distressed mothers constantly showed worse mood than less distressed mothers and they reported significantly worse mood than less distressed mothers especially on the day when mothers had less fragmented sleep than usual. In other words, even when mothers
had relatively better sleep the night before, the better sleep quality did not improve the mood of more distressed mothers whereas the better sleep quality significantly enhanced the next day mood for less distressed mothers.

Figure 1-2. Interaction between mothers’ sleep fragmentation and their overall distress level in mothers’ daily mood.

In the sleep minutes model, maternal overall distress interacted with fathers’ sleep minutes in predicting maternal daily mood, $B= -0.0009$ ($SE=0.00004$), $t=2.35$, $p < .05$ (Figure 1-3). When fathers had longer sleep minutes than usual the night before, more distressed mothers reported worse mood next day, compared to less distressed mothers who reported better mood next day. This result provided evidence suggesting that fathers’ sleep during the early postpartum period may play an essential role in determining mothers’ daily mood, especially for mentally distressed mothers. Information for the conditional model for sleep variables is included in Table 1-3, 1-4, and 1-5.
Figure 1-3. *Interaction between fathers’ sleep minutes and mothers’ overall distress level in mothers’ daily mood.*

Table 1-3. *Estimates for model of parents’ sleep efficiency predicting mothers’ daily mood across 21 days over infants’ 1, 3, and 6 month*

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>S.E.</th>
<th>t (N=151)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
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<td>0.050</td>
<td>76.88***</td>
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<tr>
<td>Time(Month)</td>
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<td>0.013</td>
<td>-1.86†</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Efficiency</td>
<td>0.029</td>
<td>0.004</td>
<td>6.85***</td>
</tr>
<tr>
<td>Person-Mean centered Fathers’ Sleep Efficiency</td>
<td>0.008</td>
<td>0.004</td>
<td>2.23*</td>
</tr>
<tr>
<td>Maternal Overall Distress</td>
<td>-0.024</td>
<td>0.006</td>
<td>-4.30***</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Efficiency x Maternal Overall Distress</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Person-Mean centered Fathers’ Sleep Efficiency x Maternal Overall Distress</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, UN(1,1)</td>
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<td>5.91***</td>
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<tr>
<td>Time(Month), UN(2,2)</td>
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<td>0.003</td>
<td>3.65***</td>
</tr>
<tr>
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<td>0.0002</td>
<td>0.01*</td>
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<tr>
<td>Fathers’ Sleep Efficiency, UN(4,4)</td>
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</tr>
<tr>
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<td>0.009</td>
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<tr>
<td>Residual</td>
<td>0.659</td>
<td>0.021</td>
<td>31.33***</td>
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</tbody>
</table>

*Note.* ***Significant at p < .001, *Significant at p < .05, †Significant at p < .10.
Table 1-4. Estimates for model of parents’ sleep fragmentation predicting mothers’ daily mood across 21 days over infants’ 1, 3, and 6 month

<table>
<thead>
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<th></th>
<th>Estimate</th>
<th>S.E.</th>
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<td>Person-Mean centered Mothers’ Sleep Fragmentation</td>
<td>-0.009</td>
<td>0.002</td>
<td>-5.21***</td>
</tr>
<tr>
<td>Person-Mean centered Fathers’ Sleep Fragmentation</td>
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<td>0.002</td>
<td>-1.01</td>
</tr>
<tr>
<td>Maternal Overall Distress</td>
<td>-0.024</td>
<td>0.006</td>
<td>-4.24***</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Fragmentation x Maternal Overall Distress</td>
<td>0.0004</td>
<td>0.0002</td>
<td>2.29*</td>
</tr>
<tr>
<td>Person-Mean centered Fathers’ Sleep Fragmentation x Maternal Overall Distress</td>
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<td>.</td>
<td>.</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
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<td>0.044</td>
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<td>0.003</td>
<td>3.78***</td>
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<tr>
<td>Residual</td>
<td>0.683</td>
<td>0.022</td>
<td>31.47***</td>
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*Note.* ***Significant at p < .001, *Significant at p < .05.
Table 1-5. *Estimates for model of parents’ sleep minutes predicting mothers’ daily mood across 21 days over infants’ 1, 3, and 6 month*

<table>
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<td>77.11***</td>
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<tr>
<td>Time(Month)</td>
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<td>0.011</td>
<td>0.76</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Minutes</td>
<td>0.003</td>
<td>0.0004</td>
<td>8.65***</td>
</tr>
<tr>
<td>Person-Mean centered Fathers’ Sleep Minutes</td>
<td>-0.0001</td>
<td>0.0003</td>
<td>-0.45</td>
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<tr>
<td>Maternal Overall Distress</td>
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<td>0.006</td>
<td>-4.31***</td>
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<td>Person-Mean centered Mothers’ Sleep Minutes x Maternal Overall Distress</td>
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<tr>
<td>Person-Mean centered Fathers’ Sleep Minutes x Maternal Overall Distress</td>
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<td>0.00004</td>
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<td>Intercept and Time, UN(2,1)</td>
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<td>-1.73†</td>
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<tr>
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<td>0.002</td>
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<tr>
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<td>0</td>
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<tr>
<td>Residual</td>
<td>0.653</td>
<td>0.021</td>
<td>30.39***</td>
</tr>
</tbody>
</table>

*Note.* ***Significant at p < .001, **Significant at p < .01, *Significant at p < .05, †Significant at p < .10.

**Discussion**

Overall, these results suggest that there were within-person associations between mothers’ sleep and mood across 21 days during infants’ first 6 months. Additionally, they suggest that fathers’ sleep also had within-person associations with mothers’ mood across 21 days of infants’ first 6 months. Maternal overall distress appears to moderate the effect of both mothers’ and fathers’ sleep on maternal mood, in addition to the negative direct effect on maternal daily mood. These results provide evidence that mothers’ daily well-being is not only determined by their own sleep, but also affected by fathers’ sleep as theorized by family systems theory. Furthermore, mothers’ overall psychological distress played a role as a risk factor aggravating the effect of
parents’ poor sleep on maternal mood. These results have significant implications for understanding the role of fathers in influencing maternal daily mood and for recommendations that are made to interventionists on how to help promoting mother’s daily mood during early postpartum period.

**Day-to-day association between parents’ sleep and maternal mood**

**Mothers’ sleep and mood.** First, the results supported Hypothesis 1 that mothers’ better sleep the night before would be associated with better mood next day with all three kinds of sleep variables. When mothers’ sleep was more efficient, less fragmented, and longer than usual the night before, their next day mood was better than usual. To our knowledge, this is the first study to report the relationship between day-to-day variations in actigraphically assessed sleep and mood in mothers of early postpartum period. These results demonstrated that there was an association between mothers’ sleep and mood across early postpartum days and therefore replicated and extended previous cross-sectional findings of associations between maternal sleep and overall mood such as depressive symptoms and anxiety (Seymour, Giallo, Cooklin, & Dunning, 2014) into a day-to-day level in a temporal manner. As in the relationship between average levels of sleep and mood, mothers’ more disrupted sleep of the previous night may worsen the next day mood due to interferences in brain processes, particularly those including the amygdala and prefrontal cortex, which are critical for the expression, experience and regulation of emotion (Kahn, Sheppes, & Sadeh, 2013; Lisa S Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010). Particularly, the result that both sleep maintenance (fragmentation and reductions in sleep efficiency) and sleep quantity (sleep minutes) were significantly associated with maternal mood suggests that all aspects of maternal sleep are important in affecting mothers’ day-to-day mood (Park et al., 2013).
The results also show that objectively assessed maternal sleep can be a strong predictor of maternal daily mood, unlike other studies suggesting the superiority of subjective measures of sleep as more accurate predictors of overall postpartum mood compared to objective measure of sleep (Bei et al., 2010; Dørheim et al., 2009b; Park et al., 2013). Considering that people tend to be unable to recall their own sleep experiences accurately and therefore depend on other related factors, such as current mood, as indicators of sleep quality (Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008), objective assessments of sleep may reflect more actual and unbiased nature of sleep, thus revealing more independent relationship between sleep and mood.

**Fathers’ sleep and maternal mood.** In Hypothesis 2, we predicted that fathers’ better sleep the night before would be associated with better maternal mood next day. This hypothesis was partially supported, showing that only fathers’ sleep efficiency was predicting mothers’ next day mood, but fathers’ sleep fragmentation and minutes were not. When fathers’ sleep was more efficient than usual the night before, mothers’ next day mood was better than usual. This finding is consistent with our expectation that changes in fathers’ sleep can stimulate changes in mothers’ mood as theorized by family systems theory suggesting that individuals are interdependent in various family subsystems with a change at one level can prompt further changes in individuals, relationship, and the whole family systems (Cox & Paley, 2003). It is also consistent with the emotional transmission model that one individual’s daily experiences including certain events and emotions can have crossover effects to other family members in predicting their subsequent emotions and behaviors. Fathers’ sleep has been found to show no significant difference from mothers’ sleep (Elek et al., 1997, 2002) and, like mothers, their sleep can be disturbed due to frequent infant night wakings, helping mothers’ care for newborns or taking full charge for certain part of nighttime care such as changing diapers and bottle feeding, or merely due to their
own physical and emotional symptoms such as postpartum nervousness and anxiety (Clinton, 1987; Fawcett & York, 1986). This disrupted paternal sleep may indicate and reflect the levels of their own psychological well-being and of paternal involvement and support for mothers’ nighttime caregiving, which in turn influences maternal daytime mood and functioning (Lin, Chang, Chen, Lee, & Chen, 2017; Meltzer-Brody et al., 2013; Redshaw & Henderson, 2013). It is worth noting that this work extends the sparse literature about the role of fathers in the early postpartum period by providing a better understanding the link between fathers’ sleep and maternal mood. We did not find evidence for the direct effects of paternal sleep fragmentation and sleep minutes on mothers’ next day moods, but there was a moderating effect of maternal overall distress in a relationship between fathers’ sleep minutes and mothers’ moods that we will describe at the end.

