Developmental Review 53 (2019) 100871

Contents lists available at ScienceDirect

Developmental Review

journal homepage: www.elsevier.com/locate/dr

Intrinsic and extrinsic factors predicting infant sleep: Moving beyond main effects

Marie Camerota[a,*], Cathi B. Propper[a], Douglas M. Teti[b]

[a] *Center for Developmental Science, The University of North Carolina at Chapel Hill, United States*
[b] *Department of Human Development and Family Studies, The Pennsylvania State University, United States*

A R T I C L E I N F O

Keywords:
Sleep
Intrinsic
Extrinsic
Interaction
Developmental science

A B S T R A C T

Sleep patterns change dramatically across the earliest years of life and play an important role in children's daytime functioning. As a result, psychological research has taken an increasing interest in unpacking the many intrinsic (i.e., child characteristics) and extrinsic (i.e., environmental input) factors that influence children's sleep development. Considerably less attention has been given to understanding the transactional relationships among intrinsic and extrinsic factors, or to the underlying mechanisms, that both initiate and maintain individual differences in infant sleep development. In the current review, we begin by summarizing what is known about the development of sleep across the first two years of life, making explicit reference to the dual-process model of sleep consolidation and regulation. Next, we synthesize existing literature on the intrinsic and extrinsic factors that influence the development of sleep consolidation and regulation in infants. Finally, we reconsider extant findings in the infant sleep literature using theories and concepts from developmental science, posing new hypotheses about the ways in which environmental input both shapes infant sleep patterns and modulates the effects of sleep on later developmental outcomes. We conclude with an examination of current challenges in this field and a suggested roadmap for future research.

Introduction

The importance of adequate sleep for optimal daytime functioning has long been acknowledged in the adult literature. Considerably less is known about the role of sleep in the broader context of child development. This relative dearth of research is surprising, given that children spend more time asleep than awake in the entire first decade of life (Iglowstein, Jenni, Molinari, & Largo, 2003). Further, sleep problems are among the most common clinical concerns across early childhood (Goodlin-Jones, Burnham, & Anders, 2001; Mindell, Owens, & Carskadon, 1999), and have been linked to myriad problems in cognitive, emotional, and behavioral functioning (Sadeh, 2007). These emerging lines of research suggest that, despite the clear primacy of sleep among infants and children, sleep disruption is common and problematic. Therefore, understanding the normative process of sleep development, as well as the factors that help or hinder this process, are of utmost concern.

Several theoretical models have been proposed to describe the dramatic changes in sleep behavior observed across the first years of life. These include models that distinguish between dimensions of sleep quantity and quality (El-Sheikh & Sadeh, 2015), as well as between circadian-homeostatic (Jenni & Lebourgeois, 2006), and consolidation-regulation processes (Goodlin-Jones, Burnham,

* Corresponding author at: Center for Developmental Science, University of North Carolina at Chapel Hill, Campus Box 8115, Chapel Hill, NC 27599-8115, United States.
E-mail address: marie.camerota@unc.edu (M. Camerota).

https://doi.org/10.1016/j.dr.2019.100871
Received 10 July 2018; Received in revised form 19 July 2019

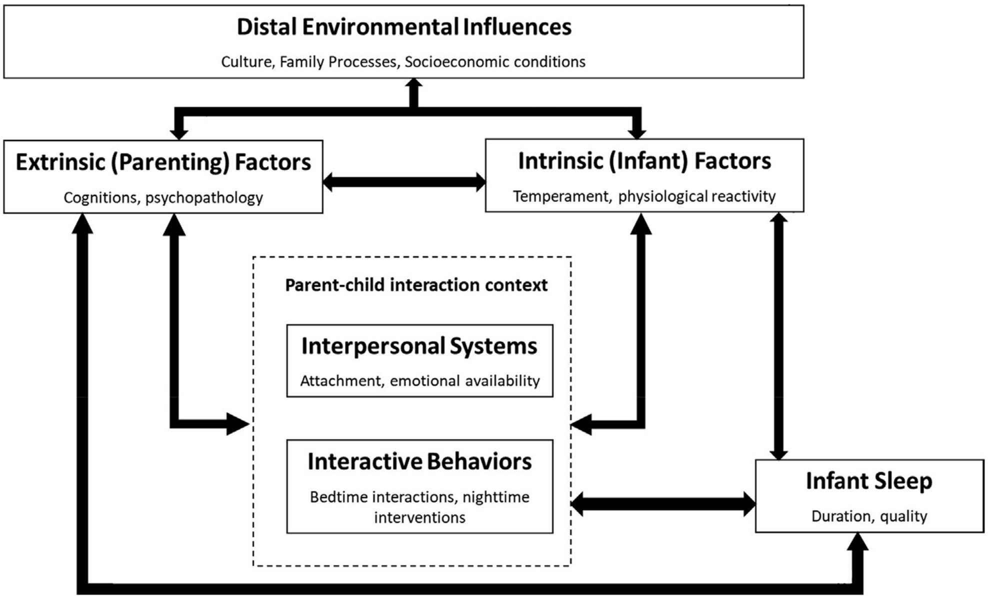

Fig. 1. Sadeh's transactional model. Adapted from Sadeh et al. (2010).

Gaylor, & Anders, 2001). In part one of the current paper, we review the literature on sleep development framed within the dual-process model of consolidation and regulation. We chose to center our review around the consolidation-regulation framework because it is the most specific model that has been widely used in developmental research (e.g., Goodlin-Jones, Burnham, Gaylor, et al., 2001; Sadeh & Anders, 1993; Staples, Bates, & Petersen, 2015). Briefly, sleep consolidation refers to the emergence of a diurnal patterning of sleep/wake states. Sleep regulation refers to the process by which children become able to independently transition between wakefulness and sleep, as indicated by the ability to fall asleep at bedtime and resume sleep following a nighttime waking without relying on parental intervention. Considering sleep development within this dual-process framework allows us to more concisely synthesize findings from studies using diverse indicators of infant sleep quality, while also inspiring novel questions regarding the development timelines of different components of sleep quality.

Due to variability in the development of consolidated and regulated sleep (e.g., Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Iglowstein et al., 2003; Sadeh, Mindell, Luedtke, & Wiegand, 2009), an extensive body of literature has focused on predicting these individual differences in sleep patterns from a variety of intrinsic and extrinsic factors. We review this work in the second part of the manuscript. By intrinsic factors, we refer to child characteristics that have a biological basis and include constructs such as temperament and physiological reactivity. Extrinsic factors, on the other hand, refer to contextual influences that shape the environment in which the child develops. Most notably, these include caregiver qualities, strategies, and behaviors that support or hinder appropriate modulation of sleep/wake state. Specific parenting behaviors and practices as well as parent-child interaction quality have been shown to contribute substantially to infant sleep development (Teti, Philbrook, et al., 2015).

Sadeh and colleagues have proposed a transactional model which highlights the direct and indirect contributions of infant characteristics and caregiver behaviors to the development of infant sleep, through mechanisms such as nighttime parent-child interactions (Fig. 1; Sadeh & Anders, 1993; Sadeh, Tikotzky, & Scher, 2010). This model has recently been extended from an ecological systems perspective to more fully incorporate the influence of proximal and distal systems (e.g., social, cultural, time) as well as interactions between systems, that influence sleep development (El-Sheikh & Sadeh, 2015). Thus far, these models have been successful in drawing attention to the importance of infant characteristics, parental input, and parent-child interactions that contribute to individual differences in infant sleep quality. However, whereas ecological models provide a heuristic framework for identifying putative determinants of infant sleep quality, they do not fully explicate the range and nature of dynamic and bidirectional interactions between children and parents that both initiate and maintain individual differences in infant sleep quality, nor do they grapple with the cascading influence of these differences for later developmental outcomes. The third section of the manuscript begins to address these issues.

The novel aim of this review is to reconsider extant findings in infant sleep research from a developmental science perspective. By highlighting and applying relevant theories and concepts derived from this domain, we argue that we can substantially expand existing sleep frameworks and inspire a new sleep research agenda. Specifically, we argue that differential susceptibility and biological sensitivity to context (BSC; Boyce & Ellis, 2005) theories have direct relevance for how we study both antecedents and consequences of individual differences in infant sleep quality. Together, these theories suggest that child physiological reactivity is both influenced by early environmental input, as well as a modifier of later environmental influences. Considering infant sleep as one index of reactivity allows us to pose new questions relating to the factors that promote or hinder sleep development in the first years of life. It also allows us to consider new questions about how infant sleep may interact with characteristics of the environment to predict outcomes in a variety of domains. Relatedly, we apply the concept of developmental cascades to illustrate how successes or difficulties in one domain of behavior (e.g., sleep consolidation and regulation) transfer, or spill over, to successes or difficulties in other domains of behavior (e.g., cognitive and emotional capacities) later in development (Masten & Cicchetti, 2010).

Given the multiple goals of the current review, we organize the manuscript into three main sections. First, we summarize what is known about the normal course of sleep development across the first two years of life. Presenting existing findings in terms of how they map on to the processes of sleep consolidation and regulation affords a more nuanced approach to understanding the development of distinct components of sleep quality in infancy. Next, we describe the main effects of intrinsic and extrinsic factors on infant sleep development. Although not meant to be an exhaustive review, we highlight several specific exemplars that have garnered attention in the literature, and that have the most direct relevance for infants. The third and most novel part of the review attempts to marry existing sleep research with core ideas and theories from developmental science, in an effort to recast previous findings in a new light, as well as inspire novel areas of inquiry. In closing, we present a roadmap for future research that aims to further integrate the study of infant sleep into developmental science. At the same time, we acknowledge the practical, theoretical, and empirical challenges that still hinder our progress.

Sleep development in infancy

The study of sleep development in infants and children has a long history, stemming from both psychological and medical literatures. The medical literature tends to emphasize a normative perspective, which seeks to describe overall patterns of change, derive reference values for sleep variables for different age groups, and identify the prevalence of sleep disorders (e.g. Acebo et al., 2005; Iglowstein et al., 2003). A second body of work has arisen from an individual differences perspective, which seeks to describe stability and change in sleep patterns over time, as well as identify the causes and consequences of individual variability in sleep parameters (e.g. Anders & Keener, 1985; Scher, Epstein, & Tirosh, 2004; Zuckerman, Stevenson, & Bailey, 1987). Much of this work has made use of longitudinal designs, though only a handful of studies have followed children past the first year of life (Scher et al., 2004; Tikotzky & Shaashua, 2012; Touchette et al., 2007; Zuckerman et al., 1987).

One way to understand the dramatic changes in sleep patterns across infancy is through the joint processes of sleep consolidation and regulation (Goodlin-Jones, Burnham, Gaylor, et al., 2001). As discussed previously, sleep becomes consolidated as children begin to sleep in longer continuous stretches primarily during the nighttime period. Some sleep variables that are indicative of consolidation include the number and duration of daytime naps, longest continuous sleep period (LSP) and nighttime sleep ratio (NSR; ratio of nighttime sleep to 24-hour sleep; Bernier, Carlson, Bordeleau, & Carrier, 2010), where fewer naps, longer LSP, and higher NSR values indicate more consolidated sleep.[1] On the other hand, sleep regulation concerns the child's ability to transition independently between wake and sleep states. Less wake time, fewer night wakings, and high sleep efficiency (i.e., ratio of time asleep to time in bed) may all be used as crude indicators of self-regulated sleep, as children who soothe themselves to sleep spend less time awake at night (Goodlin-Jones, Burnham, Gaylor, et al., 2001). Further specifying wakings into those that are signaled versus self-soothed provides more direct indices of sleep regulation, with more self-soothed wakings indexing better regulated sleep. However, deriving these variables requires the use of videosomnography, a method that remains rare in the literature.

In the follow sections, we review the research documenting development in sleep consolidation and regulation across the first two years of life. Because of their individual strengths and weaknesses (see Sadeh, 2015 for a review), we rely on studies that use both objective (e.g., actigraphy, videosomnography, polysomnography) and subjective (e.g., sleep diaries) sleep assessment methods. We end with a discussion of two key questions that have yet to be fully addressed in the literature.

Sleep consolidation

Much of the work on early sleep development has dealt solely with infants from birth through age one, possibly motivated by the dramatic changes in sleep patterns across the first year of life. These dramatic changes in sleep consolidation are guided in part by the emergence of a distinct circadian rhythm. At birth, the circadian rhythm is immature, and periods of wakefulness and sleep are guided largely by hunger and satiety (rather than light and dark) cues: when babies are hungry, they wake up and feed; after feeding, they fall into another bout of sleep. Driven by these cues, newborns sleep an average of 16 h a day in 5–6 episodes interspersed equally between daytime and nighttime. By the end of the first year of life, total sleep time decreases to between 12 and 13 h a day, consolidated into one extended episode of nighttime sleep and one or more daytime naps (de Roquefeuil, Djakovic, & Montagner, 1993; El-Sheikh & Sadeh, 2015; Mindell & Owens, 2015; Sadeh et al., 2009). However, there is considerable variability around these average values for sleep duration. For example, infants who are breastfed tend to sleep in shorter bouts than formula-fed infants, due to quicker rates of digestion of breastmilk (Mindell & Owens, 2015).

The decrease in total sleep time across the first year of life is due mainly to a reduction in the amount of daytime sleep, specifically a reduction in the number of daytime naps (Iglowstein et al., 2003; Sadeh et al., 2009). In one study using parent-report of daytime

[1] Although we will discuss changes in total sleep duration as well, primarily we will rely on changes in amounts and bouts of daytime versus nighttime sleep as stronger evidence for sleep consolidation. This is consistent with the viewpoint that total sleep duration is a developmentally inappropriate measure of sleep quality in infants (Bernier, Matte-Gagné, & Bouvette-Turcot, 2014). Further, while there is likely to be some overlap between the constructs of sleep duration and quality (e.g., Goodlin-Jones, Burnham, Gaylor, et al., 2001), meta-analyses in older children support that these are separable constructs (Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010).

and nighttime sleep durations, Sadeh et al. (2009) found that the nighttime sleep ratio (NSR) increases from 60% to 75% between 0 and 2 and 9–11 months, with the largest increase occurring between 0 and 2 and 3–5 months. This finding indicates that daytime sleep constitutes 40% of total sleep in the first two months, but decreases to 25% by the end of the first year. At the same time, periods of sustained sleep during the night increase. One meta-analysis showed that, whereas the longest continuous sleep period (LSP) is between 3 and 4.5 h in one month olds, it increases to about 6 h by 2–3 months of age and then plateaus (Henderson, France, & Blampied, 2011).