**Maternal overall distress and their daily mood**

We found evidence in support of Hypothesis 3, that maternal overall distress would predict their daily mood across infants’ first 6 months, in all models with sleep efficiency, fragmentation, and minutes. When mothers reported higher level of overall psychological distress on average across 1, 3, and 6 months, they reported lower day-to-day mood on average compared to those with lower overall distress level. This finding is in line with previous research indicating that psychological distress was associated with lower overall levels of daily mood (Costello et al., 1991; Cowdry et al., 1991; Peeters et al., 2006). Unlike that the previous findings were based mainly on clinical samples with diverse mood disorders, the present result further suggests that overall psychological distress including depression and anxiety symptoms has a critical influence on non-clinical mothers’ everyday mood during early postpartum period. The lower level of daily mood of more distressed mothers may be related to deficits in their daily
executive functions such as defining a goal, creating a plan of action, and updating and monitoring information due to the exposure to constant feelings of distress and this link seems to be mediated by emotion regulation and reappraisal process (García-Villamisar & Armentia, 2014). Especially, mothers’ higher level of overall distress during the transition to parenthood, a dynamic period with a number of changes at a neurobiological, hormonal, and psychological level (Rutherford, Wallace, Laurent, & Mayes, 2015), may reflect their poor regulatory capacity of various emotions including infants’ emotions as well as their own that is particularly necessary ability to maintain daily activity and mood (García-Villamisar & Armentia, 2014). In addition to the direct effects of maternal overall distress on their daily mood, several interactive effects detected in our study, which we will discuss next, support this premise.

**Interactive effects of maternal overall distress on parental sleep and maternal mood**

Hypothesis 4 concerned interactive effects between maternal sleep and their overall distress on maternal daily mood. We expected that mothers who are more psychologically distressed on average will show worse mood next day even with better sleep quality the night before, whereas mothers with less overall distress will show better mood next day with better sleep the night before. We found support for this hypothesis via an interaction between mothers’ overall distress and their sleep fragmentation on their next day mood. We found that when mothers are more distressed, they showed generally worse mood than less distressed mothers regardless of sleep fragmentation. Particularly, more distressed mothers reported significantly worse mood than less distressed mothers even on the day when they had less fragmented sleep than usual, whereas less distressed mothers reported much better mood next day when they had less fragmented sleep the night before. That is, even when mothers had relatively better sleep the night before, the better sleep quality did not improve the mood of more distressed mothers,
whereas the better sleep quality significantly enhanced the next day mood for less distressed mothers. On the contrary, when mothers’ sleep was more fragmented and disturbed, the next day’s mood of less distressed mothers significantly decreased to the similar level of more distressed mothers’ mood. This suggests that less distressed mothers with lack of sleep may function similarly to highly distressed mothers, demonstrating and replicating prior evidence of the critical role of sleep quality in affecting postpartum mothers’ psychological well-being and daily functioning (Bhati & Richard, 2015; Goyal et al., 2009; Lawson, Murphy, Sloan, Uleryk, & Dalfen, 2015; Ross, Murray, & Steiner, 2005). This finding also supports previous work that prolonged exposure to the feeling of distress is associated with the decrease of everyday well-being (García-Villamisar & Armentia, 2014). Particularly, this result supports earlier finding suggesting that women with postpartum depression tend to report higher level of negative affect and lower level of positive affect compared to those without PPD (Buttner et al., 2015). More distressed mothers may be already experiencing significantly lower level of daily mood and this decreased daily well-being may not be able to be alleviated even by positive experiences such as better sleep quality as in this study.

Hypothesis 5 concerned an interactive influence between paternal sleep and maternal overall distress on mothers’ daily mood. With regard to fathers’ sleep, we expected that mothers’ overall distress will have a negative impact on the positive association between fathers’ sleep quality and maternal mood, but no direction was specifically hypothesized because there was not enough earlier work to support the specific directions of the possible negative effect. We found that more distressed mothers reported worse mood the next day when fathers slept longer than usual the night before, compared to less distressed mothers who reported better mood the next day with fathers’ longer sleep. These results suggested that longer-than-usual sleep in fathers has
opposite “effects” on mothers’ mood, depending on the level of mothers’ overall distress. One possible explanation for this result is that, assuming that fathers’ sleep disturbance or shorter sleep time during the early postpartum period may be due to the involvement in the nighttime parenting either to help mothers’ care for newborns or to substitute for mothers’ caregiving roles, more distressed mothers may consider fathers’ longer sleep minutes as less amount of nighttime paternal support, either emotional or instrumental, which in turn affects mothers’ next day mood negatively.

Implications

Taken together, the results suggest that parents’ daily sleep and maternal overall distress were associated with mother’s daily mood during early postpartum period. This indicates that mothers’ day-to-day mood are sensitive to variations not only in their own sleep but also in fathers’ sleep, and to variations in mothers’ overall level of distress. These findings could inform early intervention for parents in early postpartum period because understanding how parents’ sleep as well as mothers’ overall psychological well-being may affect mothers’ mood in a daily level has critical implications for promoting healthy psychological well-being and daily adjustment of early postpartum parents. If both mothers’ and fathers’ postpartum sleep forecast mothers’ daily mood, early interventions aiming to improve parents’ sleep right after birth may lead to mothers’ enhanced daily mood. Intervention strategies that improve the quality of parents’ sleep such as increasing the efficiency of, in spite of the lack of absolute amount of sleep, may help enhancing mothers’ daily mood. Introducing a sleep intervention even during pregnancy may offer a practical benefit of allowing expectant parents time to focus on their sleep before the births of the infant and also to mentally prepare for postpartum sleep deprivation since there is evidence of some resilience among mothers in expectation of dramatic changes and disruptions.
to their postpartum sleep (Bei et al., 2010). Also, because the results suggest that more distressed mothers were not responsive to better sleep quality and more affected by fathers’ longer sleep minutes, interventions to postpartum depression and anxiety may boost the overall level of mothers’ mood in a daily context, so maternal daily mood can be more reactive to positive events and resilient to negative stimuli.

**Limitations and future directions**

There are several limitations of this study that must be addressed. First, our sample was predominantly Caucasian American. Although early postpartum period may be a period with new stressors and requirements for most parents, their daily sleep and mood would be differently influenced by diverse cultural and ethnical backgrounds. Future work investigating these research issues in more diverse groups may reveal a different relationship between sleep and mood, as culture and ethnicity have been shown to modify postpartum adjustments and experience of motherhood (Abdollahi, Etemadinezhad, & Lye, 2016; Dankner, Goldberg, Fisch, & Crum, 2000). Additionally, because it has been widely known that mothers’ postpartum mood has significant influences on mother-infant relationships and infant development (Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Swanson, Flynn, Wilburn, Marcus, & Armitage, 2010; Teti & Crosby, 2012), we focused on mothers’ daily mood for the current study. However, according to family systems theory and emotional transmission models, fathers’ daily mood may be an influential factor on mothers’ daily well-being, and fathers’ mood may eventually affect infant development in different ways from mothers’ mood. Thus, it will be an important avenue to study fathers’ mood in the future research in order to understand the unique role of fathers’ mood in the family systems and interactions as well as diverse directions of influences between parents and between parents and children. Thirdly, maternal daily mood data was collected with one self-
report item at each day during daily phone interviews. This may limited our ability to detect more detailed relationships between sleep and mood, although single item ratings of mood have been considered as a valuable alternative to multi-item ratings (Bergkvist & Rossiter, 2007; DeSalvo et al., 2006), especially in the context of intensive data collection across multiple days (Oerlemans, Bakker, & Veenhoven, 2011). Future studies may benefit from specifying mood items into various categories of emotions such as happiness, joy, anger and sadness, which may better account for the variability in daily relationships between sleep and mood. Finally, it is important to note that many studies suggest a bi-directional relationship between sleep problems and mood disturbances (Armitage et al., 2009; Perlis et al., 1997). Some evidence suggests that certain emotions such as stress, anxiety, and depressed mood may lead to compromised sleep through poor emotion regulation and physiological-emotional reactivity (Galambos, Howard, & Maggs, 2011; Kahn, Sheppes, & Sadeh, 2013; Mayers & Baldwin, 2006; Roberts, Roberts, & Xing, 2011; Talbot, Hairston, Eidelman, Gruber, & Harvey, 2009). Thus, in future work, it is necessary to consider the possibility of transactional processes between postpartum parents’ sleep and mood examining their mutual influences.

Conclusions

These findings cast light on how mothers’ mood is influenced by multiple factors in a daily level during early postpartum period. Not only mothers’ daily sleep and overall distress, but also fathers’ daily sleep, and interactions between parental daily sleep and maternal overall distress emerged as critical predictors of mothers’ daily mood. These results highlight the need for greater focus on dynamic processes in relationships between sleep and mood as well as the importance of paternal influence in mothers’ early postpartum well-being, which suggest avenues
for future research exploring how these dynamic associations between parental sleep and maternal mood are related to mothers’ parenting quality and mother-infant relationships.
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Study II
Maternal Daily Mood Dynamics and Bedtime Emotional Availability during Infants’ First Six Months

Introduction

Based on existing studies on parents’ overall mood and its impact on parental behaviors (Kim, Teti, & Cole, 2012; Lovejoy & Graczyk, 2000; Teti & Crosby, 2012; Wilson & Durbin, 2010), it is expected that parents with positive daily mood will show better parenting than those with negative daily mood. However, beyond overall, average levels of daily mood, understanding the impact of fluctuations in mood over time may also be important to capture, because emotional volatility may reflect an underlying capacity for self- and emotion regulation (Lorber & Slep, 2005). In theories of emotion regulation and self-development, people who are competent at regulating their emotions are characterized by less variability in their reports of emotional experience over time and show better psychological adjustment (Ram, Gerstorf, Lindenberger, & Smith, 2011; Röcke, Li, & Smith, 2009). Indeed, various studies on mood variability have demonstrated that greater day-to-day fluctuations in mood tend to be associated with poor psychological adjustment and health outcomes such as depression, anxiety, bipolar disorders and less effective aging (Benazzi & Akiskal, 2005; Benedetti, Barbini, Colombo, Campori, & Smeraldi, 1996; Bowen, Clark, & Baetz, 2004; MacKinnon et al., 2003; Ram et al., 2011).

Examining maternal mood variability during early postpartum period may be especially important because early infancy lays a foundation for mother-infant relationships, and well-regulated and predictable maternal emotions have been found to be essential pre-requisites to
organized and competent parenting (Lorber, 2012; Teti & Cole, 2011). Mothers with increased mood variability may have less energy to sustain effective functioning in their parenting roles due to a greater need to regulate their own emotions (Gruber, Kogan, Quoidbach, & Mauss, 2013). For example, mothers with borderline personality disorder (BPD) who typically have difficulties in regulating their affect and impulse control, have been found to be less sensitive and less effectively structuring during interactions with their infants (Newman, Stevenson, Bergman, & Boyce, 2007). To date, many studies have investigated the important effects of mothers’ overall mood states such as depression and anxiety (Gelfand & Teti, 1990; Lovejoy et al., 2000; Martin et al., 2002; Weisman et al., 2010). However, no study has yet explored the influence of maternal daily mood, including mood variability, on parenting during the early post-partum period.

**Dynamics of Daily Mood**

**Level of Daily Mood.** Using a variety of dairy methods and experience-sampling method (ESM) (Bolger et al., 2003), most studies on daily mood have investigated daily mood level as a correlate of diverse daily stressors (Gil et al., 2004; Kleiboer et al., 2007) and psychological and physical well-being (Fredrickson & Losada, 2005; Wichers et al., 2007). For example, negative daily mood has been found to be associated with increased reports of pain in both same-day and subsequent-day of Sickle-Cell Disease patients (Gil et al., 2004). Also, Kleiboer and colleagues (2007) found that, on days when patients with multiple sclerosis (MS) and their partners reported more experience of negative responses from the partner, both patients and partners reported more negative mood (Kleiboer et al., 2007). On the other hand, positive daily mood has been found to buffer against stress and to decrease genetic risks for depression (Wichers et al., 2007). When people reported more positive mood at moments of daily stress using ESM, they showed lower
levels of negative mood and reduced endophenotypic expression of genetic vulnerability for depression. Further, Fredrickson and Losada (2005) found that when people experience positive daily mood more frequently than negative mood, they showed more positive psychological and social functioning (Fredrickson & Losada, 2005). Finally, in a recent study with older adults, it was found that, compared to cognitively healthy control adults, those with mild cognitive impairment and Alzheimer’s disease reported less positive day-to-day mood (Kaspar, Oswald, Wahl, Voss, & Wettstein, 2015). Those older adults also reported better mood on days when they had more recreational and leisure activities. Considering that the early postpartum period is a period which has a variety of daily stressors that impact parents’ well-being both physically and psychologically, it is necessary to examine the possible effects of mothers’ overall level of daily mood on parenting quality during this early post-partum period.

**Variability of Daily Mood.** As a distinct aspect of emotion dynamics, variability in emotional state is usually represented by the within-person standard deviation of emotions over time (Eaton & Funder, 2001) and indicates how much individuals’ emotional experiences deviate from an “average”. Variability in mood can be measured with time-intensive methodologies such as diary designs. These designs can not only reduce problems associated with retrospective recall (a common concerns of single point assessments) by allowing family members to report experiences nearer to the time they occur (Almeida et al., 1999), but also show how much people change over short-term periods of time (Bolger et al., 2003). Mood variability can be assessed reliably (Trull et al., 2008) and is stable within individuals (Eid & Diener, 1999).

Although some emotional variability is considered to be normative as a reaction to certain environmental stressors (Cole & Hall, 2008), large fluctuations in mood over time can indicate psychological instability, which, in turn, is related to distress and mental illness
(Kashdan & Rottenberg, 2010; Waugh, Thompson, & Gotlib, 2011). For instance, greater variability in negative emotion was significantly associated with increased level of depressive symptoms (Peeters et al., 2006). Interestingly, greater variability in positive emotions was also linked to increased depression and anxiety, decreased daily satisfaction and general life satisfaction as well as lower subjective happiness (Gruber et al., 2013). Similarly, mild positive mood, which is usually adaptive, becomes maladaptive when accompanied by high variability (Bowen et al., 2006). Also, mood variability is a core feature of bipolar disorder (Macfie & Swan, 2009) and rapid switching of moods is related to early onset and comorbidity of the disorder (MacKinnon et al., 2003). Finally, mood fluctuation is negatively related to older adults’ cognitive aging. More positive cognitive aging, defined as less decline or increase in the perceptual speed, was associated with less emotion variability (Ram et al., 2011).

To date, most of studies on mood variability have focused on samples of patients with mood disorders such as depression and bipolar disorder (Cowdry, Gardner, O’Leary, Leibenluft, & Rubinow, 1991; MacKinnon et al., 2003), on college students (Eid & Diener, 1999; McConville & Cooper, 1996) and on older adults (Hülür, Hoppmann, Ram, & Gerstorf, 2015; Ram et al., 2011; Röcke & Brose, 2013). However, no study has yet examined mood variability in parents with young infants. In light of the findings, discussed above, linking mood variability with compromised functioning in adults, and that mood stability more generally is an important aspect of parents’ emotional make-up (Eid & Diener, 1999; Morris, 1989; Teti & Cole, 2011), it is important to understand the potential impact of mood variability on parenting quality.

**Parents’ Daily Mood Dynamics and Parenting**

According to the functionalist theory of emotions, a central function of emotions is to motivate behavior and prepare individuals for action (Levenson, 1994). Teti and his colleagues
(Killeen & Teti, 2012; Teti & Cole, 2011) propose that emotion is a critical component of parenting, and that one’s capacity to regulate emotion, particularly negative emotion, is directly relevant to parenting quality (Dix, 1991). Prior works on the relationship between parental emotion and parenting have mostly focused on the impact of overall levels of parental emotion complexes such as depression and anxiety on parenting (Cassidy, Zoccolillo, & Hughes, 1996; Easterbrooks, Biesecker, & Lyons-Ruth, 2000; Gelfand & Teti, 1990; Kim et al., 2012). For example, depressed mothers show less response to their children’s behaviors, less effective communications, lack of synchrony, higher rates of negative and coercive interactions, and more impatient directives during interactions with their children than non-depressed mothers do (Gelfand & Teti, 1990; Lovejoy et al., 2000). Anxious mothers were found to show more intrusive behaviors that are not matched with the infant’s state by over-stimulating and overriding the infants’ moment-by-moment signals (Feldman, 2007; Feldman et al., 2009; Lynne Murray et al., 2007).

Studies of parents’ daily mood have been examined daily mood as an outcome of various daily stressors. Some studies have shown that higher workload days and more work-related stressors such as nighttime work were associated with lower levels of positive mood and higher levels of negative mood, which may lead to negative parent-child interactions (Gassman-Pines, 2011, 2013; Repetti, 1993; Repetti, Wang, & Saxbe, 2009). Other studies have found that parents of children with serious disabilities reported more negative and less positive daily mood. For example, for parents of children with Autism Spectrum Disorder (ASD), greater social support they received predicted higher levels of positive mood and lower level of negative mood (Pottie, Cohen, & Ingram, 2009). For parents with ADHD children, mothers’ perception of a child’s difficult behaviors was related to the level of maternal daily distress (Whalen, Odgers, Reed,
Henker, 2011). Although there has been some research on the levels of parents’ daily mood in relation to different daily stressors, no study has yet examined parents’ daily mood in the context of parenting during early infancy. The present study will investigate the impact of level of parental daily mood, using parents’ daily diary reports, on parenting quality.

In light of the fact that emotion varies and fluctuates dynamically over time (Davidson, 1998), the present study will also examine its dynamics “in the moment” to have more thorough knowledge of the influence of parental mood on the quality of parenting behaviors (Gruber et al., 2013). Indeed, parents inevitably face a range of emotions and challenges when interacting with their young infants, and it is necessary for them to have effective emotion regulation strategies to be more consistent and sensitive in responding to their infants’ signals (Cassidy, 1994; Gottman, Katz, & Hooven, 1996; Lorber & O’leary, 2005; Martin et al., 2002). For instance, parents with unstable mood and poor quality strategies of tension reduction tend to be less emotionally aware (Marziali et al., 2003) and to react intensely and unpredictably to their children (Pearlman & Courtois, 2005). Such parents, it appears, cannot regulate their emotions well enough to be sensitive to their children’s needs during interaction (Gottman et al., 1996). Furthermore, dysregulated parents may show both excessively activated and underactivated emotional expressions (i.e., high mood lability), which can be very confusing and disorganizing to the child (Litz et al., 2000). For example, Lorber and Slep (2005) found that mothers who reported more predictable moment-to-moment emotions were found to engage in less harsh or lax discipline with their toddlers than mothers who showed more unpredictable emotions over time.

Although, with increasing use of daily dairy designs, more studies have examined dynamic associations between parents’ psychological daily stress and parent-child interactions (Almeida et al., 1999; Almeida, Wethington, & McDonald, 2001), to date no study has examined
linkages between mood variability in parents and quality of parenting during the early postpartum period. The present study does so with a specific focus on parenting quality in the context of infants’ bedtime. Infants’ bedtime, in addition to infants’ daytime interactions with mothers, is a significant context for mother-infant interactions in a sense that a calm and stable bedtime can provide a good foundation for infant sleep (Teti, Kim, Mayer, & Countermine, 2010). In order to have high quality interactions during bedtime, stable and consistent quality of parenting is, theoretically, a key ingredient for creating and enhancing infants’ feeling of safety and predictability about their surrounding environments (Dahl & El-Sheikh, 2007; Teti et al., 2010). However, if mothers have highly fluctuating mood throughout the day, it is reasonable to assume that such mood volatility may compromise quality of parenting during bedtime interactions. The present study will examine the effect of maternal daily mood, both in terms of levels and variability, on the mothers’ emotional availability during bedtime interactions from 1 to 6 months of age.

**Bedtime Emotional Availability**

The parenting outcome of central interest in the present study is emotional availability (EA) at bedtime, using the well-established Emotional Availability Scales (EAS; Biringen, Robinson, & Emde, 1993; Biringen & Robinson, 1991). EA is a relational construct that reflects the overall quality of dyadic interaction between caregiver and child within an emotion framework (Biringen, 2000; Bretherton, 2000; Emde, 1980). A small, but increasing number of studies have directly examined EA in relation to parental mood. These studies reported that maternal depression, other mood disorders, and affective communication difficulties were significantly associated with low levels of EA, with mothers being less attuned and less joyful during the interaction with their children (Vliegen et al., 2009). For example, depressed mothers
were found to be less emotionally available to their infants and children than non-depressed mothers showing less sensitivity (Lok & McMahon, 2006) as well as less structuring and more intrusiveness (Vliegen et al., 2009). Also, mothers who experienced a depressive illness combined with other disorders such as an anxiety, substance, or eating disorder showed the lowest EA score with their 4 month-old infants compared to mothers with depression only or with no history of psychopathology (Carter, Garrity-Rokous, Chazan-Cohen, Little, & Briggs-Gowan, 2001).