Fewer studies have addressed sleep consolidation in the second year of life. The work that does exist documents changes in sleep consolidation that continue the trends seen across the first year (Acebo et al., 2005; Iglowstein et al., 2003; Sadeh et al., 2009; Scher et al., 2004; Zuckerman et al., 1987). For example, researchers examining 24-hour sleep patterns have reported that total sleep time continues to decrease during this period, from an average of 12 to 13 h at age 1 to an average of 11 to 13 h at age 3 (Iglowstein et al., 2003; Mindell & Owens, 2015; Sadeh et al., 2009). Because duration of nighttime sleep tends to remain constant after age 1 (Acebo et al., 2005), much of this reduction in total sleep time is due to a continued reduction in the number of daytime naps. Whereas taking two naps a day is common at age 1, multiple studies have shown that by 18 months, most children transition to taking only one nap a day (Acebo et al., 2005; Iglowstein et al., 2003; Sadeh et al., 2009). However, sleep is not considered to be fully consolidated until between ages 5 and 7, when most children stop napping altogether (Acebo et al., 2005; Iglowstein et al., 2003; Mindell & Owens, 2015; Weissbluth, 1995). Similarly, a meta-analysis examining change in infants' LSP across the first two years of life showed that LSP continues to increase in the second year, but at a slower rate than observed in the first 6 months of life (Galland, Taylor, Elder, & Herbison, 2012).

Sleep regulation

Concerning sleep regulation, wake time during sleep periods tends to decrease across the first year of life (e.g., Sadeh et al., 2009); however, there are less consistent findings regarding change in the *number* of infant night wakings. Some researchers have reported declines in night wakings by 3 (Burnham et al., 2002; Hoppenbrouwers, Hodgman, Arakawa, Geidel, & Sterman, 1988) or 6 months of life (Scher et al., 2004), whereas others have found no systematic change in the number of night wakings across the first year (Goodlin-Jones, Burnham, Gaylor, et al., 2001). While differences in methodologies and rates of signaled (i.e., vocalized) wakings could possibly account for these disparate findings, it is important to note that all the aforementioned studies used objective measurement to determine infant sleep state (e.g., videosomnography or polysomnography). Different thresholds for continuous wakefulness needed to code a waking (e.g. 5 versus 10 min of wakefulness) may contribute to this lack of consistent findings. Or, the degree of individual differences in wakefulness may preclude the identification of a single, 'normative' pattern of change. In support of this notion, one meta-analysis showed that, although night waking did decrease across the first two years of life, this sleep variable demonstrated the greatest amount of variability compared to other measures (Galland et al., 2012).

Individual differences in the milestone of 'sleeping through the night' further highlight the considerable variability that exists in terms of sleep regulation in the first year. Considered by some to be the most significant sleep milestone in infancy (Anders, Halpern, & Hua, 1992), as well as the hallmark of self-regulated sleep (Henderson, France, Owens, & Blampied, 2010), sleeping through the night does not mean that an infant experiences no wakings during the nighttime sleep period. Rather, this criterion is met when an infant is able to fall asleep independently at bedtime and self-soothe back to sleep following night wakings, rather than rely on caregiver intervention. As a result, caregivers of self-soothing infants perceive that their child has slept continuously throughout the typical nighttime sleep period (i.e., from 12:00 to 5:00 AM or 10:00 PM to 6:00 AM; see Henderson et al., 2010). Given this criterion, sleep diaries (alone or in combination with objective measures) can be a useful measure of whether an infant's sleep is regulated, as it necessarily relies on parental perceptions of their children's signaling behavior. If an infant wakes (i.e., observed via actigraphy or videosomnography) but does not signal (i.e., the waking is not reported on sleep diary), then an infant may be displaying self-soothing.

Researchers using these types of measures have found that a majority of infants are 'sleeping through the night' by 12 months of age (Anders et al., 1992; Burnham et al., 2002; Goodlin-Jones, Burnham, Gaylor, et al., 2001; Henderson et al., 2010). For example, one study used videosomnography to observe and classify infant night wakings into two categories (Goodlin-Jones, Burnham, Gaylor, et al., 2001). Non-self-soothed wakings were those where the infant received parental intervention to return to sleep, whereas self-soothed wakings were those where the infant resumed sleep without parental assistance. Infants were then classified as self-soothers (SS) or non-self-soothers (NSS), based on their modal response. Whereas the majority of 3 month old infants were NSS, at 6, 9, and 12 months, the majority of infants were SS, indicating an increase in sleep regulation across the first year of life. These findings are supported by a more recent meta-analysis, which showed that rates of sleeping through the night increased from 31 to 58% at 2 months, to 67–85% at 6 months, to 80–95% at 12 months (Henderson et al., 2011).

Turning to the second year of life, there are continuing decreases in both the number and duration of nighttime wakings after age 1 (Acebo et al., 2005; Sadeh et al., 2009; Scher et al., 2004). Again, the use of different methodologies within the same study allows us to compare the prevalence of signaled versus non-signaled wakings. In one study that used both maternal report and actigraphy to assess night waking across one week of observation, a majority (71%) of mothers of one- to three-year-olds reported that their child did not wake on any of the seven nights of observation (Acebo et al., 2005). Actigraphy data provided a different view, with the average number of nightly wakings remaining between three and eight for the one- to three-year-olds. While these findings may be partially due to actigraphy's tendency to overestimate wakefulness (e.g., Insana, Gozal, & Montgomery-Downs, 2010; Meltzer, Montgomery-Downs, Insana, & Walsh, 2012), the results may also indicate that night waking remains common beyond the first year of life, but increasingly, the majority of children are able to return to sleep without signaling. Conversely, approximately one third of children may continue to signal for nighttime intervention, similar to the rates observed towards the end of the first year of life (Burnham et al., 2002). Given the shortcomings of actigraphy, studies using videosomnography in the second year of life are needed to confirm this pattern of findings.

Thus, in all of these studies, there is a subset of children who either cannot fall asleep independently, or who continue to signal upon waking and require parental assistance to fall back to sleep. These children are more likely to be perceived by parents as having sleep problems (Anders et al., 1992; Goodlin-Jones et al., 2001). Understanding the intrinsic and extrinsic factors that contribute to these differences is important because infants with self-regulated sleep tend to have longer continuous sleep periods and greater overall sleep duration (Anders et al., 1992; Goodlin-Jones, Burnham, Gaylor, et al., 2001). In addition, sleep problems that are established in infancy may persist across the toddler and preschool years (Scher et al., 2004; Tikotzky & Shaashua, 2012; Zuckerman et al., 1987).

Continuity and change in sleep consolidation and regulation

As mentioned above, most studies investigating sleep patterns across the first years of life have tended to use cross-sectional samples of infants at different ages, meaning that they are primarily investigating between-individual, rather than within-individual changes. As a result, we know much more about expected or reference values for sleep constructs at different ages than we know about individual trajectories of sleep development. Nonetheless, several researchers have tested whether individual differences in sleep consolidation and regulation in the first year of life predict individual differences in these same constructs at later time points.

One study which addressed this question included actigraphic assessments of nighttime sleep with children aged 3, 6, 9, 12, 20, and 42 months, and showed that children's LSPs were moderately correlated across this time period (Scher et al., 2004). Sleep consolidation may therefore be stable from infancy into the preschool years, although additional indicators of sleep consolidation (e.g., NSR) have yet to be tested.

Concerning the stability of sleep regulation, the same study described above showed that the number of children's night wakings was not significantly correlated from 3 to 42 months (Scher et al., 2004). However, results of a second, similar study demonstrated that more actigraphic night wakings at 12 months predicted more night wakings at 4 years (Tikotzky & Shaashua, 2012). Although both studies used actigraphy, the former study included children who had at least two nights of actigraphy monitoring, while the latter study collected actigraphy data for four nights. Averaging across more nights may have resulted in more reliable estimates of average waking activity, which would allow for enhanced ability to detect correlations across time.

Despite conflicting findings from actigraphy studies, parental perceptions of child sleep problems have been shown to be stable across infancy and toddlerhood (Morrell & Steele, 2003; Zuckerman et al., 1987). That is, parents who reported that their child had a sleep problem in their first year of life were more likely to report the child had a sleep problem at a follow-up visit in the second (Morrell & Steele, 2003) or third (Zuckerman et al., 1987) year of life. In another study, researchers plotted trajectories of reported night wakings across 6, 15, 24, and 36 months and found that there were two distinct groups of children (Weinraub et al., 2012). The predominant group, labeled Sleepers, showed low, stable levels of parent-reported night wakings. A minority (1/3) of children fell into a second group, labeled Transitional Sleepers, who were characterized by non-linear declines in night wakings across the same time period, starting off with higher rates of night waking than Sleepers at 6 months, but declining to similar levels by 24 months. Thus, these findings from self-report studies suggest that there may be qualitatively different patterns of change in sleep regulation (e.g., children with perceived sleep problems/Transitional Sleepers and children without perceived sleep problems/Sleepers). Further research using a combination of objective and subjective measures may allow us to disentangle whether there are differing trajectories of signaled vs. non-signaled night wakings, which may add a layer of nuance to our understanding of stability in sleep regulation in infancy.

Beyond continuity in sleep consolidation and regulation themselves, a second question is the extent to which sleep consolidation and regulation are related to one another across time. That is, is there any evidence that one process (i.e., sleep consolidation or regulation) precedes the other developmentally? Given the immaturity of the circadian rhythm at birth, one hypothesis is that a certain level of sleep consolidation is necessary before sleep regulation becomes relevant. This is because, until day/night patterning of sleep is at least partially established, infants sleep and wake based on hunger and satiety cues. Differences in the numbers of night wakings during these first months may have more to do with individual differences in feeding method (e.g., breast versus bottle) or metabolism, rather than the infant's own ability to regulate their sleep/wake states. By six months of age, however, the majority of typically-developing infants no longer require nighttime feeding (Mindell & Owens, 2015), and the circadian rhythm is well-established (e.g., de Roquefeuil et al., 1993). At this point, the stage is set for infants to begin to regulate their own night wakings. It is therefore not surprising that there are dramatic changes in rates of self-soothing between 3 and 6 months of age (e.g., Goodlin-Jones, Burnham, Gaylor, et al., 2001). Later in the first year of life, sleep regulation may in turn support further advances in sleep consolidation. This hypothesis is supported by research showing that infants who self-soothe following night wakings are likely to have longer continuous sleep periods (Goodlin-Jones, Burnham, Gaylor, et al., 2001). Therefore, the question of which process precedes the other is likely to have a complex answer, one which depends on the period of time being investigated. Empirical research should be brought to bear on this developmental question, as it has clear implications for research and practice.

Intrinsic and extrinsic influences on sleep development

Clearly, there is a great degree of variability in the rate at which children develop consolidated and regulated sleep. We turn next to a consideration of the intrinsic and extrinsic factors that influence these two processes. Because the existing literature has tended to

Table 1
Characteristics of studies examining intrinsic and extrinsic predictors of sleep.