Whereas most studies on EA examined EA within the context of free play interaction during daytime either at home or in the lab setting (Carter et al., 2001; Easterbrooks et al., 2000; Easterbrooks, Bureau, & Lyons-Ruth, 2012; Kim et al., 2012; Stack et al., 2012; Vliegen et al., 2009), a recent study by Kim and Teti (2014) investigated the relationship between maternal mood and EA within the context of infants’ bedtime (Kim & Teti, 2014). They looked at mothers’ EA during infants’ bedtime and found that changes in mothers’ depressive symptoms from 1 to 6 months predicted their emotional availability at 9 months. Furthermore, mothers’ bedtime EA was found to be associated with infants’ sleep quality and cortisol patterning (Philbrook et al., 2014; Teti et al., 2010). Teti et al. (2010) found that infants had better sleep when mothers showed more emotionally available behaviors to their infants during bedtime. Philbrook et al. (2014) found that, with higher maternal EA, infants showed lower levels and healthier pattern of cortisol. This suggests that studying parent-infant interaction during infant’s bedtime, a context which is much less studied than day time interactions, is critical because bedtime EA has important impact on infant development (Carter et al., 2001; Easterbrooks et al., 2012). Thus, the present study will examine parents’ bedtime emotional availability as a measure of parenting quality from infants’ 1 to 6 month.
Mothers’ Sleep Quality as a control

Mothers’ sleep during the early post-partum period may be compromised by various physiological changes mothers experience during late pregnancy and the early post-partum period, which may hinder them from having restful sleep (Brunner et al., 1994). There has been a considerable amount of research on the influence of sleep loss on behavioral functioning in a variety of task domains, including work-related incidents (Ayas et al., 2006), medical errors (Gold, Rogacz, Bock, Tosteson, & Baum, 1992; K. K. Papp et al., 2004), and hazardous driving events (Ftouni et al., 2013; Stutts, Wilkins, Scott Osberg, & Vaughn, 2003).

In terms of mothers’ sleep loss and their functioning, mother’s fragmented sleep has been associated with significant impairment of their daytime functioning (Bayer et al., 2007; Meltzer & Mindell, 2007; Meltzer & Walsh, 2013; Montgomery-Downs, 2010). Meltzer and Mindell (2007) found mothers with disrupted sleep reported more daytime fatigue and sleepiness as well as greater parenting stress and caregiving overload. Bayer and colleagues (2007) also found interrupted sleep patterns place mothers at risk of overload and dysfunction, making it difficult to provide adequate physical and emotional care for their infants.

In addition to parents’ daytime functioning, sleep deprivation also have been found to be a significant correlate of parental mood (Coo et al., 2012; Park, Meltzer-Brody, & Stickgold, 2013). Poor self-reports of sleep quality during the first 17 weeks postpartum were found to be risk factors for the onset of postnatal depression in women with a history of postnatal depression (Okun, Luther, Prather, Perel, Wisneiwski, & Wisner, 2011). A very recent study by Saxbe and colleagues (2016) also found that both mothers' and fathers’ sleep quality at 6 month postpartum predicted their depressive symptoms at both 6 and 12 months. Furthermore, there is some evidence that partial sleep deprivation in adults predict mood lability and increased susceptibility
to dysphoria through stress-related neurobehavioral processes (Belenky et al., 2003; Dinges et al., 1997; Van Dongen, Maislin, Mullington, & Dinges, 2003).

Considering the link between parental sleep and their daytime functioning and mood, in order to investigate the pure influence of maternal daily mood dynamics on their parenting quality, it is reasonable to control the effect of maternal sleep. No study has yet investigated the link between parental mood, and actual, observed parenting, controlling for the influence of poor parental sleep quality. Further, no study has controlled the dynamics of parental daily sleep including the variability of sleep across multiple days, in addition to the average level of sleep quality. Therefore, this study will investigate how maternal daily mood influences parenting quality observed in the bedtime context, controlling for the dynamic influence of maternal sleep quality, including both level and variability of sleep quality during early post-partum period.

Current Study

The current study investigated how mothers’ daily mood dynamics including mood level and variability were associated with mothers’ parenting during bedtime interactions after controlling for the effect of maternal daily sleep quality. This study adds to the existing research in several ways. First, mothers’ mood was assessed daily and longitudinally, creating both overall level and variability of mood across multiple days over three time points during infants’ 6 months, which allowed for the examination of the within-person associations between variations in maternal mood and parenting. Second, parenting was assessed during bedtime interactions, possibly a more challenging caregiving context that has seldom been investigated, using behavioral coding of video recordings. Third, effects of maternal sleep dynamics including both the overall level and variability of sleep quality across multiple days were controlled in both
within-person and between-person levels, in order to find the pure association between maternal mood dynamics and parenting quality.

**Hypotheses**

The following hypotheses were proposed:

Hypothesis 1: Higher maternal daily mood level than usual will predict higher maternal bedtime EA than usual across infants’ 1, 3, and 6 month, after controlling for maternal sleep (sleep efficiency, fragmentation, and minutes).

Hypothesis 2: Higher maternal daily mood variability than usual will predict lower maternal bedtime EA than usual across infants’ 1, 3, and 6 month, after controlling for maternal sleep (sleep efficiency, fragmentation, and minutes).

Hypothesis 3: Higher maternal daily mood level on average will predict higher maternal bedtime EA on average across infants’ 1, 3, and 6 month, after controlling for maternal sleep (sleep efficiency, fragmentation, and minutes).

Hypothesis 4: Higher maternal daily mood variability on average will predict lower maternal bedtime EA on average across infants’ 1, 3, and 6 month, after controlling for maternal sleep (sleep efficiency, fragmentation, and minutes).

Hypothesis 5: The role of mothers’ daily mood variability in moderating associations between mothers’ daily mood level and bedtime EA across infants’ 1, 3, and 6 month, after controlling for maternal sleep (sleep efficiency, fragmentation, and minutes), will be examined. Among mothers with lower daily mood variability, EA was expected to be positively associated with daily mood level. By contrast, following the results of Bowen et al. (2006), among mothers with higher daily mood variability, no
association, or perhaps even a negative association, was expected between EA and increases in daily mood.

Methods

Participants

Participants were part of Project SIESTA, a large NIH-funded longitudinal study of parenting, infant sleep, and infant development across infants’ first two years (NIH R01HD052809). A total of 167 parents and infants were recruited within 1 or 2 days after delivery from the obstetric floors of two local hospitals in central Pennsylvania, the Mt. Nittany Medical Center and the Milton S. Hershey Medical Center. In order to be recruited to the study, mothers had to be 18 years or older and to speak English fluently. One hundred sixty seven mothers participated in the study when their infants were 1 month old. Mother’s average age was 29.4 years old (SD=5.3) ranging in age from 18 to 43 and 138 (83%) of mothers were married and living with a partner. A total of 84% of mothers identified themselves as White, 3.6% as African American, 3.6% as Asian American, 5.5% as Latino and 3.6% as Other. A total of 30% of mothers completed high-school but had no further education, 38.6% attended or graduated from college, 30.1% received graduate or professional degrees, and a remaining 1.3% did not complete high-school education. Sixty two percent of mothers were employed and the average yearly family income was $69,503.59 ranging from $0 up to $300,000.

Of the 167 mothers, 162 mothers who had data for at least one time point on all study variables could be included in the analyses. There were no demographic differences between the final analytic sample and the dropped sample, except the race of the mothers: mothers in the final sample were more likely to be White, $\chi^2 (4, 165) = 10.96, p < .05$ than the dropped mothers.
Measures

Maternal Daily Mood Level and Variability

Maternal daily mood was assessed from daily phone interviews which were conducted with mothers respectively on their convenient times for the seven consecutive days of the data collection week at 1, 3 and 6 month. During these interviews, mothers were asked to rate how energetic they felt during the day on a 5-point Likert scale (1 = feeling low and tired, 5 = feeling positive and energetic). Since the interview item specifically asked mothers for their overall energy level of the day, mothers’ daily mood was operationalized as mothers’ daily vitality in this study. Mothers’ responses on this item were averaged to produce the overall level of maternal daily mood for the seven days at each age point. In addition, a standard deviation of their responses across 7 days was also obtained to describe the variability of maternal daily mood across 7 days.

Maternal Sleep

Parental sleep was measured across seven consecutive days of the data collection week at each age point (1, 3, and 6 month) using Mini-Mitter Actigraphy wristwatches (Model AW-64). Actigraph watches have been validated as a reliable method to assess objective sleep, with good reliability between actigraphy and polysomnography (Ancoli-Israel et al., 2003; Kushida et al., 2001; Tryon, 2004). In the current study, we used the following nighttime sleep variables as covariates of maternal mood, generated using the accompanying software, Actiware (Version 5.0): a) sleep efficiency, b) sleep fragmentation, and c) sleep minutes. Sleep efficiency refers to a percentage of time spent asleep between the sleep onset and final awakening (De Souza et al., 2003) and sleep fragmentation provides an overall measure of restless sleep which is generated by calculating both the individual’s activity level during sleep and the frequency of sleep activity.
being interrupted by bouts of activity. Finally, sleep minutes represent the amount of sleep time in minutes.

**Bedtime Videos**

*Video recording of parent-infant interactions*

When infants were 1, 3, and 6 month, families were visited by project staff on the 6th day of data collection to set up video recording equipment, consulting with parents about the locations where the infant was taken for bedtime routines and for their nighttime sleep. Two to four cameras were used to catch the majority of parent-infant interaction across bedtime and nighttime. Parent-infant interactions were recorded by and stored in a Bosch Divar XF 8-Channel Digital Versatile Recorder (DHR-0800B-150A; Bosch Security Systems) using infrared security cameras (C420BCVFIR; ARM Electronics) and microphones (CV-5104MIC; Channel Vision). Parents and project staff could check the camera placement and see the recordings on a 9-inch portable DVD Player (A299-1040; Audiovox D9000). For all families, one camera was set up above the crib or bed where the infant slept. Up to three additional cameras were placed to capture an overview of the room including the door to identify who was entering and exiting the room, a view of the infants’ changing table, and a chair where the infant was fed or rocked. Among four cameras, up to two cameras could be set up wirelessly if the infant’s bedtime and nighttime routines took place across different rooms. Cameras were located using boom stands, gorilla pods, or foam pieces in a way that they were as less intrusive to the families as possible. Since all equipment was connected to one power strip, parents were asked to turn on the main power button one hour prior to infants’ bedtime in order to make sure that all of the bedtime routine was recorded, and off in the morning when the infant is awake and out of bed for the day.
Mother’s Emotional availability during the bedtime interactions with their infants was coded with the Emotional Availability Scales (EAS; Biringen et al., 1998). The EAS is designed to assess the emotional quality of parenting and consists of four parenting scales: Sensitivity (parent’s ability to read accurately and respond contingently to child signals), structuring (parent’s capacity for appropriate scaffolding of child activities and setting appropriate limits), non-intrusiveness (reverse-scored, parent’s ability to respect the child’s autonomy and personal space), and non-hostility (reverse-scored, parent’s capacity to interact with the child without signs of covert or overt irritability/anger).

Because most of previous studies have examined EA in the context of parent-infant play, in order to code EA in the bedtime context, this study used the following adaptations that were established by Teti and colleagues (2010). Sensitivity was rated high when parents showed accurate and contingent response to infant signals during their bedtime interactions such as changing diapers, book reading, and nursing or bottle feeding. If parents took longer than 1 minute in responding to their infants’ distressed vocalizations, they were rated low on sensitivity and structuring. Structuring was scored high if parents provided their infants with organized, positive and soothing bedtime routines that gently prepared infants for sleep. Non-intrusiveness was scored highly when parents reduced the initiation of new interactions with their infants and keep the volume of their voices low and quiet not only to the infants but also to other family members, noticing when the infants became drowsy and ready for sleep. Non-hostility was scored highly if mothers showed no overt and covert irritability, sarcasm or anger towards their infant during bedtime interactions. These four dimensions were standardized into z-scores, and then combined into a composite EA score with higher scores indicating greater emotional
availability.

All coding of maternal EA was conducted by reliable coders who were trained and certified to use the Emotional Availability Scales scoring system, and coders were blind to all other data on the families. Coders coded bedtime from when the infant first appeared on cameras until the beginning of five consecutive minutes of infant sleep which was determined by the absence of gross motor movement and closed eyes. Inter-rater reliability was established periodically between coders on the four EA dimensions and the composite EA score and any disagreements were resolved by consensus between coders. The intraclass-correlations (ICC) for maternal EA was calculated for 9-10 randomly selected videos at each age: At 1 month, ICCs were .99 for the composite EA score, .99 for sensitivity, 1.00 for structuring, .83 for non-intrusiveness, and .98 for non-hostility; At 3 month, ICCs were .98 for the composite EA score, .95 for sensitivity, .94 for structuring, .91 for Non-intrusiveness, and .99 for Non-hostility; At 6 month, ICCs were .99 for the composite EA score, .96 for sensitivity, .98 for structuring, .89 for Non-intrusiveness, and .87 for Non-hostility. For paternal EA, ICCs were calculated for 20 randomly selected videos across all time points due to the limited numbers of father-infant bedtime interactions: ICCs were .98 for the composite EA score, .99 for sensitivity, .94 for structuring, .94 for Non-intrusiveness, and 1.00 for Non-hostility.

Results

Preliminary analyses

In order to examine the relational characteristics of primary and control variables with socio-economic status variables, correlational analyses were conducted between mothers’ mood and sleep variables and socio-economic status variables over the first 6 months of infant life. For
mothers’ mood level and variability, mothers with more income reported higher mood level ($r=0.111$, $p<.05$) than mothers with less income, and mothers who were white (vs. non-white), married (vs. unmarried), more educated (vs. less educated), and had more income (vs. less income) reported less variable mood ($r=-0.123$, $p<.001$, $r=-0.125$, $p<.01$, $r=-0.13$, $p<.01$, $r=-0.153$, $p<.01$). For mothers’ sleep efficiency, mothers who were white showed higher levels of sleep efficiency than non-white mothers ($r=0.179$, $p<.01$) and mothers who were white (vs. non-white), married (vs. unmarried), more educated (vs. less educated) and had more income (vs. less income) showed less variable sleep efficiency ($r=-0.16$, $p<.001$, $r=-0.193$, $p<.001$, $r=-0.179$, $p<.001$, $r=-0.172$, $p<.001$). For mothers’ sleep fragmentation, mothers who were white (vs. non-white) and married (vs. unmarried) showed lower levels of sleep fragmentation ($r=-0.143$, $p<.01$, $r=-0.123$, $p<.01$), and mothers who were white (vs. non-white) and more educated (vs. less educated) showed less variable sleep fragmentation ($r=-0.122$, $p<.05$, $r=-0.113$, $p<.05$). For mothers’ sleep minutes, mothers who were older (vs. younger) and white (vs. non-white) showed higher amounts of sleep minutes ($r=0.13$, $p<.01$, $r=0.233$, $p<.001$) and mothers who were older (vs. younger), married (vs. unmarried), more (vs. less) educated, and had more (vs. less) income showed less variable sleep minutes ($r=-0.113$, $p<.05$, $r=-0.208$, $p<.001$, $r=-0.221$, $p<.001$, $r=-0.111$, $p<.05$). Although these relationships between mothers’ mood and sleep and socio-economic status variables were significant, all of them were very small in magnitude. Correlational information between the variables is provided in Table 2-1.
Table 2-1. Correlations between mothers’ SES and predictor variables across infants’ 1, 3, and 6 month

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>Age (N=462)</th>
<th>Race (N=461)</th>
<th>Education (N=462)</th>
<th>Income (N=427)</th>
<th>Marital Status (N=462)</th>
<th>Employment (N=462)</th>
<th>Work hours (N=271)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mood Level</td>
<td>3.77 (0.65)</td>
<td>-0.084</td>
<td>0.090</td>
<td>-0.014</td>
<td>0.111*</td>
<td>0.040</td>
<td>-0.046</td>
<td>0.097</td>
</tr>
<tr>
<td>Mood Variability</td>
<td>0.77 (0.35)</td>
<td>-0.020</td>
<td>-0.123**</td>
<td>-0.130**</td>
<td>-0.153**</td>
<td>-0.125**</td>
<td>-0.069</td>
<td>-0.088</td>
</tr>
<tr>
<td>Sleep Efficiency Level</td>
<td>84.08 (6.00)</td>
<td>0.029</td>
<td>0.179**</td>
<td>0.020</td>
<td>-0.009</td>
<td>0.075</td>
<td>0.022</td>
<td>0.030</td>
</tr>
<tr>
<td>Sleep Efficiency Variability</td>
<td>4.30 (2.21)</td>
<td>-0.048</td>
<td>-0.160***</td>
<td>-0.179***</td>
<td>-0.172***</td>
<td>-0.193***</td>
<td>-0.020</td>
<td>0.108</td>
</tr>
<tr>
<td>Sleep Fragment. Level</td>
<td>33.25 (10.39)</td>
<td>-0.085</td>
<td>-0.143**</td>
<td>-0.093</td>
<td>-0.059</td>
<td>-0.123**</td>
<td>-0.023</td>
<td>-0.064</td>
</tr>
<tr>
<td>Sleep Fragment. Variability</td>
<td>9.07 (3.81)</td>
<td>-0.003</td>
<td>-0.122*</td>
<td>-0.113*</td>
<td>-0.083</td>
<td>-0.066</td>
<td>0.040</td>
<td>0.074</td>
</tr>
<tr>
<td>Sleep Minutes Level</td>
<td>397.09 (51.39)</td>
<td>0.130**</td>
<td>0.233***</td>
<td>0.043</td>
<td>0.053</td>
<td>0.047</td>
<td>-0.016</td>
<td>-0.065</td>
</tr>
<tr>
<td>Sleep Minutes Variability</td>
<td>53.90 (22.58)</td>
<td>-0.113*</td>
<td>-0.089</td>
<td>-0.221***</td>
<td>-0.111*</td>
<td>-0.208***</td>
<td>0.007</td>
<td>-0.012</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001. N=Sample size. M=Mean. SD=Standard Deviation

Primary analyses

The analyses examining the associations between maternal mood dynamics, mood level and variability, and maternal bedtime EA over time were tested via multilevel modeling in SAS 9.4 using Proc Mixed. The models included time, within-person variables of maternal mood level and variability, within-person variables of maternal sleep level and variability, and interactions between mood dynamics and time at level 1. Between-person variables for maternal mood level and variability as well as sleep level and variability were included at level 2. All analyses used
maximum likelihood estimation to account for missing data in the dependent variables.

Mothers’ bedtime EA was an overall EA score which added up the scores of its four subscales including sensitivity, structuring, non-intrusiveness, and non-hostility. Maternal mood level and mood variability variables were created by calculating the mean and the standard deviation of mothers’ mood across 7 days at each time point. Due to the nested character of the longitudinal data, it was required to separate within-person effects from between-person effects of maternal mood dynamics on bedtime EA. Estimates of within-person association indicated how deviations in mothers’ month-to-month mood level and variability from their averaged mood level and variability across 1, 3, and 6 month were associated with mothers’ bedtime EA across 1, 3, and 6 month (for example, whether a mother’s bedtime EA score tended to be lower than usual when her mood varied more than usual). Estimates of between-person associations represented how mothers’ mood level and variability were associated with their bedtime EA on average across the 3 time points (for example, whether mothers with more variable mood on average across 1, 3, and 6 month tended to show lower bedtime EA on average). In order to test these two associations separately, person-mean centered mood level and variability variables were created first by subtracting the person-mean of each mother from her mood level and variability score at each time point, which indicated the within-person effects. For between-person effects, grand-mean centered variables were created for mothers’ mood level and variability by subtracting the grand-mean from each mother’s person mean of mood level and variability across 1, 3, and 6 month. Mothers’ sleep quality variables (sleep efficiency, sleep fragmentation, sleep minutes) were also person-mean centered for the within-person effects and grand-mean centered for the between-person effects in the same way, so they could be used as controls in both levels. Four cross-level interaction terms were created by multiplying mothers’
person-mean centered mood level and variability by both grand-mean centered mood level and
variability respectively in order to examine how the within-person associations of EA and mood
level and variability differed by maternal mood dynamics on average. Another cross-level
interaction term was created by multiplying mothers’ grand-mean centered mood level and
grand-mean centered mood variability by time to see how the linear trend of EA across 6 months
differed by mothers’ mood dynamics on average. Finally, an interaction between grand-mean
centered mood level and grand-mean centered mood variability was created in order to test
whether the association between mothers’ mood level and bedtime EA on average differed by
mothers’ mood variability on average.