Author, year	N	Child age	Study Type	Predictor	Predictor assessment method	Sleep assessment method
Intrinsic Factors						
Pesonen et al. (2009)	289	8 y	Longitudinal	Birth weight	Birth records	Actigraphy
Anders and Keener (1985)	64	2 w; 4 w, 8 w, 20 w, 24 w, 36 w, 52 w	Longitudinal	Prematurity	Birth records	Videosomnography
Troese et al. (2008)	13	6–8 w	Longitudinal	Prenatal alcohol exposure	Parent-report	Actigraphy; EEG; Videosomnography
Stéphan-Blanchard et al. (2008)	39	0–8 w	Cross-sectional	Prenatal tobacco exposure	Parent-report	Polysomnography
Halpern et al. (1994)	21	3 w; 3 m	Longitudinal	Infant temperament	Behavioral assessment	Videosomnography
Keener et al. (1988)	23	6 m	Cross-sectional	Infant temperament	Parent-report	Videosomnography
Scher et al. (1992)	31	11–27 m	Cross-sectional	Infant temperament	Parent-report	Actigraphy
Bright et al. (2014)	47	12–24 mo	Cross-sectional	Cortisol	Saliva sample	Actigraphy
El-Sheikh et al. (2008)	64	7–11 y	Cross-sectional	Cortisol	Saliva sample	Actigraphy
Hatzinger et al. (2010)	82	4–5 y	Cross-sectional	Cortisol	Saliva sample	Actigraphy
Räikkönen et al. (2010)	282	8 y	Cross-sectional	Cortisol	Saliva sample	Actigraphy
Scher et al. (2009)	27	12–36 mo	Cross-sectional	Cortisol	Saliva sample	Actigraphy
Stalder et al. (2013)	33	2–12 mo	Cross-sectional	Cortisol	Saliva sample	Actigraphy; Parent-report
Elmore-Staton et al. (2012)	29	3–5 y	Cross-sectional	RSA	HR monitoring	Actigraphy
El-Sheikh and Buckhalt (2005)	41	6–13 y	Cross-sectional	RSA	HR monitoring	Actigraphy; Child-report; Parent-report
El-Sheikh et al. (2013)	224	10 y	Cross-sectional	RSA	HR monitoring	Actigraphy; Child-report
Gueron-Sela et al. (2017)	156	3 m; 6 m; 18 m	Longitudinal	RSA	HR monitoring	Parent-report
Extrinsic Factors						
Adair et al. (1991)	122	8–12 m	Cross-sectional	Parental presence at bedtime	Parent-report	Parent-report
Mindell et al. (2010)	29,287	0–36 m	Cross-sectional	Parental presence at bedtime	Parent-report	Parent-report
DeLeon and Karraker (2007)	41	9 m	Cross-sectional	Infant put into crib asleep	Parent-report	Parent-report
Goodlin-Jones, Burnham, Gaylor, et al. (2001)	80	3–12 m	Cross-sectional	Infant put into crib asleep	Parent-report	Videosomnography
Burnham et al. (2002)	80	1 m; 3 m; 6 m; 9 m; 12 m	Longitudinal	Active nighttime intervention	Parent-report	Videosomnography
Morrell and Cortina-Borja (2002)	288	1 y; 2 y	Longitudinal	Active nighttime intervention	Parent-report	Parent-report
Morrell and Steele (2003)	100	1 y; 2 y	Longitudinal	Active nighttime intervention	Parent-report	Parent-report
Sadeh et al. (2009)	5006	0–36 m	Cross-sectional	Active nighttime intervention	Parent-report	Parent-report
Sheridan et al. (2013)	121	12 m; 18 m; 5 y	Longitudinal	Active nighttime intervention	Parent-report	Actigraphy; Parent-report
Touchette et al. (2005)	1741	5 m; 17 m; 29 m	Cross-sectional	Active nighttime intervention	Parent-report	Parent-report
Voltaire and Teti (2018)	107	1 m; 3 m; 6 m; 9 m	Longitudinal	Active nighttime intervention	Observer ratings	Parent-report
Mindell et al. (2011)	171	18–36 m; 30–48 m	Longitudinal	Bedtime routine	Behavioral intervention	Parent-report
Mindell et al. (2015)	10,085	0–5 y	Cross-sectional	Bedtime routine	Parent-report	Parent-report
Mindell et al. (2009)	405	7–18 m; 18–36 m	Cross-sectional	Bedtime routine	Behavioral intervention	Parent-report
Staples et al. (2015)	87	30 m; 36 m; 42 m	Longitudinal	Bedtime routine	Parent-report	Actigraphy; Parent-report
Philbrook and Teti (2016)	109	1 m; 3 m; 6 m	Longitudinal	Maternal EA at bedtime	Observer ratings	Videosomnography
Teti et al. (2010)	45	1 m; 3 m; 6 m; 12 m; 24 m	Cross-sectional	Maternal EA at bedtime	Observer ratings	Parent-report
Bordeleau et al. (2012)[a]	55	1 y; 4 y	Longitudinal	Daytime sensitivity	Observer ratings	Parent-report
Dearing et al. (2001)	62	7 m; 19 m; 31 m	Longitudinal	Daytime sensitivity	Observer ratings	Parent-report
Priddis (2009)	65	7–18 m	Cross-sectional	Daytime sensitivity	Observer ratings	Parent-report
Scher (2001)	37	12 m	Cross-sectional	Daytime sensitivity	Observer ratings	Actigraphy
Tétreault et al. (2017)	143	12 m; 18 m; 24 m; 36 m; 48 m	Longitudinal	Daytime sensitivity	Observer ratings	Parent-report
Weinraub et al., 2012	1364	6 m; 15 m; 24 m; 36 m	Longitudinal	Daytime sensitivity	Observer ratings	Parent-report
Interactions of Intrinsic and Extrinsic Factors						
Gueron-Sela et al. (2017)	156	3 m; 6 m; 18 m	Longitudinal	Infant RSA; Maternal depression	HR monitoring; Parent-report	Parent-report

(*continued on next page*)

Table 1 (*continued*)

Author, year	N	Child age	Study Type	Predictor	Predictor assessment method	Sleep assessment method
Jian and Teti (2016)	72	1 m; 3 m; 6 m	Longitudinal	Infant temperament; Maternal EA at bedtime	Parent-report; Observer ratings	Actigraphy

Note. EA = emotional availability; EEG = electroencephalogram; HR = heart rate; m = month; RSA = respiratory sinus arrythmia; w = week; y = year.

consider intrinsic and extrinsic factors independently, we primarily review studies describing main effects. In subsequent sections, we discuss possible interactions across intrinsic and extrinsic factors. Table 1 summarizes the studies described in these sections.

Intrinsic factors

Intrinsic factors that have been examined in relation to sleep development include temperamental characteristics and physiological reactivity (i.e., autonomic nervous system function). We acknowledge that these factors are not necessarily innate (e.g., Propper & Holochwost, 2013). Rather, we use the term intrinsic here to mean characteristic of the child himself, rather than his environmental surroundings.

For the most part, studies on intrinsic factors have tended to begin at birth. Although we too will consider postnatal factors, it is important to note that prenatal risk factors, such as low birth weight (e.g., Pesonen et al., 2009), prematurity (e.g., Anders & Keener, 1985), and exposure to alcohol (e.g., Troese et al., 2008) and tobacco (Stéphan-Blanchard et al., 2008) may predispose infants to sleep problems, and therefore constitute an important area of future study.

Infant temperament

Infant temperament is one commonly investigated intrinsic characteristic hypothesized to relate to early sleep development, though the evidence supporting this link has been mixed. Most of the research linking difficult temperament to sleep problems in infancy has utilized parent-report measures, which are likely to be biased by parents' experiences with their infant at bedtime and throughout the night (e.g., Scher, Epstein, Sadeh, Tirosh, & Lavie, 1992). In fact, the Revised Infant Behavior Questionnaire (IBQ-R; Gartstein & Rothbart, 2003), one of the most popular infant temperament questionnaires, includes questions that directly reference infant's sleep behavior (e.g., "When going to sleep at night, how often did your baby have a hard time settling down to sleep?"). Therefore, it is not surprising that reports of infant sleep and temperament are intimately yoked, though whether this represents a true relationship between the two constructs, or merely shared method variance, remains to be determined.

In support of the latter hypothesis, one study showed that the link between temperament and sleep depended on whether the mother or father was the respondent (Keener, Zeanah, & Anders, 1988), with fathers' ratings of temperament being more strongly linked to infant sleep. The authors explain that in their sample, fathers primarily worked outside the home, and therefore mainly interacted with their infant during the nighttime (as opposed to mothers, who tended to be home with infants throughout the day and night). Thus, fathers in the study based their perceptions of their infant's temperament more strongly on the infant's nighttime behaviors, as opposed to mothers. Of course, the opposite explanation is also possible: parents' perceptions of their infants' temperament may influence their perceptions of their infant's sleep. These two hypotheses cannot be easily distinguished based on current studies.

Only one study of which we are aware has shown links between observed temperament and infant sleep (Halpern, Anders, Coll, & Hua, 1994), though their findings were mixed in terms of which temperamental characteristics related to which sleep outcomes. These mixed findings raise a second issue in this area, regarding the general lack of specificity in terms of hypothesized linkages between temperament and sleep. Although different dimensions of temperament have been proposed, Rothbart's three temperament "superfactors" (positive emotionality/surgency, negative affectivity, and orienting/regulatory capacity; Gartstein & Rothbart, 2003) may be the most useful for studies of infant sleep, given that these superfactors describe infant's tendencies towards reactivity and/or regulation. Given this conceptualization, we might hypothesize that these three superfactors may be differentially related to indices of infant sleep consolidation and regulation. For example, infant orienting/regulatory capacity may be a stronger predictor of infant sleep regulation than of sleep consolidation. Future longitudinal studies should test specific predictive relationships among dimensions of sleep and temperament, using at least one non-parent report or objective measure, in order to uncover whether there is a true association between these two domains.

Physiological reactivity

Individual variation in physiological reactivity and regulation may also be implicated in the development of early sleep patterns. We discuss influences of two branches of the autonomic nervous system (ANS), the sympathetic (SNS) and parasympathetic (PNS) systems, as indexed by cortisol secretion and vagal tone, respectively. Although these systems clearly work together to influence behavior, we discuss these systems separately in our review, given the relative lack of studies that integrate findings across the SNS and PNS, at least in infancy (for a recent example in older children, see Alkon, Boyce, Neilands, & Eskenazi, 2017).

Researchers have increasingly become interested in baseline cortisol, the primary glucocorticoid secreted by humans, as an index of SNS functioning and reactivity. Cortisol is secreted by the adrenal glands and is the end-product of the hypothalamic-pituitaryadrenal (HPA) axis. Similar to sleep, cortisol levels are governed by a circadian rhythm, with a spike in levels shortly after awakening (cortisol awakening response; CAR), followed by a gradual decline across the day (Clow, Hucklebridge, Stalder, Evans, & Thorn, 2010). Atypical cortisol rhythms (characterized by both under- and overarousal) have been linked to a variety of problem behaviors in children, such as internalizing and externalizing disorders (Alink, van IJzendoorn, Bakermans-Kranenburg, Mesman, Juffer, & Koot, 2008; Ruttle et al., 2011). Concerning sleep specifically, several studies have found that children with poor sleep quality and/or higher self-reported sleep problems have higher daytime cortisol levels (El-Sheikh, Buckhalt, Keller, & Granger, 2008; Hatzinger et al., 2010; Räikkönen et al., 2010), as well as higher CAR (Räikkönen et al., 2010). In infants, poor sleep has also been shown to predict higher CAR. For example, shorter nighttime sleep duration, as measured by actigraphy, has been shown to predict higher CAR in 12 and 24 month old infants (Bright, Frick, Out, & Granger, 2014). Researchers have similarly found that more variability in night-to-night efficiency and a greater number of daytime naps were both associated with higher CAR (Scher, Hall, Zaidman-Zait, & Weinberg, 2009; Stalder et al., 2013).

Turning to the PNS, vagal tone is a commonly-studied metric that indexes parasympathetic control of the heart. It is measured as the amplitude of respiratory sinus arrhythmia (RSA), or the variability in heart rate coinciding with respiration. Baseline RSA reflects an individual's ability to adaptively change states in response to a challenge, and to return to homeostasis after the disruption (Porges, 1996). During a challenging situation, however, the withdrawal of vagal control allows for increases in heart rate that are necessary for adaptive engagement with the environment. Thus, high baseline RSA and high RSA withdrawal are indicative of better physiological regulation, and have been shown to predict various aspects of sleep. Studies with school-age children have found associations between daytime RSA and sleep (El-Sheikh & Buckhalt, 2005; El-Sheikh, Erath, & Bagley, 2013), with lower baseline RSA and lower RSA withdrawal being linked to increased sleep problems and other actigraphic indicators of poor sleep quality (e.g., long wake episodes). In infants, lower RSA withdrawal during the still-face paradigm was found to predict higher parent-reported sleep problems at 18 months (Gueron-Sela et al., 2017), while in preschoolers, higher baseline RSA predicted lower actigraphic sleep activity and higher sleep efficiency at age 4 (Elmore-Staton, El-Sheikh, Vaughn, & Arsiwalla, 2012). Taken together, these findings suggest that variations in PNS functioning may be related to sleep, at least in the second year of life and beyond.

Therefore, existing research suggests that ANS activity and infant sleep quality are coupled, although several questions remain. First, relations between PNS reactivity and sleep in the first year of life have yet to be examined. Additionally, it is unknown whether SNS and PNS activity are causally related to infant sleep development, or whether the opposite is true. While it is possible that more physiologically reactive infants (e.g., those exhibiting hyper-arousal of the HPA axis) have more difficulty sleeping, infant sleep patterns may also shape physiological reactivity, for better or worse.

Extrinsic factors

In addition to the multitude of intrinsic characteristics that may predispose a child to better or worse sleep, the role of the environment in shaping sleep development, particularly during the early years, cannot be overstated. One consistent research finding is that parents are the single largest contributor to the development of sleep patterns in the first five years of life (Sadeh et al., 2010). Caregivers initially provide external regulation to support infant wake and sleep states, by promoting alertness and attention during wake periods, and engaging in soothing, quiet activities (e.g., feeding, rocking) to facilitate drowsiness during the transition to sleep (Sameroff, 2010). Successful experiences of state regulation provided by caregivers early in development shape the child's own regulatory competency within this domain. Given the primacy of parent-child interactions as an influence on infant development, our review of extrinsic factors primarily describes parenting influences on infant sleep, although we acknowledge that more distal factors (e.g., neighborhoods, culture) also contribute (e.g., Grimes, Camerota, & Propper, 2018). Relatedly, although a large body of literature has examined the role of parental cognitions about sleep (e.g., Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007; Tikotzky & Sadeh, 2009; Tikotzky & Shaashua, 2012) and infant sleep location (e.g., Sadeh et al., 2009; Volkovich, Ben-Zion, Karny, Meiri, & Tikotzky, 2015), these likely have an impact on infant sleep development via patterns of parent-child interaction (or other familial factors), and therefore are not considered here.

Thus, in the following section, we investigate parenting practices, bedtime routines, emotional availability, and daytime sensitivity as proximal factors that contribute to the development of infant sleep. While parenting practices and bedtime routines describe *what* parents do at bedtime and throughout the night, emotional availability and sensitivity describe *how* parents do it (Teti, Philbrook, et al., 2015). Although these domains are not necessarily independent, each provides unique information about the social ecology of infant sleep, and have tended to be studied separately. We therefore consider them as both independent and interactive predictors of sleep outcomes. Additionally, although we use the term 'parent', the vast majority of studies report solely on mothers' behaviors (cf. Tikotzky & Sadeh, 2015). We explicitly mention when fathers are included as study participants.

Parenting practices

The largest body of research on parent-child interactions in a sleep context describes specific parenting practices (also referred to as settling strategies) occurring at bedtime and throughout the night that help or hinder children's sleep consolidation and regulation. Cross-sectional work measuring parenting practices and children's sleep concurrently has yielded initial evidence linking parents' settling strategies at bedtime to children's self-regulated sleep. For example, 9 month old infants whose parents were present at bedtime (regardless of parent gender or specific bedtime behavior) tended to wake up twice as much during the night, compared to infants whose parents were not present at bedtime (Adair, Bauchner, Philipp, Levenson, & Zuckerman, 1991). Similarly, infants put to bed asleep tended to wake up a greater number of times (Mindell, Sadeh, Kohyama, & How, 2010), spent more time awake at night (DeLeon & Karraker, 2007), and required parental assistance to settle back to sleep (Goodlin-Jones, Burnham, Gaylor, et al., 2001), compared to infants who were put into their crib awake. These findings indicate that infants who are given the opportunity to fall asleep independently also have better regulated sleep.