The equations for the model predicting mothers’ bedtime EA across 1, 3, and 6 month are
described below:

Level 1: Individual level

\[
Bedtime\ EA_{ti} = \beta_{0i} + \beta_{1i}Month_{ti} + \beta_{2i}MoodLevel_{WP_{ti}} + \beta_{3i}MoodVar_{WP_{ti}} + \beta_{4i}SleepLevel_{WP_{ti}} + \beta_{5i}SleepVar_{WP_{ti}} + e_{ti}
\]

Level 1 equation represents that mothers’ bedtime EA at time \( t \) is a function of the
intercept specific to each mother \( i \) as well as slopes indicating linear change in EA with time,
person-mean centered mothers’ mood level and variability, person-mean centered mothers’ sleep
quality level and variability as controls.
Level 2: Group level

\[ \beta_{0i} = \gamma_{00} + \gamma_{01} \text{MoodLevel}_{BP_i} + \gamma_{02} \text{MoodVar}_{BP_i} + \gamma_{03} (\text{MoodLevel}_{BP_i} \times \text{MoodVar}_{BP_i}) + \gamma_{04} \text{SleepLevel}_{BP_i} + \gamma_{05} \text{SleepVar}_{BP_i} + \mu_{0i} \]

\[ \beta_{1i} = \gamma_{10} + \gamma_{11} \text{MoodLevel}_{BP_i} + \gamma_{12} \text{MoodVar}_{BP_i} + \mu_{1i} \]

\[ \beta_{2i} = \gamma_{20} + \gamma_{21} \text{MoodLevel}_{BP_i} + \gamma_{22} \text{MoodVar}_{BP_i} + \mu_{2i} \]

\[ \beta_{3i} = \gamma_{30} + \gamma_{31} \text{MoodLevel}_{BP_i} + \gamma_{32} \text{MoodVar}_{BP_i} + \mu_{3i} \]

\[ \beta_{4i} = \gamma_{40} + \mu_{4i} \]

\[ \beta_{5i} = \gamma_{50} + \mu_{5i} \]

Level 2 equations allowed the estimates of the intercept, a slope for the linear change with time, and slopes for mothers’ mood level and variability to vary as a function of the person–mean predictors. Between-person variation in the intercept was a function of the overall intercept, person-mean variables for maternal mood level and variability, an interaction between person-mean of mood level and variability, person-mean variables for mothers’ sleep quality level and variability, and a residual specific to each mother. Between-person variation in the linear slope for maternal bedtime EA was a function of the overall slope, person-mean variables for maternal mood level and variability, and a residual specific to each mother. Between-person variation in the slope for mothers’ mood level was a function of overall slope, person-mean variables for maternal mood level and variability, and a residual specific to each mother. Between-person variation in the slope for mothers’ mood variability was also a function of overall slope, person-mean variables for maternal mood level and variability, and a residual
specific to each mother. Between-person variations in the slopes for mothers’ sleep quality level and variability were a function of overall slopes and residuals specific to each mother.

An unconditional means model was tested first to examine the percent of the variance in mothers’ bedtime EA accounted for by each level of analysis. Intraclass correlation (ICC) indicated that 52% of the variance was due to between-person factors, and 48% of the variance was attributable to within-person factors. The equations for this model are:

Level 1:  \( Bedtime\ EA_{ti} = \beta_{0i} + e_{ti} \)

Level 2:  \( \beta_{0i} = \gamma_{00} + \mu_{0i} \)

Next, an unconditional model examining the linear change in bedtime EA was tested. The month variable was entered into the model to investigate a linear change in mothers’ bedtime EA over time. The results showed that mothers’ bedtime EA was not changing significantly over 1, 3, and 6 month. The equations for this model are:

Level 1:  \( Bedtime\ EA_{ti} = \beta_{0i} + \beta_{1i}Month_{t} + e_{ti} \)

Level 2:  \( \beta_{0i} = \gamma_{00} + \mu_{0i} \)
\[
\beta_{1i} = \gamma_{10} + \mu_{1i}
\]

A conditional model including person-mean centered mothers’ mood level, mood variability, sleep level, and sleep variability as time-varying predictors was fit to the data next. Level and variability of each sleep variable (sleep efficiency, sleep fragmentation, and sleep minutes) were entered separately as time-varying covariates, so it would be possible to see the effects of maternal mood dynamics on the outcome after controlling the effects of each sleep quality. The results showed that none of within-person predictors of mothers’ mood-level and
variability significantly predicted mothers’ bedtime EA across 1, 3, and 6 months, after
controlling for their sleep level and variability. The equations for this model are:

Level 1:

\[ \text{Bedtime EA}_{t_i} = \beta_{0_{it}} + \beta_{1_{it}} \text{Month}_{t_i} + \beta_{2_{it}} \text{MoodLevel}_{WP_{t_i}} + \beta_{3_{it}} \text{MoodVar}_{WP_{t_i}} + \beta_{4_{it}} \text{SleepLevel}_{WP_{t_i}} + \beta_{5_{it}} \text{SleepVar}_{WP_{t_i}} + e_{t_i} \]

Level 2:

\[ \beta_{0_{it}} = \gamma_{00} + \mu_{0_{it}} \]
\[ \beta_{1_{it}} = \gamma_{10} + \mu_{1_{it}} \]
\[ \beta_{2_{it}} = \gamma_{20} + \mu_{2_{it}} \]
\[ \beta_{3_{it}} = \gamma_{30} + \mu_{3_{it}} \]
\[ \beta_{4_{it}} = \gamma_{40} + \mu_{4_{it}} \]
\[ \beta_{5_{it}} = \gamma_{50} + \mu_{5_{it}} \]

Finally, a conditional model including grand-mean centered person mean variables for
maternal mood level and variability, an interaction between the mood level and variability,
grand-mean centered person-mean variables for mothers’ sleep level and variability in level 2
was tested in order to see whether there was any between-person variability across the sample.
The equations for this final model are:
Level 1:

\[ \text{Bedtime EA}_{t_i} = \beta_{0_{it}} + \beta_{1_{it}} \text{Month}_{t_i} + \beta_{2_{it}} \text{MoodLevel}_{WP_{t_i}} + \beta_{3_{it}} \text{MoodVar}_{WP_{t_i}} + \beta_{4_{it}} \text{SleepLevel}_{WP_{t_i}} + \beta_{5_{it}} \text{SleepVar}_{WP_{t_i}} + e_{t_i} \]
Level 2:

\[ \beta_{0i} = \gamma_{00} + \gamma_{01} \text{MoodLevel}_{BP_i} + \gamma_{02} \text{MoodVar}_{BP_i} + \gamma_{03} (\text{MoodLevel}_{BP_i} \times \text{MoodVar}_{BP_i}) + \gamma_{04} \text{SleepLevel}_{BP_i} + \gamma_{05} \text{SleepVar}_{BP_i} + \mu_{0i} \]

\[ \beta_{1i} = \gamma_{10} + \gamma_{11} \text{MoodLevel}_{BP_i} + \gamma_{12} \text{MoodVar}_{BP_i} + \mu_{1i} \]

\[ \beta_{2i} = \gamma_{20} + \gamma_{21} \text{MoodLevel}_{BP_i} + \gamma_{22} \text{MoodVar}_{BP_i} + \mu_{2i} \]

\[ \beta_{3i} = \gamma_{30} + \gamma_{31} \text{MoodLevel}_{BP_i} + \gamma_{32} \text{MoodVar}_{BP_i} + \mu_{3i} \]

\[ \beta_{4i} = \gamma_{40} + \mu_{4i} \]

\[ \beta_{5i} = \gamma_{50} + \mu_{5i} \]

The results indicated that the person-mean variable for mothers’ mood variability was found to be the significant predictor of bedtime EA, after controlling for all three sleep levels and variabilities respectively. After controlling for sleep efficiency level and variability, when mothers reported more variable mood across 1, 3, and 6 month on average, they showed poorer bedtime EA on average, compared to mothers who reported less variable mood, \(B=-3.11\) (\(SE=1.02\), \(t=-3.05, p < .01\)). Similarly, after controlling for sleep fragmentation level and variability, mothers who reported more variable mood than others over 6 months showed poorer overall bedtime EA than others, \(B=-3.12\) (\(SE=1.03\), \(t=-3.04, p < .01\)). Finally, after controlling for sleep minutes level and variability, mothers with more variable mood across 6 months also showed poorer bedtime EA, \(B=-2.16\) (\(SE=1.00\), \(t=-2.16, p < .05\)). Only in the model controlling for sleep minutes did the variability of mothers’ sleep minutes, included as a covariate, inversely predict bedtime EA, \(B=-0.05\) (\(SE=0.01\), \(t=-4.17, p < .001\), as expected. This suggests that when mothers’ sleep duration fluctuated more, they showed poorer bedtime EA across 6 months. That it was mothers’ mood variability, not their mood level, which predicted their bedtime EA implied that mothers’ capacity to regulate their emotion, rather than overall level of their emotion itself,
functioned as a key factor in predicting parenting quality. Information for these conditional models predicting mothers’ bedtime EA is included in Table 2-2, 2-3, and 2-4.

Table 2-2. Estimates for model of mothers’ daily mood dynamics predicting mothers’ overall bedtime EA over 1, 3, and 6 month, Sleep Efficiency controlled

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>S.E.</th>
<th>t (N=162)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.087</td>
<td>0.265</td>
<td>-0.31</td>
</tr>
<tr>
<td>Time(Month)</td>
<td>0.015</td>
<td>0.074</td>
<td>0.21</td>
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<tr>
<td>Person-Mean centered Mothers’ Mood Level</td>
<td>0.037</td>
<td>0.430</td>
<td>0.09</td>
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<tr>
<td>Person -Mean centered Mothers’ Mood Variability</td>
<td>-0.596</td>
<td>0.618</td>
<td>-0.96</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Efficiency Level</td>
<td>-0.043</td>
<td>0.036</td>
<td>-1.21</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Efficiency Variability</td>
<td>-0.037</td>
<td>0.087</td>
<td>-0.42</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Mood Level</td>
<td>-0.632</td>
<td>0.436</td>
<td>-1.45</td>
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<tr>
<td>Grand -Mean centered Mothers’ Mood Variability</td>
<td>-3.107</td>
<td>1.020</td>
<td>-3.05***</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Sleep Efficiency Level</td>
<td>0.053</td>
<td>0.051</td>
<td>1.04</td>
</tr>
<tr>
<td>Grand -Mean centered Mothers’ Sleep Efficiency Variability</td>
<td>-0.209</td>
<td>0.165</td>
<td>-1.27</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, UN(1,1)</td>
<td>4.352</td>
<td>0.831</td>
<td>5.24***</td>
</tr>
<tr>
<td>Residual</td>
<td>3.927</td>
<td>0.570</td>
<td>6.89***</td>
</tr>
</tbody>
</table>

Note. *** Significant at p < .001, ** Significant at p < .01.
Table 2-3. Estimates for model of mothers’ daily mood dynamics predicting mothers’ overall bedtime EA over 1, 3, and 6 month, Sleep Fragmentation controlled

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate</th>
<th>S.E.</th>
<th>$t$ (N=162)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.025</td>
<td>0.261</td>
<td>-0.10</td>
</tr>
<tr>
<td>Time(Month)</td>
<td>0.004</td>
<td>0.071</td>
<td>0.05</td>
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<tr>
<td>Person-Mean centered Mothers’ Mood Level</td>
<td>-0.008</td>
<td>0.432</td>
<td>0.09</td>
</tr>
<tr>
<td>Person -Mean centered Mothers’ Mood Variability</td>
<td>-0.633</td>
<td>0.620</td>
<td>-1.02</td>
</tr>
<tr>
<td>Person-Mean centered Mothers’ Sleep Frag. Level</td>
<td>0.014</td>
<td>0.021</td>
<td>0.65</td>
</tr>
<tr>
<td>Person -Mean centered Mothers’ Sleep Frag. Variability</td>
<td>0.003</td>
<td>0.044</td>
<td>0.08</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Mood Level</td>
<td>-0.582</td>
<td>0.440</td>
<td>-1.32</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Mood Variability</td>
<td>-3.118</td>
<td>1.025</td>
<td>-3.04**</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Sleep Frag. Level</td>
<td>-0.044</td>
<td>0.028</td>
<td>-1.59</td>
</tr>
<tr>
<td>Grand -Mean centered Mothers’ Sleep Frag. Variability</td>
<td>-0.042</td>
<td>0.088</td>
<td>-0.48</td>
</tr>
</tbody>
</table>

| Random Effects                                |          |       |            |
| Intercept, UN(1,1)                            | 4.413    | 0.836 | 5.28***    |
| Residual                                      | 3.958    | 0.570 | 6.95***    |

Note. *** Significant at $p < .001$, ** Significant at $p < .01$. 
Table 2-4. Estimates for model of mothers’ daily mood dynamics predicting mothers’ overall bedtime EA over 1, 3, and 6 month, Sleep Minutes controlled

<table>
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<th></th>
<th>Estimate</th>
<th>S.E.</th>
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<tr>
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<td>0.042</td>
<td>0.239</td>
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<tr>
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<td>0.01</td>
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<td>-1.17</td>
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<tr>
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<td>0.004</td>
<td>-0.59</td>
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<tr>
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<td>0.002</td>
<td>0.009</td>
<td>0.24</td>
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<td>Grand-Mean centered Mothers’ Mood Level</td>
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<td>-0.80</td>
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<td>1.001</td>
<td>-2.16***</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Sleep Minutes Level</td>
<td>0.006</td>
<td>0.005</td>
<td>1.28</td>
</tr>
<tr>
<td>Grand-Mean centered Mothers’ Sleep Minutes Variability</td>
<td>-0.051</td>
<td>0.012</td>
<td>-4.17***</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
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</tr>
<tr>
<td>Intercept, UN(1,1)</td>
<td>3.701</td>
<td>0.761</td>
<td>4.86***</td>
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<tr>
<td>Residual</td>
<td>3.741</td>
<td>0.664</td>
<td>5.63***</td>
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*Note.* ***Significant at p < .001, *Significant at p < .05.

**Discussion**

Overall, these results indicate that there were between-person associations between mothers’ mood variability and bedtime EA across infants’ first 6 months, after controlling for maternal sleep. This finding indicates that it was not the overall level, but the variability of maternal mood that determined mothers’ parenting quality during bedtime interactions. This provides evidence for the specific mechanisms underlying maternal mood and parenting quality, and also provide supports for the usefulness of studying parents’ bedtime context with their infants in relation to maternal mood as a meaningful parenting context.
Maternal mood variability and maternal bedtime EA

The results of the current study did not provide support for within-person associations between daily mood dynamics and bedtime parenting (Hypothesis 1 & Hypothesis 2), that higher maternal daily mood level and variability than usual would predict higher maternal bedtime EA than usual across infants’ first 6 months. Also, Hypothesis 3, that higher maternal daily mood level on average would predict higher maternal bedtime EA on average across infants’ first 6 months was not supported, nor was support provided for Hypothesis 5, that higher maternal daily mood variability on average would moderate the associations between maternal daily mood level and bedtime EA across 1, 3, and 6 months. However, the results did show a between-person association between mothers’ day-to-day mood variability and bedtime EA across infants’ first 6 months, supporting Hypothesis 4. Mothers with higher mood variability on average showed lower bedtime EA on average across infant’s 1, 3, and 6 months.

To our knowledge, this is the first study to show that mothers’ parenting quality, especially in the bedtime context, is reactive to the fluctuation of day-to-day mood during very early postpartum period. This finding is consistent with our expectation that mood variability may reflect mothers’ ability to regulate their emotions and thus influence their parenting quality during interactions with their infants. The present findings are in line with prior evidence indicating that mothers with poor emotion regulation such as unpredictable moment-to-moment emotions and higher emotional reactivity tended to show more harsh or indulgent parenting behaviors (Crandall, Ghazarian, Day, & Riley, 2016; Lorber & Slep, 2005). Furthermore, these findings suggest a mechanism for explaining how mothers’ poor emotion regulation affects children’s developmental outcomes such as lower positive affect and poor sleep quality (K. M. Lawson, Davis, McHale, Hammer, & Buxton, 2014), less cognitive flexibility (Samuelson,
Krueger, & Wilson, 2012), and child aggression (Crandall et al., 2016), by identifying parenting as a mediator between maternal emotion regulation and child outcomes. In other words, mothers who have difficulties with emotion regulation may be more likely to engage in maladaptive parenting behaviors, which in turn may lead to negative developmental outcomes in children. Finally, this finding replicates and extends the previous research indicating the significant influence of examining parenting quality in the bedtime context (Kim & Teti, 2014; Philbrook et al., 2014; Teti et al., 2010). Unlike prior findings on the link between overall level of mood and parental functioning (Feldman et al., 2009; Field, 2010; Seymour et al., 2015), mothers’ overall level of daily mood did not predict mothers’ bedtime parenting. Since the most of previous studies on maternal mood assessed mothers’ overall mood with single point measurements with multiple items, characteristics of one-time assessed overall mood such as depression and anxiety may be different from overall level of day-to-day mood, yielding different results. Another possible reason for the discrepancy between the present and previous studies may be the underspecified assessment of mothers’ daily mood in this study, in that we used only one item to measure daily mood during daily phone interviews.

**Implications**

Taken together, the result suggests that day-to-day variability of mothers’ mood, rather than the overall level of mood, is an important predictor of parenting quality early in infants’ life. This indicates that mothers’ emotion regulation in the form of mood variability plays a critical role in determining parenting quality, particularly in the bedtime context during early postpartum period. This finding could inform early intervention for mothers because the early postpartum period is when mothers’ mood may be more susceptible to perturbations in response to hormonal fluctuations, sleep changes, and adjustments to a new role and identity. Prior research has
demonstrated that early interventions targeting maternal postpartum depression and anxiety are useful in improving early parent-infant interactions (Mendelson, Cluxton-Keller, Vullo, Tandon, & Noazin, 2017; Tsivos, Calam, Sanders, & Wittkowski, 2015). However, if it is the variability of mothers’ early postpartum mood, rather than the average of mood, that have a significant impact in their parenting quality, early intervention programs providing mothers with strategies to maintain their daily mood as more stable and predictable may be more helpful in promoting the quality of parent-infant interactions ultimately.

**Limitations and future directions**

There are several limitations in the current study. First, the current study only examined mothers’ daily mood and their bedtime EA. Due to the limited number of fathers who participated in the bedtime interactions, the association between fathers’ daily mood dynamics and parenting quality could not be investigated. However, it is likely that fathers’ mood dynamics, particularly day-to-day mood variability, may be associated with their own parenting quality, which may in turn affect infant developments probably in unique ways different from mothers, as theorized by family systems theory (Cox & Paley, 1997). Furthermore, paternal mood dynamics may also be related to mothers’ parenting quality as suggested by cross over effects between family members in emotional transmission models (Larson & Almeida, 1999; Westman et al., 2001). This suggests important directions for future research examining how fathers’ parenting as well as mothers’ parenting may mediate the link between paternal daily mood dynamics and infant developments, particularly when fathers become more actively involved in the bedtime interactions as their infants grow older. Additionally, it must be noted that mothers’ daily mood data was measured with a single self-report item from daily phone interviews. More specified measurement of diverse emotions such as positive and negative
emotions would help elucidating the detailed characteristics of dynamics of various emotions and their associations to parenting quality. Finally, our sample largely consisted of Caucasian, middle-class mothers. In order for this finding to be generalizable to broader population, this finding must be replicated with parents of diverse ethnicities and socioeconomic backgrounds.

**Conclusions**

The current study provides unique evidence of the influence of mothers’ day-to-day mood variability on parenting quality during the bedtime interactions of the early postpartum period. This finding contributes to a relatively new literature addressing the implications of within-person variability of mothers’ mood on parenting. In addition to elucidating the association between maternal mood variability and parenting, the present study highlights the need for early interventions to promote mothers’ capacities for emotion regulation, which clearly have implications for parenting quality. More broadly, the present study emphasizes the need for additional research examining mothers’ mood dynamics, parenting, and child development.
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https://doi.org/10.1007/s10826-008-9224-z
General Discussion

This dissertation aimed to shed light on how parental daily sleep, maternal daily mood, and mothers’ bedtime EA were related during the early postpartum period. Both studies included daily data of parental sleep and maternal mood and examined daily within-person associations between parental sleep and maternal mood in Study I and predictive links between mothers’ daily mood dynamics, within-person variability as well as level of daily mood, and maternal bedtime EA in Study II. The fact that both studies are connected by the function of mothers’ daily mood provides evidence for a potential underlying mechanism in which parental daily sleep influences mothers’ parenting during early infancy via the impact of maternal daily mood. These studies highlight the usefulness of daily diary approaches for exploring the dynamic nature of parental sleep and mood during the early postpartum period. These points will each be addressed in the following sections, followed by a discussion of avenues for future work.