Concerning specific parenting behaviors during the night, more active parental interventions during the night (e.g., feeding, bringing into parent's bed) have been associated with less consolidated and regulated sleep, indexed by a higher number of reported night wakings, shorter continuous sleep periods, and short (< 6 h) nighttime sleep durations (Sadeh et al., 2009; Touchette et al., 2005). Parents tend to employ the same strategies to settle infants at bedtime and to help them resume sleep following a night waking (Sadeh et al., 2009), meaning that parents who are more actively involved at bedtime tend to also engage in active interventions during the night. Thus, it seems that parents who engage in more active settling behaviors at bedtime and throughout the night have children with less consolidated and regulated sleep. However, based on these cross-sectional studies alone, it is not possible to determine whether these relationships are causal. An alternative explanation is that children who have more trouble falling and staying asleep at night elicit more active parental involvement at bedtime (Adair et al., 1991; Sadeh, Gruber, & Raviv, 2003).

Fortunately, several longitudinal studies have shed light on the direction of effects between parent-child interaction and nighttime sleep. Morrell and Steele (2003) found that active physical comforting at bedtime (e.g., cuddling, feeding) predicted continuity in parent-reported sleep problems from age 1 to age 2, where sleep problems were defined as frequent issues with infant settling or waking over the past two months. The consequences of early setting strategies extend into the preschool years as well. Using the same parenting practices scale as Morrell and Steele (2003), another study showed that parents' use of active physical settling strategies at 1 year predicted lower reported and objective sleep duration at age 5, as well as greater reported sleep disturbances (Sheridan et al., 2013). Studies using observational measurement of infant sleep regulation have revealed similar findings. For example, higher parental latency to intervention at 3 months predicted more self-soothed awakenings at 12 months (Burnham et al., 2002). This study also assessed whether changes in parenting practices across the first year predicted infant sleep regulation, and found that infants who had steeper declines in out-of-crib time (i.e., were removed from their crib less over time) were more likely to self-soothe following night wakings at 12 months. In a similar study with an older age group, children whose sleep problems persisted or arose between 1 and 2 years of age had parents who continued or increased their use of active physical comforting strategies over this time period (Morrell & Cortina-Borja, 2002). Parents of infants without sleep problems still engaged in some active comforting, but they balanced these behaviors with increasing use of autonomy-encouraging strategies (e.g., offering a special cloth/toy). Further supporting a causal relationship between bedtime practices and children's sleep regulation, behavioral interventions that limit active parental involvement at bedtime have been related to decreases in infant nighttime waking (e.g., Gradisar et al., 2016).

Findings from these longitudinal and experimental studies provide initial support for a causal relationship between bedtime practices and children's sleep regulation, where more active parental involvement at night is associated with less consolidated and regulated sleep. From the few studies that have examined changes in parenting practices over time, it seems that the developmental timing of specific parenting strategies may be an especially important factor in predicting child outcomes (Erath & Tu, 2011). Whereas active parental strategies may be necessary in early infancy, in order to give children successful experience with state regulation, this other-regulation provided by caregivers must shift to more passive strategies that give the child a chance to harness his/her own self-regulatory capacities. These strategies might include waiting before responding to infant signals, verbally (rather than physically) reassuring the child, and providing a comforting transitional item, such as a blanket or a stuffed toy (Mindell et al., 2010; Morrell & Cortina-Borja, 2002). The exact age at which this shift should begin remains unknown, and may vary among children. Given that the majority of sleep training programs are recommended for children beginning around 6 months of age (e.g., Ferber, 2006; Weissbluth, 2015), this time period may be particularly well-suited for transitioning to passive comforting strategies, although this remains to be empirically demonstrated.

Bedtime routines

Whereas the study of nighttime parenting practices has a long history, researchers are now beginning to examine the importance of consistent bedtime routines for children's sleep. For example, greater adherence to a bedtime routine was concurrently associated with longer sleep duration at 36 and 42 months (Staples et al., 2015). In a large, cross-sectional sample of children aged 0 through 5, researchers found a dose-dependent association between frequency of adherence to a bedtime routine and child sleep outcomes (Mindell, Li, Sadeh, Kwon, & Goh, 2015), with greater consistency (i.e., number of days per week the routine was followed) predicting shorter sleep onset latency, fewer night wakings, and greater nighttime sleep duration.

Further evidence of a causal relationship between bedtime routines and sleep comes from an experimental study of sleep-disturbed infants and toddlers (Mindell, Telofski, Wiegand, & Kurtz, 2009). Parents in the experimental group were instructed to follow a three-step bedtime routine for two weeks, whereas parents in the control group were told to follow their normal routine. Compared to baseline, children in the experimental group exhibited fewer night wakings, longer LSPs, and greater nighttime sleep duration at the end of the study period (Mindell et al., 2009). There were no improvements for children in the control group. Intervention effects endured over a one-year period, although control group children also showed improvements in sleep across the year, limiting the study's conclusions about long-term efficacy (Mindell et al., 2011). Given this, coupled with the clinical nature of the sample and reliance on maternal report of child sleep, it is unclear whether bedtime routines are causally linked to better sleep in all children. Objective, longitudinal research assessing bedtime routine adherence and sleep over time may better inform this question.

Emotional availability at bedtime

Unlike parenting practices and bedtime routines, emotional availability describes how parents interpret and respond to infant cues in a sleep context (Philbrook & Teti, 2016; Teti, Kim, Mayer, & Countermine, 2010). This work is built upon the notion that it is not necessarily *what* parents do, but *how* they do it, that influences infant and child outcomes (Darling & Steinberg, 1993). Drawing from sleep theory, this work hypothesizes that the emotional quality of parent-child interactions at bedtime can either support or undermine the infant's feeling of safety in his or her sleep environment, which in turn promotes or hinders sleep (Dahl, 1996; Teti, Philbrook, et al., 2015). Researchers examining this hypothesis have coded parents' emotional availability (EA) from videotaped parent–child interactions at bedtime (Philbrook & Teti, 2016; Teti et al., 2010). Parents who score high on EA accurately interpret and respond to their infants' cues, while engaging in comforting activities that guide the child towards sleep. Parents who score low on EA ignore their infants' cues and engage in arousing behaviors that prolong wakefulness. Therefore, this coding scheme does not merely document what parents are doing at bedtime, but whether the infant signaled for and benefitted from parent actions.

The first study examining parental EA at bedtime was comprised of a cross-sectional sample of parents and their infants aged 24 months and younger (Teti et al., 2010). This study showed that observed bedtime practices (e.g., holding, nursing, singing, reading) were unrelated to reported infant sleep disruption. However, EA was significantly and negatively related to infant sleep disruption, such that parents who were rated as more emotionally available to their infants at bedtime reported fewer infant night wakings. This association was especially strong for younger infants. A follow-up study by the same group used objective observation of both EA and infant sleep (via videosomnography) when infants were 1, 3, and 6 months of age to examine the direct and interactive effects of parenting practices and EA on infant sleep and nighttime distress (Philbrook & Teti, 2016). Within-person effects indicated that at time points when mothers were more emotionally available than their average, infants exhibited less nighttime distress and longer sleep duration. Additionally, the effect of parenting practices (e.g., close physical contact) on infant sleep depended on mothers' EA. Less close contact at bedtime predicted more infant sleep when maternal EA was high; when maternal EA was low, infants spent less time asleep regardless of the amount of close contact at bedtime.

The findings from the above two studies indicate that parents' sensitivity and responsiveness to infant cues at bedtime are important correlates of infants' sleep consolidation and regulation. Depending on the specific parenting practices and age group studied, EA has been shown to either directly predict infant sleep quality or moderate the effect of specific practices on infant sleep. Therefore, although this body of research is just beginning, early findings support moving beyond the sole consideration of specific nighttime practices toward a model that examines the appropriateness of parental input given the infant's regulatory needs.

Daytime sensitivity

Similarly, research on parental sensitivity investigates the extent to which appropriate, contingent responses to infant cues during the daytime predict infants' ability to initiate and maintain sleep. Given that maternal sensitivity is crucial in the development of self-regulation (Bernier, Carlson, & Whipple, 2010), and may contribute to the feeling of safety needed to relinquish vigilance and initiate sleep (Dahl, 1996), theoretically, there should be a strong association between daytime sensitivity and infant sleep. However, empirical findings are mixed.

One group of studies document the expected positive associations between parental sensitivity and child sleep. For example, Priddis (2009) found that observed parental sensitivity was significantly lower among infants characterized as poor sleepers, compared to good sleepers. Similarly, observed maternal sensitivity at 12 months was shown to predict children's NSR at 3 and 4 years of age (Bordeleau, Bernier, & Carrier, 2012a; Tétreault, Bouvette-Turcot, Bernier, & Bailey, 2017). However, a number of studies have found no relationship (Scher, 2001), or a negative relationship (Dearing, Mccartney, Marshall, & Warner, 2001; Weinraub et al., 2012), between maternal sensitivity and sleep in the first years of life.

Researchers have speculated (e.g., Tétreault et al., 2017) that differences in child age and method of sleep assessment may contribute to these mixed findings. There may also be differences in the extent to which parents exhibit sensitivity in the context of daytime and nighttime parenting. To our knowledge, there have not been any studies that explicitly compare parenting in these two contexts as predictors of children's development. Because nighttime parenting offers its own set of challenges (e.g., parental fatigue, concerns over child safety), it is possible that the correlates and consequences of daytime and nighttime sensitivity are different. These hypotheses remain to be tested.

Defining competent nighttime parenting

Given the multitude of parenting factors that have been investigated as contributors to infant sleep development, one lingering question is how to define competent nighttime parenting. Clearly, the goals of daytime and nighttime parenting differ, and therefore, what might be considered 'sensitive' or 'responsive' parenting during the daytime (e.g., responding to all infant vocalizations) might be considered over-involvement during the nighttime. In support of this proposition, one study found that more parental responses to non-distressed vocalizations during the nighttime predicted less decline in night waking across the first year of life. However, greater responsiveness to distressed vocalizations at 1 and 3 months predicted steeper declines in infant night waking (Voltaire & Teti, 2018). As we reviewed earlier, the type of intervention also matters; the later parents begin to rely on autonomy-encouraging interventions as their primary strategy, the more likely that persistent infant sleep problems are observed (Morrell & Cortina-Borja, 2002). Therefore, the type of infant cue (e.g., distress or non-distress), age of the infant, and type of parental intervention (e.g., active or passive) may all be pertinent factors to consider when defining developmentally-appropriate, sleep-supportive parenting across the first years. Intrinsic infant characteristics (e.g., physiological and temperamental reactivity) and situational factors (e.g., child illness, new sleep environment) may also contribute to children's nighttime parenting needs.

Contributions of developmental science to infant sleep research

From previous sections of this review, it is clear that recent decades have seen increased interest in the domain of infant sleep, from tracing both normative trajectories of development to predicting individual differences in sleep consolidation and regulation. However, the complexity of research questions in the field have not necessarily kept pace with this surge in interest. For example, the majority of studies described above have tended to consider independent, direct effects of various child characteristics or parenting behaviors on infant sleep development. Less well-understood are the ways in which parenting and child characteristics may interact to predict infant sleep, as well as how early patterns of parent-child interactions centered around sleep may initiate a developmental cascade leading to different patterns of child adaptation or maladaptation. The final section of this review explores the ways in which developmental science can advance the study of infant sleep, primarily by providing theoretical and empirical grounding for understanding these unanswered questions.

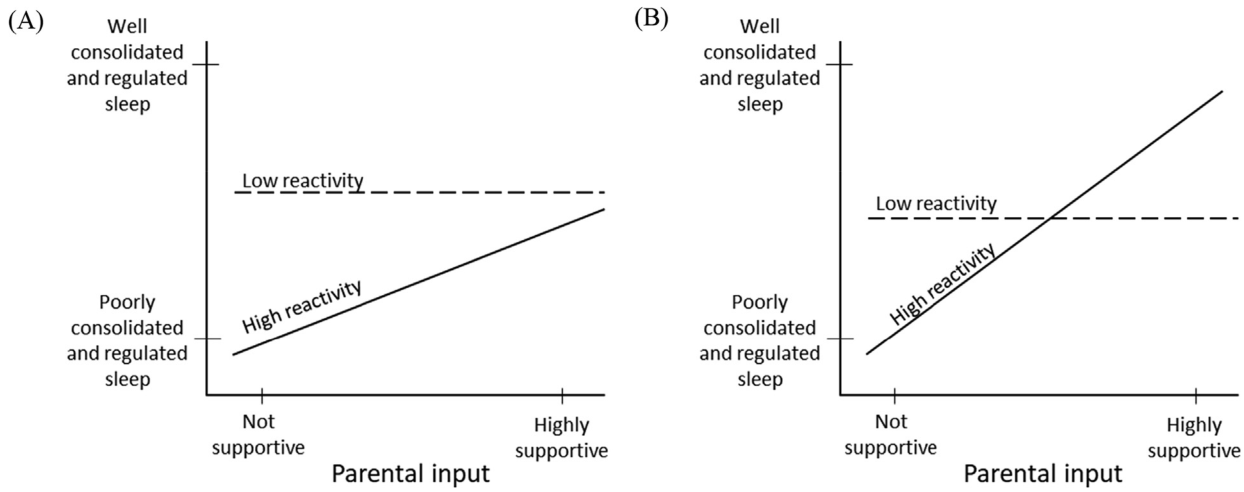

Fig. 2. Theoretical models describe the ways in which infant reactivity interacts with parental input to predict consolidated and regulated sleep. (A) Diathesis-stress (Monroe & Simons, 1991) predicts that highly reactive infants will have the worst sleep outcomes when parents are non-supportive of sleep, whereas (B) differential susceptibility (Belsky & Pluess, 2009) and biological sensitivity to context (Boyce & Ellis, 2005) hypothesize that, in the face of highly supportive parenting, highly reactive infants are expected to fare the best, whereas in the face of non-supportive parenting, highly reactive infants are expected to fare the worst.