Underlying mechanism of parental sleep, mood and parenting during early infancy

Study I provided evidence of daily within-person associations not only between mothers’ sleep and mood but also between fathers’ sleep and mothers’ mood. Fathers’ more efficient sleep as well as mothers’ more efficient, less fragmented, and longer sleep during the previous night predicted mothers’ better mood next day. In Study II, mothers’ day-to-day mood variability significantly predicted their bedtime EA after controlling for mothers’ daily sleep level and variability, suggesting that mothers’ capacity for emotion regulation, captured here in terms of daily mood volatility, influences parenting quality and eventually child development.

Both of the two present studies are linked by a common factor, mothers’ daily mood, as an outcome in study I and a predictor in study II, although in different analytical forms. The
present findings are consistent with a hypothetical mechanism proposed by Abidin (1992) suggesting that parental emotional distress functions critically as a bridge between contextual factors and parenting behaviors, facilitating or impeding parents’ ability to make use of available personal and environmental resources when interacting with their children (Abidin, 1992). Considering that parents’ daily mood is another subjective and more dynamic feeling state which energizes and motivates parents to act on a daily basis, the findings of both studies suggest a similar hypothetical model in which mothers’ day-to-day mood and daily changes in mood may function as mediators between proximal ecological factors, like sleep deprivation, and parenting quality.

These findings have significant implications for early intervention for parents because they suggest that mothers’ daily mood plays a role in bridging the gap between parental sleep and parenting quality. The complex pathways between sleep, mood, and parenting identified in the present studies call for multilevel intervention strategies that draw on family systems theory. According to the family systems theory, changes in individuals embedded within diverse family subsystems such as parent-child, marital, and parental relationships, can bring about changes in other family subsystems due to their interdependence (Cox & Paley, 1997). Thus, early interventions for postpartum parents should consider the interdependence of parental sleep, mood, and parenting, particularly the possible mediating role of maternal daily mood, when developing the specific intervention plans and strategies.

**Utility of daily diary approach for capturing parents’ daily sleep and mood during early infancy**

The results from both studies of this dissertation also emphasize the usefulness of daily
diary approaches in providing more detailed understanding of parents’ day-to-day sleep and mood, both of which are critical elements to consider in parental postpartum well-being. Particularly for mothers’ daily mood, the present findings suggest that even a single item of mood assessment at each day can provide adequate information on the characteristics of mothers’ postpartum daily mood, information that can help explain linkages between parents’ daily sleep and parenting quality. For study I, daily assessments of mothers’ mood and parental sleep allowed for a more detailed investigation of within-person associations between parental sleep and maternal mood. Although prior studies have demonstrated significant links between parental sleep and mood during early postpartum period (Cooklin et al., 2012; Dørheim et al., 2009a; Giallo, Wood, Jellett, & Porter, 2013; Huang et al., 2004; Seymour et al., 2015), rarely have these associations been studied at a daily level. Additionally, daily assessments of maternal mood made it possible to separate everyday mood from average postpartum distress and enabled an examination of the moderating effect of mothers’ overall postpartum distress on the link between parental sleep and maternal mood.

For Study II, daily assessments of mothers’ mood enabled us to assess within-person variability of mothers’ daily mood across the early postpartum period, allowing for the investigation of its impact on mothers’ bedtime parenting, in addition to the effect of the average of maternal daily mood. Although a growing body of studies suggest the potential influence of maternal mood volatility on parenting quality (Crandall et al., 2016; Litz et al., 2000; Lorber & Slep, 2005; Marziali et al., 2003; Pearlman & Courtois, 2005), relations between maternal day-to-day mood variability and postpartum emotional availability, particularly during mothers’ bedtime interactions with their young infants, had not been examined prior to the present study. Furthermore, daily assessments of maternal daily sleep, including within-person variability of
mothers’ daily sleep as well as the level of daily sleep, were used as meaningful covariates in controlling the effect of maternal sleep on their parenting quality (Bayer et al., 2007; Meltzer & Mindell, 2007; Meltzer & Walsh, 2013; Montgomery-Downs, 2010), thus allowing an assessment of the independent association between maternal daily mood dynamics and their bedtime parenting.

**Future directions**

The results across the two studies provided support for maternal daily mood and its dynamics as mediators of linkages between parental sleep and parenting quality. Although a recent study by Kouros and El-Sheikh (2015) found evidence supporting children’s daily mood as a mediator linking their poor sleep quality to internalizing and externalizing problems (Kouros & El-Sheikh, 2015), a model including mothers’ daily mood as a mediator connecting parental sleep to the quality of parenting had not been tested prior to this dissertation. The pathways identified in these studies can even be extended to include child developmental outcomes as final outcomes in the future work. More predictable and positive mothers’ daily mood, which is found to be affected by parents’ daily sleep, may be one path that could promote quality of parenting and, in turn, positive child outcomes such as secure attachment relationships, and fewer behavioral problems. Interventions that not only aim to increase overall mood level, but also help parents manage mood volatility (i.e., reduce it across days) may be very important in promoting better parenting.

There are several additional avenues that could be examined in future work. First, although this dissertation was limited to observed parenting data collected once at each time point, adding a daily assessment of parenting quality rather than across months may allow for
more in-depth understanding of everyday well-being of parents in the early postpartum period and how their daily well-being may spill over and affect parent-infant interactions. Previous studies on the work-family spillover have showcased the daily links between parents’ workload, everyday well-being, and parent-child interactions. For instance, days of higher workload were found to be associated with lower levels of positive mood, higher levels of negative mood and strain, more physical health complaints, and with more withdrawn and less affectionate parenting interactions (Fifield et al., 2004; Fuller et al., 2003; Ilies et al., 2007; Ilies, Dimotakis, & De Pater, 2010; Repetti, 1993; Repetti & Wood, 1997). A study by Gassman-Pines (2013) demonstrated that both lower-than-average and higher-than-average workload days were related to mothers’ increased negative and tired mood, decreased positive mood, and finally increased harsh mother-child interactions (Gassman-Pines, 2013). In a similar vein, repeated assessments of parenting quality across multiple days linking with parental daily sleep and mood may elucidate whether and how parents’ poor sleep quality on the previous night and worse mood during the following day may spill over onto parenting interactions with their infants and children.

Additionally, while parenting was examined in the bedtime context in this dissertation, examining parenting in daytime contexts may provide a more comprehensive understanding of the underlying linkages between parental sleep, mood and parenting. Study II found an association between mothers’ daily mood variability and their bedtime EA, but bedtime is a particularly challenging context that usually requires more intensive emotional support over a relatively shorter time period, compared to daytime contexts, for infants who may resist being separated from their parents physically and psychologically (Teti et al., 2010). On the other hand, parents and infants are more likely to share a same goal during daytime contexts such as free
play, feeding, and problem-solving interactions. Different aspects of parenting strategies, other than the emotional support, may be more emphasized during daytime parenting, and thus parental daily sleep and mood may be associated with daytime parenting in different ways from bedtime parenting. For example, although mothers’ daily mood level was not related to bedtime parenting in Study II, it may be linked to daytime parenting which likely continues for longer and more varied periods of time during the day.

Finally, it will be critical for future work to include fathers in examining the overall mechanism between parental sleep, mood, and parenting. Although Study I included fathers’ daily sleep and its daily link to mothers’ mood, daily mood and parenting data in the present studies were limited to mothers. Family systems theory suggests that individuals within families are interdependent (Cox & Paley, 2003). Fathers’ mood and their parenting may affect mothers’ mood and parenting, and vice versa (Lin et al., 2017; L. M. Papp, Cummings, & Goeke-Morey, 2005). For example, considering that fathers’ sleep has significant impact on maternal daily mood as demonstrated in Study I, it is reasonable to expect that mothers’ sleep may be able to affect fathers’ mood. A recent study by Saxbe and colleagues (2016) actually demonstrated that more sleep problems of depressed mothers lead to fathers’ depressive symptoms at 6 months postpartum (Saxbe et al., 2016). Furthermore, fathers’ daily mood seems to play an important role in determining both the quality and the quantity of their interactions and mothers’ interactions with their children (Field, 2010; Wilson & Durbin, 2010). For instance, Almeida and colleagues (2001) found a daily association between fathers’ mood and parenting, reporting that fathers tend to show more conflictual interactions with their children on days when fathers experienced negative mood (Almeida et al., 2001). Also, fathers’ postpartum depression has been found to worsen the effects of maternal depression on maternal parenting and later child behavior.
problems (Mezulis, Hyde, & Cleeck, 2004). Thus, in addition to the daily measures of maternal mood and parenting, future work may benefit from the inclusion of daily assessments of fathers’ mood and parenting in enriching the understanding the relations between parental sleep, mood, and parenting within the diverse levels of family dynamics.

Conclusion

The present findings contribute to a growing body of literature concerning within-person associations between parental sleep and mood. These findings also build upon prior studies by incorporating daily assessments of parental sleep and maternal mood in the early postpartum period. Finally, they demonstrate that daily mood dynamics impact upon quality of parenting. It is hoped that future work integrates maternal and paternal sleep, mood, parenting, and children’s outcomes into more comprehensive path models. Doing so should provide a clearer understanding of how parental sleep, daily mood, and parenting in early infancy interrelate, and how they function jointly to predict child development.
General Introduction and Discussion References


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# VITA

## Hye Young Rhee

### Education

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<td>Department of Human Development and Family Studies, The Pennsylvania State University</td>
</tr>
<tr>
<td>2006</td>
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<td>Child Development and Family Studies, Seoul National University, Korea</td>
</tr>
<tr>
<td>2004</td>
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### Scholarships and Awards

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### Research Experiences

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<td>Research Assistant</td>
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<td>2004 – 2006</td>
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<td>Psychological Adaptation of North Korean Refugee Families in South Korea (P.I.: Dr. Soon-Hyung Yi)</td>
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<td>Specialized Counseling Technique for Runaway Children (P.I.: Dr. Soon-Hyung Yi)</td>
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<td>Psychological Adaptation of Children with Divorced Parents (P.I.: Dr. Soon-Hyung Yi)</td>
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### Publications