Sleep as jointly influenced by intrinsic and extrinsic factors

The idea that intrinsic and extrinsic factors interact to predict child outcomes is strongly grounded in developmental theory. Two predominant models describe the mechanism by which person-environment interactions operate (Fig. 2). The diathesis-stress model (Monroe & Simons, 1991) indicates that individuals possessing certain risk factors are more susceptible to the negative effects of adverse environments (e.g., suboptimal parenting). Commonly investigated risk factors include indicators of high reactivity, such as negative emotionality. Based on the child characteristics we previously discussed, we might expect that reactive temperament and heightened ANS activity may serve as risk factors when considering infant sleep development. According to the diathesis-stress model, poor sleep outcomes would only result when children with these risk factors also experience suboptimal nighttime parenting behaviors, such as poor bedtime structuring or low emotional availability (Fig. 2A).

On the other hand, the biological sensitivity to context (BSC; Boyce & Ellis, 2005) and differential susceptibility (Belsky & Pluess, 2009) hypotheses propose that certain intrinsic characteristics make children more susceptible to both positive and negative environmental experiences. Child characteristics indicative of high reactivity are therefore susceptibility factors, rather than risk factors per se. In the face of negative environmental conditions, susceptible children are expected to fare the worst, while in the presence of supportive environmental conditions, these children are expected to fare the best. Thus, children possessing the intrinsic characteristics discussed previously (e.g., reactive temperament, heightened ANS activity) might have the best sleep outcomes when parents appropriately support consolidated and regulated sleep, but the worst outcomes when parents do not provide such support (Fig. 2B). Indeed, researchers have demonstrated that difficult temperament (Bates, Pettit, Dodge, & Ridge, 1998) and baseline RSA (Conradt, Measelle, & Ablow, 2013) modulate the effect of environmental input on other developmental outcomes, such as self-control and problem behavior.

Despite differences in whether child characteristics are viewed as risk or susceptibility factors, these theories lead to similar predictions: infants who are highly reactive may require more extensive and contingent parental input in order to develop consolidated and regulated sleep, as compared to less reactive infants. As of yet, only two studies have tested this hypothesis. Using objective measurement of infant sleep, Jian and Teti (2016) found that mothers' observed emotional availability (EA) interacted with infant surgency (characteristic of infants who are emotionally positive, physically active, easily excited, and likely to express approach tendencies) to predict nighttime sleep duration. Specifically, infants who were rated as highly surgent showed greater increases in nighttime sleep duration between 1 and 6 months when their mothers were rated as high on EA, compared to highly surgent infants whose mothers were low on EA. Thus, infants who are more active and excitable may require more responsive external regulation from caregivers in order to settle and stay asleep at night. These findings partially support differential susceptibility and BSC theories, in that highly reactive (i.e., surgent) infants who received highly sensitive nighttime parenting had the best outcomes. However, highly surgent infants who received less sensitive nighttime parenting did not necessarily fare worse than low surgency infants (Jian & Teti, 2016).

A second study examined the interaction between infant RSA and maternal depressive symptoms in predicting toddlers' sleep problems (Gueron-Sela et al., 2017). It is well-established that maternal depression interferes with infants' development of sleep regulation, as mothers who are depressed tend to have dysfunctional cognitions about infant sleep, and are more likely to intervene with infants during the night, even when intervention is not necessary (Teti & Crosby, 2012). However, this longitudinal study showed that the detrimental effects of maternal depression were particularly pronounced for children with high baseline RSA

(Gueron-Sela et al., 2017). That is, children with high baseline RSA had the highest levels of sleep problems when maternal depression was high, as compared to children with low baseline RSA. Again, these findings partially support differential susceptibility and BSC theories, because although infants with high baseline RSA showed more sleep problems when exposed to negative environmental conditions (i.e., high maternal depression), they did not necessarily show the best outcomes when exposed to positive environmental conditions (i.e., low maternal depression). However, the authors argue that the absence of maternal depression does not necessarily indicate a highly supportive environment. Therefore, findings may have been more fully in line with these theories had a broader index of nighttime caregiving (e.g., EA) been studied.

These two studies provide preliminary support for the hypothesis that infant characteristics and parental input jointly influence the development of consolidated and regulated sleep. However, it is difficult to draw conclusions on the basis of two studies alone. It remains unclear whether other infant characteristics, beyond temperament and RSA, interact with environmental input in similar ways. Additionally, only one of these studies examined interactive effects as early as the first six months of life (Jian & Teti, 2016), meaning we know very little about how these processes operate during a period of time that is characterized by rapid change in sleep patterns. There is clearly a need for more research investigating the interactions of child characteristics and parenting input that predict infant sleep development.

Sleep as an index of reactivity

Not only does the BSC theory make predictions about how infant characteristics interact with environmental input to predict developmental outcomes, it also goes further, to describe the environmental origins of individual differences in reactivity (Boyce & Ellis, 2005). According to the BSC theory, children's reactivity profiles represent evolutionary adaptations to anticipated developmental environments. Through early experiences with the environment (primarily via interactions with caregivers), children forecast and adapt to the type of environment they are likely to encounter throughout their development (Ellis & Boyce, 2008). In conditions that are either highly stressful or highly supportive, reactivity is up-regulated (Boyce & Ellis, 2005). In stressful environments, high reactivity enables children to remain vigilant to detect threats and avoid danger. In supportive environments, high reactivity enables children to reap the rewards of abundant resources. In environments that are less extreme (neither highly threatening nor supportive), reactivity is down-regulated to buffer individuals from chronic, moderate-level stressors. Thus, BSC posits a U-shaped relationship between environmental quality and reactivity (Boyce & Ellis, 2005).

Of course, environmental influences are not the sole contributor to individual differences in reactivity. Rather, there are likely genetic and physiological contributors that predispose or constrain an individual's phenotype within a certain range or around a predetermined 'set point' (Boyce & Ellis, 2005; Ellis & Boyce, 2008). These intrinsic (and possibly inherited) differences are expected to preserve variability in reactivity profiles, even when environments are homogeneous. Therefore, intrinsic characteristics of children continue to be important influences at all points in development.

While BSC attempts to explain both the causes and consequences of individual differences in reactivity, this theory tends to consider stress reactivity specifically (i.e., pertaining to functioning of the autonomic and adrenocortical systems). However, we might also consider infant sleep consolidation and regulation as additional manifestations of physiological reactivity that may operate in similar ways as stress reactivity. For example, BSC would hypothesize that early experience with both highly stressful and highly supportive environments would up-regulate reactivity, defined here by poorer sleep consolidation and regulation. Indeed, research shows that environments that are stressful, such as those characterized by low maternal EA (e.g., low sensitivity, high intrusiveness, high hostility), are associated with poorer infant sleep quality (Teti et al., 2010). Although not concerning parenting per se, high levels of family stress (Richman, 1981), and household (El-Sheikh, Bagley, et al., 2013; Gellis, 2011) and neighborhood deprivation (Bagley, Fuller-Rowell, Saini, Philbrook, & El-Sheikh, 2016; Grimes et al., 2018) are also associated with poor sleep consolidation and regulation. These alterations could be adaptive in dangerous environments, as sleeping in shorter continuous bouts and signaling for parental intervention might allow the infant additional opportunities to ensure that his/her sleep environment is safe.

Regarding the highly supportive end of the spectrum, research shows that when parents are extremely involved in infant's nighttime sleep, either through increased parental presence at bedtime (Adair et al., 1991), more active nighttime interventions (Morrell & Cortina-Borja, 2002), or more interventions to non-distressed or asleep states (Voltaire & Teti, 2018), poor sleep (i.e., high reactivity) also results. These sub-optimal sleep patterns may result from the infant being unable to separate his/herself from supportive caregivers and the opportunities for stimulation and care that they provide. However, these findings also raise an important question regarding what conditions BSC would define as being highly supportive. In the domain of sleep, a highly 'supportive' environment might be better characterized as parental over-involvement or enmeshment, which subverts infants' ability to develop self-regulated, consolidated sleep. Therefore, it may be more appropriate to consider parental under- and over-involvement as the endpoints of the environmental quality spectrum that Boyce and Ellis propose, rather than low and high supportiveness, at least in the context of infant sleep. This reframing would suggest that conditions of parental under- and over-involvement lead to the worst infant sleep outcomes, whereas appropriate levels of involvement (described in the section on defining competent parenting) lead to the best sleep outcomes. Whether this broad reconceptualization of BSC could apply to other domains of infant behavior remains to be seen.

Sleep as a moderator of environmental experience

The second part of the BSC theory concerns the ways in which individual reactivity interacts with environmental input to predict developmental outcomes. Previously, we discussed this theory in relation to the interactions of intrinsic infant characteristics and caregiver behaviors that predict infant sleep consolidation and regulation. However, continuing with our consideration of infant sleep as an index of reactivity itself, we can also apply this portion of BSC to understand how infant sleep may predict downstream outcomes in multiple domains.

According to BSC, individuals who are highly reactive are more susceptible to environmental influence, compared to individuals who display more moderate reactivity. Extending this hypothesis to sleep, we might expect that infants with poorly consolidated and/or regulated sleep may be more influenced by environmental conditions than infants with better quality sleep. Research testing this hypothesis has the ability to expand the current state of knowledge concerning the role of sleep in other developmental processes, an area of research that is beginning to gain momentum.

For example, research demonstrates that sleep is implicated in both cognitive and socio-emotional development (for a review, see Sadeh, 2007). While the majority of this research is correlational, studies using sleep restriction and extension paradigms provide initial evidence that these relationships may be causal (Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012; Sadeh et al., 2003). Generally, findings indicate that infants and children with poor sleep are more likely to suffer delays or deficits in cognition (e.g., Bernier, Beauchamp, Bouvette-Turcot, Carlson, & Carrier, 2013; Bernier, Carlson, Bordeleau, et al., 2010; Sadeh et al., 2003), and are at increased risk for a variety of behavioral problems including internalizing and externalizing disorders (e.g., Aronen, Paavonen, Fjällberg, Soininen, & Törrönen, 2000; Chorney, Detweiler, Morris, & Kuhn, 2008). These findings are consistent with the idea of a developmental cascade (e.g., Masten & Cicchetti, 2010), where functioning in an earlier-developing domain (i.e., sleep) has spillover effects in later-emerging domains (i.e., cognition, emotion). However, a number of researchers have failed to find a relationship between sleep and these outcomes (e.g., Mäkelä et al., 2018; Mindell & Lee, 2015). We propose that one possible reason for these conflicting findings may be that previous studies have tended to solely consider main effects of sleep. Very few have examined the ways in which children's sleep and environmental experiences interact to predict downstream outcomes.

A handful of studies have explored the ways in which children's sleep interacts with socioeconomic conditions (Buckhalt, El-Sheikh, Keller, & Kelly, 2009; El-Sheikh, Buckhalt, Keller, Cummings, & Acebo, 2007) and family functioning (El-Sheikh, Hinnant, Kelly, & Erath, 2010) to predict child adaptation or maladaptation. For example, several studies showed that when school-age children had longer sleep duration or better sleep quality, there were few SES-related differences in cognitive ability. However, when children had poorer sleep, children with high SES exhibit better cognitive ability than children with low SES (Buckhalt et al., 2009; Buckhalt, Mona El-Sheikh, & Peggy Keller, 2007). Similarly, higher maternal psychological control predicted increased risk of internalizing symptoms in third-graders, but only when children's sleep efficiency was low (El-Sheikh et al., 2010). These studies have begun to draw attention to the potential role of sleep as an index of reactivity that modulates children's susceptibility to both positive and negative environmental influences.

Studies with younger children have shown the opposite direction of effects, such that infants with better sleep disproportionately reap the benefits of enriched environments. For example, one study showed that infants with better sleep quality benefitted from high levels of maternal sensitivity in the prediction of cognitive and socioemotional functioning, whereas children with worse quality sleep were not influenced by variations in maternal sensitivity (Bernier, Bélanger, Tarabulsy, Simard, & Carrier, 2014). In another study, maternal sensitivity was negatively associated with preschoolers' internalizing and externalizing problems, but only when children had longer nighttime sleep duration (Bordeleau, Bernier, & Carrier, 2012b). These findings are both consistent with vantage sensitivity (Pluess & Belsky, 2013), with infant sleep constituting an endogenous factor that increases the positive benefit of enriched environments.

Clearly, more work needs to be done to explore the role of sleep in developmental processes. Depending on the process and time period under investigation, sleep may either have a direct effect on outcomes, or serve as a susceptibility, vulnerability, or protective factor that modulates the effect of environmental experience on development.

Sleep as a developmental cascade

So far in this section, we have described a novel, developmentally-informed approach to studying infant sleep, one that seeks to uncover the transactions among child characteristics and parenting behaviors that set infants on different trajectories of sleep development. Fig. 3 visually summarizes this transactional approach to studying infant sleep. For example, the figure shows how early caregiving quality and intrinsic infant factors jointly influence patterns of reactivity (red arrows). Reactivity in turn may directly impact caregiving quality and sleep development (solid green arrows) or may moderate the impact of caregiving on sleep (dotted green arrow). Interactions become more complex later in development, as infant sleep quality and reactivity influence one another, influence caregiving quality, and moderate the impact of caregiving quality on later sleep, cognitive, and socioemotional development (blue arrows). Interactions between intrinsic and extrinsic factors (dotted arrows) may operate via patterns consistent with diathesis-stress (Monroe & Simons, 1991), BSC (Boyce & Ellis, 2005) and/or differential susceptibility (Belsky & Pluess, 2009) theories, as described earlier.

One implication of this developmental approach is that it is critical to understand parent-child interactions centered around sleep, because these interactions may initiate a developmental cascade leading to different pathways of child adaptation or maladaptation. Cascade models describe how the early determinants of behaviors within a domain may have spreading, or 'snowballing' effects on downstream developmental processes (Cox, Mills-Koonce, Propper, & Gariépy, 2010; Masten & Cicchetti, 2010). Fig. 3 is therefore also an example of a cascade model, showing how transactions between infants and caregivers early in the first year of life set the stage for later development across a wide array of domains (e.g., sleep, cognition).

To illustrate this point, consider some infants who are born predisposed to better consolidated and/or regulated sleep, perhaps

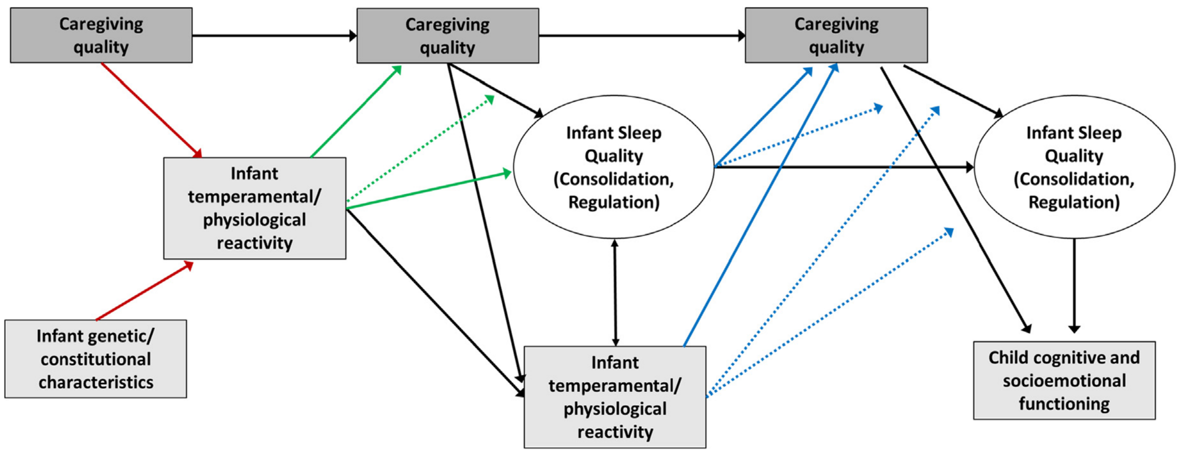

Fig. 3. A developmentally-informed, transactional model for studying infant sleep. Genetic/constitutional and caregiving influences early in life have organizational influences on infant reactivity (red arrows). As development proceeds, temperamental and physiological reactivity impact quality of care but also moderate the impact of caregiving on infant sleep (green arrows), Inter-connections become more complex with further development: Infant sleep quality and temperamental/physiological reactivity can impact caregiving quality directly; infant reactivity continues to moderate linkages between caregiving quality and infant sleep; and both infant sleep and reactivity can moderate the link between caregiving quality and socioemotional and cognitive functioning (blue arrows). Solid lines represent direct (i.e., main) effects, whereas dotted lines represent interactive (i.e., moderation) effects. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

because they are temperamentally or physiologically less reactive. We would expect it to be less challenging for parents to provide appropriate nighttime care for these infants. The nighttime parenting these infants receive further supports their sleep development. In turn, these less reactive, better sleeping infants may elicit or be better equipped for daytime interactions with caregivers that foster cognitive and socioemotional development. For example, infants who are easier to soothe and more receptive to parental attempts at cognitive stimulation might be expected to make larger gains in emotion regulation and cognition, respectively (e.g., Belsky, 1984; Bornstein, 2016). Thus, patterns of harmonious, sensitive parent-child interactions set up in the context of nighttime sleep may spill over into the daytime context, leading to more positive outcomes across many domains.

On the other hand, some infants may be predisposed to poorer consolidated and/or regulated sleep from birth, meaning that nighttime parenting presents more challenges. Some parents may respond to this challenge with emotionally available, sensitive caregiving (as described in our section on competent nighttime parenting) which promotes sleep development and leads to positive adaptation in other domains. These infants would be indistinguishable from their counterparts, described in the above example, who were predisposed to be better sleepers.

Other parents may be more poorly equipped to deal with the challenges of nighttime parenting presented by highly reactive infants, leading to parental behaviors that could be characterized as either under- or over-involved. In turn, these parents may exacerbate infant sleep difficulties. In the daytime context, sleepy infants and parents may be less likely to engage in high-quality, sensitive interactions (Bell & Belsky, 2008; Philbrook & Teti, 2016), leading to cascading negative effects across developmental domains. On the other hand, even if daytime parenting was not compromised, some studies show that sleepy infants are less likely to take advantage of enriched daytime environments (Bernier, Bélanger, et al., 2014). Thus, there are multiple pathways to adaptation or maladaptation for infants who differ in levels of reactivity. Understanding parental or family characteristics that support or undermine sensitive nighttime caregiving, especially among parents of difficult sleepers, may be an important future direction.

Conclusion

Throughout the first two years of life, children's sleep patterns change dramatically. The goal of this review has been to describe these changes in terms of the underlying biopsychosocial processes of sleep consolidation and regulation and to provide a new framework for studying the causes and consequences of individual differences in infant sleep development. Applying our transactional, developmentally-informed model to the study of infant sleep has the potential to generate many novel directions for future research. At the same time, practical and empirical challenges remain to be addressed.

Practically, there is a need for greater collaboration among scholars who study sleep from different perspectives. Currently, parallel lines of work are investigating overlapping sets of questions pertaining to sleep within the fields of psychology, medicine, anthropology, sociology, and public health. The guiding principles, theories, and methodologies within these diverse fields are likely to be complementary, rather than antagonistic. On the other hand, areas of disagreement are useful in that they offer competing hypotheses which can be empirically tested. Thus, collaboration between scholars who study sleep from different perspectives will likely result in a richer understanding of the phenomenon of early sleep development (Bernier, Matte-Gagné, et al., 2014). As demonstrated in this review, developmental psychology offers multiple theories and perspectives that have the potential to generate unique hypotheses about parenting, sleep, and cognitive and socioemotional development.

Empirically, there are multiple issues which may further contribute to a lack of cohesion among sleep researchers. One of the main areas of difficulty is the lack of consistent operational definitions of key constructs, partly due to differences in sleep assessment methods. Current methods for measuring sleep in young children include actigraphy, parent-report questionnaires, polysomnography, and videosomnography (for a review, see Sadeh, 2015). With the exception of polysomnography, all of these methods can be conducted non-intrusively in the home environment. However, each method contains its own idiosyncrasies that may contribute to findings that are not directly comparable across studies. Several recent studies comparing multiple methods of sleep assessment have begun to shed light on the magnitude of discrepancies between these measures (Camerota, Tully, Grimes, Gueron-Sela, & Propper, 2018; Tikotzky & Volkovich, 2018), concluding that different methods cannot be used interchangeably.

With all of the methodologies available to researchers, we are troubled by an overreliance in the literature on parent-report measures, such as sleep diaries. Of the studies reviewed in this manuscript, over 40% rely solely on parents' reports of sleep (Table 1). Although quick and easy to use, and reliable for certain measures such as sleep schedule (Sadeh, 1994), the data collected from parent-report measures are best described as parent's *perceptions* of their children's sleep. In some cases, parental perceptions of child sleep are useful, such as when testing the relationship between infant sleep and parent outcomes (e.g., parents' own sleep quality), or when studying phenomena such as children's signaled night wakings. However, solely using parent-report measures may be problematic for other research aims, such as investigating the effect of parenting on children sleep. For one, parent's ratings of their children are known to be influenced by parents' own characteristics, including symptoms of psychopathology and parenting stress (e.g., De Los Reyes & Kazdin, 2005). As these same characteristics are likely to influence parents' ability to provide contingent nighttime care, we may be overestimating the effect of parenting on children's sleep when we rely on parent-report measures of our outcomes. Further, for research focusing on infant's overall number of night wakings (both signaled and not signaled) or their longest sleep period, objective measurement of infant sleep is needed to provide an accurate overall assessment.

Within the same sleep assessment method, differences in equipment (e.g., different actigraphy devices; Meltzer, Walsh, Traylor, & Westin, 2012) and data processing (e.g., different actigraphy algorithms; So, Adamson, & Horne, 2007) may lead to results that are not directly comparable across studies. While we would expect directions of effects to be consistent across studies, descriptive statistics and magnitudes of effects may differ based on scoring algorithm and device brand used. Recently, attempts have been made to increase agreement between different scoring algorithms (Schoch, Jenni, Kohler, & Kurth, 2019), a promising direction for promoting consistency across studies. However, clear and detailed reporting of device and scoring decisions remains essential.

Beyond differences in operational definitions, existing studies have tended to cherry-pick individual sleep variables for entry into analyses, often without a-priori justification. As a result, it can be difficult to synthesize across studies using different variables. The dual-process model of consolidation and regulation that we rely on in this review has the ability to bring consistency and clarity to the literature regarding which sleep variables are indicative of which underlying processes. Tests of the dual-process model might use factor analytic approaches to determine whether hypothesized indicators of sleep consolidation (e.g., LSP, NSR) and regulation (e.g., self-soothed wakings, parental interventions) load onto empirically separable latent constructs. A recent study with toddlers used principal components analysis to reduce a large number of actigraphy variables into four construct scores (i.e., sleep activity, duration, variability, and timing; Hoyniak et al., 2018), demonstrating the utility of such an approach.

In addition, future research should utilize methods that tap other levels of analysis, to better understand possible intrinsic and extrinsic factors related to infant sleep. For example, adult and animal studies indicate that certain sleep disorders may have genetic underpinnings (e.g., Sehgal & Mignot, 2011). Assessing individual differences in sleep as a function of genetic or epigenetic profiles may lead to the discovery of further intrinsic infant characteristics that either directly or interactively predict differences in sleep development. On the extrinsic side, distal environmental factors contribute to infant sleep, mediated by nighttime parenting or other pathways. For example, parental cognitions (e.g., Tikotzky & Sadeh, 2009), psychopathology (e.g., Teti & Crosby, 2012), and co-parenting quality (Teti, Crosby, McDaniel, Shimizu, & Whitesell, 2015) have been shown to contribute to nighttime parenting and infant sleep. Environmental factors such as infant sleep location (e.g., Mileva-Seitz, Bakermans-Kranenburg, Battaini, & Luijk, 2017) and ambient home conditions (e.g., temperature, noise; Franco et al., 2001) have also been examined. Integrating distal and proximal factors into the same study may yield novel insights into the multiple mechanisms by which the environment impacts sleep.

Ultimately, none of these questions can be answered without the use of well-controlled, longitudinal research designs assessing multiple levels of parent and child characteristics. Thus far, we are unable to make causal inferences about the role of intrinsic and extrinsic factors in shaping sleep development because existing studies have either not included repeated measures of key constructs or have not appropriately controlled for various confounding variables. Whereas longitudinal studies are one way to begin to establish causality, experimental manipulation is another strategy. As of now, the majority of experimental research has examined the effect of different sleep training techniques on infant sleep outcomes (e.g., Gradisar et al., 2016). Intervention studies that attempt to manipulate other aspects of nighttime parenting behavior (e.g., training emotional availability) may also prove useful in determining whether there are causal effects of parenting practices on child sleep outcomes. Additionally, by further examining child characteristics that serve as susceptibility factors, we can identify the children who are most likely to benefit from such interventions.

Although much work has been done in the area of infant sleep over the past few decades, we have still only scratched the surface in terms of understanding the complex interrelations among parenting, child characteristics, and sleep in the early years of life. Moving towards developmentally-informed, interactive models of infant sleep development promises to increase our knowledge base, inspire novel research studies, and spawn innovative clinical interventions.

A developmentally-informed approach may also prove practically useful for parents and practitioners. Specifically, viewing specific infant sleep patterns as an indicator of sensitivity or susceptibility to environmental conditions, rather than as a risk factor or pathology, may help reduce the stigma and stress that parents face when they have a child who does not sleep well. BSC hypothesizes that differences in reactivity represent adaptations to environmental conditions, rather than individual characteristics that are inherently risky or protective. Further, there are multiple pathways by which children with different sleep patterns can flourish.

Our conceptualization of competent nighttime parenting as a dynamic, dyadic construct may also help the field move away from 'one size fits all' advice towards more individualized recommendations for promoting infant sleep. Different children are likely to develop consolidated and regulated sleep at different rates, and different nighttime parenting strategies are likely to be more appropriate at different points in time, or with different types of infants (e.g., surgent versus negative temperament; physiologically reactive versus well-regulated). Providing parents with developmentally-informed, age-appropriate guidance on how to support their infant's sleep is likely to lead to better sleep for children and parents, as well as better parental mental health and family functioning (e.g., Bayer, Hiscock, Hampton, & Wake, 2007), which in turn further supports optimal infant development. Thus, moving forward, it will be important not only to continue basic scientific inquiries regarding infant sleep development, but also to seek further opportunities for translational research that may help families navigate this challenging area.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

None.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dr.2019.100871.

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A., & Carskadon, M. A. (2005). Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. *Sleep, 28*, 1568–1577.

Adair, R., Bauchner, H., Philipp, B., Levenson, S., & Zuckerman, B. (1991). Night waking during infancy: Role of parental presence at bedtime. *Pediatrics, 87*(4), 500–504. https://doi.org/10.1037/a0024694.

Alink, L. R. A., van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., Mesman, J., Juffer, F., & Koot, H. M. (2008). Cortisol and externalizing behavior in children and adolescents: Mixed meta-analytic evidence for the inverse relation of basal cortisol and cortisol reactivity with externalizing behavior. *Developmental Psychobiology, 50*(5), 427–450. https://doi.org/10.1002/dev.20300.

Alkon, A., Boyce, W. T., Neilands, T. B., & Eskenazi, B. (2017). Children's autonomic nervous system reactivity moderates the relations between family adversity and sleep problems in latino 5-year olds in the CHAMACOS Study. *Frontiers in Public Health, 5*(June), 1–11. https://doi.org/10.3389/fpubh.2017.00155.

Anders, T. F., Halpern, L. F., & Hua, J. (1992). Sleeping through the night: A developmental perspective. *Pediatrics, 90*, 554–560.

Anders, T. F., & Keener, M. (1985). Developmental course of nighttime sleep-wake patterns in full-term and premature infants during the first year of life. *Sleep, 8*(3), 173–192.

Aronen, E. T., Paavonen, E. J., Fjällberg, M., Soininen, M., & Törrönen, J. (2000). Sleep and psychiatric symptoms in school-age children. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(4), 502–508. https://doi.org/10.1097/00004583-200004000-00020.

Bagley, E. J., Fuller-Rowell, T. E., Saini, E. K., Philbrook, L. E., & El-Sheikh, M. (2016). Neighborhood economic deprivation and social fragmentation: associations with children's sleep. *Behavioral Sleep Medicine, 00*(00), 1–13. https://doi.org/10.1080/15402002.2016.1253011.

Bates, J. E., Pettit, G. S., Dodge, K. A., & Ridge, B. (1998). Interaction of temperamental resistance to control and restrictive parenting in the development of externalizing behavior. *Developmental Psychology, 34*(5), 982–995. https://doi.org/10.1037/0012-1649.34.5.982.

Bayer, J. K., Hiscock, H., Hampton, A., & Wake, M. (2007). Sleep problems in young infants and maternal mental and physical health. *Journal of Paediatrics and Child Health, 43*, 66–73. https://doi.org/10.1111/j.1440-1754.2007.01005.x.

Bell, B. G., & Belsky, J. (2008). Parents, parenting, and children's sleep problems: Exploring reciprocal effects. *British Journal of Developmental Psychology, 26*(4), 579–593. https://doi.org/10.1348/026151008X285651.

Belsky, J. (1984). The determinants of parenting: A process model. *Child Development, 55*(1), 83–96.

Belsky, J., & Pluess, M. (2009). Beyond diathesis stress: Differential susceptibility to environmental influences. *Psychological Bulletin, 135*(6), 885–908. https://doi.org/10.1037/a0017376.

Bernier, A., Beauchamp, M. H., Bouvette-Turcot, A. A., Carlson, S. M., & Carrier, J. (2013). Sleep and cognition in preschool years: Specific links to executive functioning. *Child Development, 84*(5), 1542–1553. https://doi.org/10.1111/cdev.12063.

Bernier, A., Bélanger, M.È., Tarabulsy, G. M., Simard, V., & Carrier, J. (2014). My mother is sensitive, but I am too tired to know: Infant sleep as a moderator of prospective relations between maternal sensitivity and infant outcomes. *Infant Behavior and Development, 37*(4), 682–694. https://doi.org/10.1016/j.infbeh.2014.08.011.

Bernier, A., Carlson, S. M., Bordeleau, S., & Carrier, J. (2010). Relations between physiological and cognitive regulatory systems: Infant sleep regulation and subsequent executive functioning. *Child Development, 81*(6), 1739–1752. https://doi.org/10.1111/j.1467-8624.2010.01507.x.

Bernier, A., Carlson, S. M., & Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development, 81*(1), 326–339. https://doi.org/10.1111/j.1467-8624.2009.01397.x.

Bernier, A., Matte-Gagné, C., & Bouvette-Turcot, A. A. (2014). Examining the interface of children's sleep, executive functioning, and caregiving relationships: A plea against silos in the study of biology, cognition, and relationships. *Current Directions in Psychological Science, 23*(4), 284–289. https://doi.org/10.1177/0963721414534852.

Bordeleau, S., Bernier, A., & Carrier, J. (2012a). Longitudinal associations between the quality of parent-child interactions and children's sleep at preschool age. *Journal of Family Psychology, 26*(2), 254–262. https://doi.org/10.1037/a0027366.

Bordeleau, S., Bernier, A., & Carrier, J. (2012b). Maternal sensitivity and children's behavior problems: Examining the moderating role of infant sleep duration. *Journal of Clinical Child and Adolescent Psychology, 41*(4), 471–481. https://doi.org/10.1080/15374416.2012.686101.

Bornstein, M. H. (2016). Determinants of parenting. In D. Cicchetti (Ed.). *Developmental Psychopathology (Third Edit)*. Hoboken, NJ: John Wiley & Sons Inc.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*. https://doi.org/10.1017/S0954579405050145.

Bright, M. A., Frick, J. E., Out, D., & Granger, D. A. (2014). Individual differences in the cortisol and salivary α-amylase awakening responses in early childhood:

Relations to age, sex, and sleep. *Developmental Psychobiology, 56*(6), n/a-n/a. https://doi.org/10.1002/dev.21209.
Buckhalt, J. A., El-Sheikh, M., Keller, P. S., & Kelly, R. J. (2009). Concurrent and longitudinal relations between children's sleep and cognitive functioning: The moderating role of parent education. *Child Development, 80*(3), 875–892.
Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2002). Nighttime sleep-wake patterns and self-soothing from birth to one year of age: A longitudinal intervention study. *Journal of Child Psychology and Psychiatry, 43*(6), 713–725.
Camerota, M., Tully, K. P., Grimes, M., Gueron-Sela, N., & Propper, C. B. (2018). Assessment of infant sleep: How well do multiple methods compare? *Sleep,* (August), 1–12. https://doi.org/10.1093/sleep/zsy146.
Chorney, D. B., Detweiler, M. F., Morris, T. L., & Kuhn, B. R. (2008). The interplay of sleep disturbance, anxiety, and depression in children. *Journal of Pediatric Psychology, 33*(4), 339–348. https://doi.org/10.1093/jpepsy/jsm105.
Clow, A., Hucklebridge, F., Stalder, T., Evans, P., & Thorn, L. (2010). The cortisol awakening response: More than a measure of HPA axis function. *Neuroscience and Biobehavioral Reviews. Pergamon.*. https://doi.org/10.1016/j.neubiorev.2009.12.011.
Conradt, E., Measelle, J., & Ablow, J. C. (2013). Poverty, problem behavior, and promise: Differential susceptibility among infants reared in poverty. *Psychological Science, 24*(3), 235–242. https://doi.org/10.1177/0956797612457381.
Cox, M. J., Mills-Koonce, R., Propper, C., & Garié Py, J.-L. (2010). Systems theory and cascades in developmental psychopathology. *Development and Psychopathology, 22*, 497–506. https://doi.org/10.1017/S0954579410000234.
Dahl, R. E. (1996). The regulation of sleep and arousal: Development and psychopathology. *Development and Psychopathology, 8*, 3–27.
Darling, N., & Steinberg, L. (1993). Parenting style as context: An integrative model. *Psychological Bulletin, 113*(3), 487–496. https://doi.org/10.1037/0033-2909.113.3.487.
De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin, 131*(4), 483–509. https://doi.org/10.1037/0033-2909.131.4.483.
de Roquefeuil, G., Djakovic, M., & Montagner, H. (1993). New data on the ontogeny of the child's sleep-wake rhythm. *Chronobiology International, 10*(1), 43–53. https://doi.org/10.3109/07420529309064481.
Dearing, E., Mccartney, K., Marshall, N. L., & Warner, R. M. (2001). Parental reports of children's sleep and wakefulness: Longitudinal associations with cognitive and language outcomes. *Infant Behavior and Development, 24*(2), 151–170. https://doi.org/10.1016/S0163-6383(01)00074-1.
DeLeon, C. W., & Karraker, K. H. (2007). Intrinsic and extrinsic factors associated with night waking in 9-month-old infants. *Infant Behavior and Development, 30*(4), 596–605. https://doi.org/10.1016/j.infbeh.2007.03.009.
Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews, 14*, 179–189. https://doi.org/10.1016/j.smrv.2009.10.004.
El-Sheikh, M., Bagley, E. J., Keiley, M., Elmore-Staton, L., Chen, E., & Buckhalt, J.a. (2013). Economic adversity and children's sleep problems: Multiple indicators and moderation of effects. *Health Psychology, 32*(8), 849–859. https://doi.org/10.1037/a0030413.
El-Sheikh, M., & Buckhalt, J. A. (2005). Vagal regulation and emotional intensity predict children's sleep problems. *Developmental Psychobiology, 46*(4), 307–317. https://doi.org/10.1002/dev.20066.
El-Sheikh, M., Buckhalt, J. A., Keller, P. S., Cummings, E. M., & Acebo, C. (2007). Child emotional insecurity and academic achievement: The role of sleep disruptions. *Journal of Family Psychology, 21*(1), 29–38. https://doi.org/10.1037/0893-3200.21.1.29.
El-Sheikh, M., Buckhalt, J. A., Keller, P. S., & Granger, D. A. (2008). Children's objective and subjective sleep disruptions: links with afternoon cortisol levels. *Health Psychology, 27*(1), 26–33. https://doi.org/10.1037/0278-6133.27.1.26.
El-Sheikh, M., Erath, S. A., & Bagley, E. J. (2013). Parasympathetic nervous system activity and children's sleep. *Journal of Sleep Research, 22*(3), 282–288. https://doi.org/10.1111/jsr.12019.
El-Sheikh, M., Hinnant, J. B., Kelly, R. J., & Erath, S. (2010). Maternal psychological control and child internalizing symptoms: Vulnerability and protective factors across bioregulatory and ecological domains. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 51*(2), 188–198. https://doi.org/10.1111/j.1469-7610.2009.02140.x.
El-Sheikh, M., & Sadeh, A. (2015). Sleep and development: Introduction to the monograph. *Monographs of the Society for Research in Child Development, 80*(1), 1–14.
Ellis, B. J., & Boyce, W. T. (2008). Biological sensitivity to context. *Current Directions in Psychological Science, 17*(3), 183–187. https://doi.org/10.1111/j.1467-8721.2008.00571. = "http://dx.doi.org/10.1111/j.1467-8721.2008.00571.x.
Elmore-Staton, L., El-Sheikh, M., Vaughn, B., & Arsiwalla, D. D. (2012). Preschoolers' daytime respiratory sinus arrhythmia and nighttime sleep. *Physiology and Behavior, 107*(3), 414–417. https://doi.org/10.1016/j.physbeh.2012.07.005.
Erath, S. A., & Tu, K. M. (2011). The parenting context of children's sleep. In M. El-Sheikh (Ed.). *Sleep and development: Familial and socio-cultural considerations* (pp. 29–47). New York, NY: Oxford University Press. https://doi.org/10.1093/acprof.
Ferber, R. (2006). *Solve your child's sleep problems: New, revised, and expanded edition.* New York: Simon & Schuster.
Franco, P., Scaillet, S., Valente, F., Chabanski, S., Groswasser, J., & Kahn, A. (2001). Ambient temperature is associated with changes in infants' arousability from sleep. *Sleep, 24*(3), 325–329. https://doi.org/10.1093/sleep/24.3.325.
Galland, B. C., Taylor, B. J., Elder, D. E., & Herbison, P. (2012). June). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews.*. https://doi.org/10.1016/j.smrv.2011.06.001.
Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development, 26*(1), 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8.
Gellis, L. A. (2011). Children's sleep in the context of socioeconomic status, race, and ethnicity. In M. El-Sheikh (Ed.). *Sleep and development: Familial and socio-cultural considerations* (pp. 219–244). New York, NY: Oxford University Press.
Goodlin-Jones, B. L., Burnham, M. M., & Anders, T. F. (2001). Sleep and sleep disturbances: Regulatory processes in infancy. In A. J. Sameroff, M. Lewis, & S. M. Miller (Eds.). *Handbook of developmental psychopathology* (pp. 309–325). (2nd ed.). New York, NY: Kluwer Academic / Plenum Publishes.
Goodlin-Jones, B. L., Burnham, M. M., Gaylor, E. E., & Anders, T. F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental and Behavioral Pediatrics, 22*(4), 226–233.
Gradisar, M., Jackson, K., Spurrier, N. J., Gibson, J., Whitham, J., Williams, A. S., ... Kennaway, D. J. (2016). Behavioral interventions for infant sleep problems: A randomized controlled trial. *Pediatrics, 137*(6), e20151486.
Grimes, M., Camerota, M., & Propper, C. B. (2018). Neighborhood deprivation predicts infant sleep quality. *Sleep Health, 6–9*. https://doi.org/10.1016/j.sleh.2018.11.001.
Gruber, R., Cassoff, J., Frenette, S., Wiebe, S., & Carrier, J. (2012). Impact of sleep extension and restriction on children's emotional lability and impulsivity. *Pediatrics, 130*(5), 1155–1161.
Gueron-Sela, N., Propper, C. B., Wagner, N. J., Camerota, M., Tully, K. P., & Moore, G. A. (2017). Infant respiratory sinus arrhythmia and maternal depressive symptoms predict toddler sleep problems. *Developmental Psychobiology, 59*, 261–267. https://doi.org/10.1002/dev.21480.
Halpern, L. F., Anders, T. F., Coll, C. G., & Hua, J. (1994). Infant temperament: Is there a relation to sleep-wake states and maternal nighttime behavior? *Infant Behavior and Development, 17*, 255–263.
Hatzinger, M., Brand, S., Perren, S., Stadelmann, S., Wyl, A. Von, Klitzing, K. Von, & Holsboer-Trachsler, E. (2010). Sleep actigraphy pattern and behavioral/emotional difficulties in kindergarten children: Association with hypothalamic-pituitary-adrenocortical (HPA) activity. *Journal of Psychiatric Research, 44*(4), 253–261. https://doi.org/10.1016/j.jpsychires.2009.08.012.
Henderson, J. M. T., France, K. G., & Blampied, N. M. (2011). The consolidation of infants nocturnal sleep across the first year of life. *Sleep Medicine Reviews, 15*(4), 211–220. https://doi.org/10.1016/j.smrv.2010.08.003.
Henderson, J. M. T., France, K. G., Owens, J. L., & Blampied, N. M. (2010). Sleeping through the night: The consolidation of self-regulated sleep across the first year of life. *Pediatrics, 126*(5), e1081–e1087. https://doi.org/10.1542/peds.2010-0976.
Hoppenbrouwers, T., Hodgman, J., Arakawa, K., Geidel, S. A., & Sterman, M. B. (1988). Sleep and waking states in infancy: Normative studies. *Sleep, 11*(4), 387–401.

Hoyniak, C. P., Bates, J. E., Staples, A. D., Rudasill, K. M., Molfese, D. L., & Molfese, V. J. (2018). Child sleep and socioeconomic context in the development of cognitive abilities in early childhood. *Child Development, 00*, 1–20. https://doi.org/10.1111/cdev.13042.

Iglowstein, I., Jenni, O. G., Molinari, L., & Largo, R. H. (2003). Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics, 111*(2), 302–307.

Insana, S. P., Gozal, D., & Montgomery-Downs, H. E. (2010). Invalidity of one actigraphy brand for identifying sleep and wake among infants. *Sleep Medicine, 11*(2), 191–196. https://doi.org/10.1016/j.sleep.2009.08.010.

Jenni, O. G., & Lebourgeois, M. K. (2006). NIH public access. *Current Opinion in Psychiatry, 19*(3), 282–287. https://doi.org/10.1111/j.1743-6109.2008.01122.x.Endothelial.

Jian, N., & Teti, D. M. (2016). Emotional availability at bedtime, infant temperament, and infant sleep development from 1 to 6 months. *Sleep Medicine, 23*, 49–58. https://doi.org/10.1517/17425247.2014.897693.Drug.

Buckhalt, J. A., El-Sheikh1, M., & Keller, P. (2007). Children's sleep and cognitive functioning: race and socioeconomic status as moderators of effects. Retrieved from *Child Development, 78*(1), 213–231. <http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8624.2007.00993.x/full>.

Keener, M. A., Zeanah, C. H., & Anders, T. F. (1988). Infant temperament, sleep organization, and nighttime parental interventions. Retrieved from *Pediatrics, 81*(6), 762–771. <http://www.ncbi.nlm.nih.gov/pubmed/3368275>.

Mäkelä, T. E., Peltola, M. J., Nieminen, P., Juulia Paavonen, E., Saarenpää-Heikkilä, O., Paunio, T., & Kylliäinen, A. (2018). Night awakening in infancy: Developmental stability and longitudinal associations with psychomotor development. *Developmental Psychology, 54*(7), 1208–1218. https://doi.org/10.1037/dev0000503.

Masten, A. S., & Cicchetti, D. (2010). Developmental cascades. *Development and Psychopathology, 22*(03), 491–495. https://doi.org/10.1017/S0954579410000222.

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews, 16*. https://doi.org/10.1016/j.smrv.2011.10.002.

Meltzer, L. J., Walsh, C. M., Traylor, J., & Westin, A. M. L. (2012). Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep, 35*(1), 159–166. https://doi.org/10.5665/sleep.1608.

Mileva-Seitz, V. R., Bakermans-Kranenburg, M. J., Battaini, C., & Luijk, M. P. C. M. (2017). Parent-child bed-sharing: The good, the bad, and the burden of evidence. *Sleep Medicine Reviews, 32*, 4–27. https://doi.org/10.1016/j.smrv.2016.03.003.

Mindell, J. A., Du Mond, C. E., Sadeh, A., Telofski, L. S., Kulkarni, N., & Gunn, E. (2011). Long-term efficacy of an internet-based intervention for infant and toddler sleep disturbances: One year follow-up. *Journal of Clinical Sleep Medicine, 7*(5), 507–511. https://doi.org/10.5664/JCSM.1320.

Mindell, J. A., & Lee, C. (2015). Sleep, mood, and development in infants. *Infant Behavior and Development, 41*(July 2016), 102–107. https://doi.org/10.1016/j.infbeh.2015.08.004.

Mindell, J. A., Li, A. M., Sadeh, A., Kwon, R., & Goh, D. Y. T. (2015). Bedtime routines for young children: A dose-dependent association with sleep outcomes. *Sleep, 38*(5), 717–722. https://doi.org/10.5665/sleep.4662.

Mindell, J. A., & Owens, J. A. (2015). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (3rd ed.). Philadelphia, PA: Wolters Kluwer.

Mindell, J. A., Owens, J. A., & Carskadon, M. A. (1999). Developmental features of sleep. *Child and Adolescent Psychiatric Clinics of North America, 8*(4), 695–725.

Mindell, J. A., Sadeh, A., Kohyama, J., & How, T. H. (2010). Parental behaviors and sleep outcomes in infants and toddlers: A cross-cultural comparison. *Sleep Medicine, 11*(4), 393–399. https://doi.org/10.1016/j.sleep.2009.11.011.

Mindell, J. A., Telofski, L. S., Wiegand, B., & Kurtz, E. S. (2009). A nightly bedtime routine: Impact on sleep in young children and maternal mood. *Sleep, 32*(5), 599–606.

Monroe, S. M., & Simons, A. D. (1991). Diathesis-stress theories in the context of life stress research: Implications for the depressive disorders. *Psychological Bulletin, 110*(3), 406–425. https://doi.org/10.1037/0033-2909.110.3.406.

Morrell, J., & Cortina-Borja, M. (2002). The developmental change in strategies parents employ to settle young children to sleep, and their relationship to infant sleeping problems, as assessed by a new questionnaire: The Parental Interactive Bedtime Behaviour Scale. *Infant and Child Development, 11*(1), 17–41. https://doi.org/10.1002/icd.251.

Morrell, J., & Steele, H. (2003). The role of attachment security, temperament, maternal perception, and care-giving behavior in persistent infant sleeping problems. *Infant Mental Health Journal, 24*(5), 447–468. https://doi.org/10.1002/imhj.10072.

Pesonen, A.-K., Räikkönen, K., Matthews, K., Heinonen, K., Paavonen, J. E., Lahti, J., ... Strandberg, T. (2009). Prenatal origins of poor sleep in children. *Sleep, 32*(8), 1086–1092.

Philbrook, L. E., & Teti, D. M. (2016). Bidirectional associations between bedtime parenting and infant sleep: Parenting quality, parenting practices, and their interaction. *Journal of Family Psychology, 30*(4), 431–441. https://doi.org/10.1037/fam0000198.

Pluess, M., & Belsky, J. (2013). Vantage sensitivity: Individual differences in response to positive experiences. *Psychological Bulletin, 139*(4), 901–916. https://doi.org/10.1037/a0030196.

Porges, S. W. (1996). Physiological regulation in high-risk infants: A model for assessment and potential intervention. *Development and Psychopathology, 8*(1996), 43–58.

Priddis, L. E. (2009). Tuned in parenting and infant sleep patterns. *Early Child Development and Care, 179*(3), 259–269. https://doi.org/10.1080/03004430600912132.

Propper, Cathi B., & Holochwost, Steven J. (2013). The influence of proximal risk on the early development of the autonomic nervous system. *Developmental Review, 33*(3), 151–167. https://doi.org/10.1016/j.dr.2013.05.001.

Räikkönen, K., Matthews, K. A., Pesonen, A. K., Pyhälä, R., Paavonen, E. J., Feldt, K., ... Kajantie, E. (2010). Poor sleep and altered hypothalamic-pituitary-adrenocortical and sympatho-adrenal-medullary system activity in children. *Journal of Clinical Endocrinology and Metabolism, 95*(5), 2254–2261. https://doi.org/10.1210/jc.2009-0943.

Richman, N. (1981). A community survey of characteristics of one- to two-year-olds with sleep disruptions. *Journal of the American Academy of Child Psychiatry, 20*(2), 281–291. https://doi.org/10.1016/S0002-7138(09)60989-4.

Ruttle, P. L., Shirtcliff, E. A., Serbin, L. A., Ben-Dat Fisher, D., Stack, D. M., & Schwartzman, A. E. (2011). Disentangling psychobiological mechanisms underlying internalizing and externalizing behaviors in youth: Longitudinal and concurrent associations with cortisol. *Hormones and Behavior, 59*(1), 123–132. https://doi.org/10.1016/j.yhbeh.2010.10.015.

Sadeh, A. (1994). Assessment of intervention for infant night waking: Parental reports and activity-based home monitoring. *Journal of Consulting and Clinical Psychology, 62*(1), 63–68. https://doi.org/10.1037//0022-006X.62.1.63.

Sadeh, A. (2007). Consequences of sleep loss or sleep disruption in children. *Sleep Medicine Clinics, 2*(3), 513–520. https://doi.org/10.1016/j.jsmc.2007.05.012.

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development, 80*(1), 33–48. https://doi.org/10.1111/mono.12143.

Sadeh, A., & Anders, T. F. (1993). Infant sleep problems: Origins, assessment, interventions. *Infant Mental Health Journal, 14*(1), 17–34. https://doi.org/10.1002/1097-0355(199321)14:1<17::AID-IMHJ2280140103>3.0.CO;2-Q.

Sadeh, A., Flint-Ofir, E., Tirosh, T., & Tikotzky, L. (2007). Infant sleep and parental sleep-related cognitions. *Journal of Family Psychology, 21*(1), 74–87. https://doi.org/10.1037/0893-3200.21.1.74.

Sadeh, A., Gruber, R., & Raviv, A. (2003). The effects of sleep restriction and extension on school-age children: What a difference an hour makes. *Child Development, 74*(2), 444–455. https://doi.org/10.1111/1467-8624.7402008.

Sadeh, A., Mindell, J.a., Luedtke, K., & Wiegand, B. (2009). Sleep and sleep ecology in the first 3 years: A web-based study. *Journal of Sleep Research, 18*, 60–73. https://doi.org/10.1111/j.1365-2869.2008.00699.x.

Sadeh, A., Tikotzky, L., & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews, 14*(2), 89–96. https://doi.org/10.1016/j.smrv.2009.05.003.

Sameroff, A. (2010). A unified theory of development: A dialectical integration of nature and nurture. *Child Development, 81*(1), 6–22.

Scher, A. (2001). Mother-child interaction and sleep regulation in one-year-olds. *Infant Mental Health Journal, 22*(5), 515–528. https://doi.org/10.1002/imhj.1015.

Scher, A., Epstein, R., Sadeh, A., Tirosh, E., & Lavie, P. (1992). Toddlers' sleep and temperament: reporting bias or a valid link? A research note. *Journal of Child Psychology and Psychiatry, 33*(7), 1249–1254. https://doi.org/10.1111/j.1469-7610.1992.tb00943.x.

Scher, A., Epstein, R., & Tirosh, E. (2004). Stability and changes in sleep regulation: A longitudinal study from 3 months to 3 years. *International Journal of Behavioral Development, 28*(3), 268–274. https://doi.org/10.1080/01650250344000505.

Scher, A., Hall, W. A., Zaidman-Zait, A., & Weinberg, J. (2009). Sleep quality, cortisol levels, and behavioral regulation in toddlers. *Developmental Psychobiology, 52*(1), 44–53. https://doi.org/10.1002/dev.20410.

Schoch, S. F., Jenni, O. G., Kohler, M., & Kurth, S. (2019). Actimetry in infant sleep research: An approach to facilitate comparability. *Sleep, 1–9*. https://doi.org/10.1101/494427.

Sehgal, A., & Mignot, E. (2011). Genetics of sleep and sleep disorders. *Cell, 146*(2), 194–207. https://doi.org/10.1016/j.cell.2011.07.004.

Sheridan, A., Murray, L., Cooper, P. J., Evangeli, M., Byram, V., & Halligan, S. L. (2013). A longitudinal study of child sleep in high and low risk families: Relationship to early maternal settling strategies and child psychological functioning. *Sleep Medicine, 14*(3), 266–273. https://doi.org/10.1016/j.sleep.2012.11.006.

So, K., Adamson, T. M., & Horne, R. S. C. (2007). The use of actigraphy for assessment of the development of sleep/wake patterns in infants during the first 12 months of life. *Journal of Sleep Research, 16*(2), 181–187. https://doi.org/10.1111/j.1365-2869.2007.00582.x.

Stalder, T., Bäumler, D., Miller, R., Alexander, N., Kliegel, M., & Kirschbaum, C. (2013). The cortisol awakening response in infants: Ontogeny and associations with development-related variables. *Psychoneuroendocrinology, 38*(4), 552–559. https://doi.org/10.1016/j.psyneuen.2012.07.015.

Staples, A. D., Bates, J. E., & Petersen, I. T. (2015). Bedtime routines in early childhood: Prevalence, consistency, and associations with nighttime sleep. *Monographs of the Society for Research in Child Development, 80*(1), 141–159. https://doi.org/10.1111/mono.12149.

Stéphan-Blanchard, E., Telliez, F., Léké, A., Djeddi, D., Bach, V., Libert, J.-P., & Chardon, K. (2008). The influence of in utero exposure to smoking on sleep patterns in preterm neonates. *Sleep, 31*(12), 1683–1689.

Teti, D. M., & Crosby, B. (2012). Maternal depressive symptoms, dysfunctional cognitions, and infant night waking: The role of maternal nighttime behavior. *Child Development, 83*(3), 939–953. https://doi.org/10.1111/j.1467-8624.2012.01760.x.

Teti, D. M., Crosby, B., McDaniel, B. T., Shimizu, M., & Whitesell, C. J. (2015). Marital and emotional adjustment in mothers and infant sleep arrangements during the first six months. *Monographs of the Society for Research in Child Development, 80*(1), 160–176. https://doi.org/10.1111/mono.12150.

Teti, D. M., Kim, B., Mayer, G., & Countermine, M. (2010). Maternal emotional availability at bedtime predicts infant sleep quality. *Journal of Family Psychology, 24*(3), 307–315. https://doi.org/10.1037/a0019306.

Teti, D. M., Philbrook, L. E., Shimzu, M., Reader, J., Rhee, H.-Y., McDaniel, B., ... Jian, N. (2015). The social ecology of infant sleep. In S. D. Calkins (Ed.). *Handbook of infant biopsychosocial development* (pp. 359–391). New York, NY: Guilford Press.

Tétreault, É., Bouvette-Turcot, A. A., Bernier, A., & Bailey, H. (2017). Associations between early maternal sensitivity and children's sleep throughout early childhood. *Infant and Child Development, 26*(4), e2004. https://doi.org/10.1002/icd.2004.

Tikotzky, L., & Sadeh, A. (2015). Vii. Infant sleep development from 3 to 6 months postpartum: Links with maternal sleep and paternal involvement. Retrieved from *Monographs of the Society for Research in Child Development,* 107–124.

Tikotzky, Liat, & Sadeh, A. (2009). Maternal sleep-related cognitions and infant sleep: A longitudinal study from pregnancy through the 1st year. *Child Development, 80*(3), 860–874. https://doi.org/10.1111/j.1467-8624.2009.01302.x.

Tikotzky, Liat, & Shaashua, L. (2012). Infant sleep and early parental sleep-related cognitions predict sleep in pre-school children. *Sleep Medicine, 13*(2), 185–192. https://doi.org/10.1016/j.sleep.2011.07.013.

Tikotzky, L., & Volkovich, E. (2018). Infant nocturnal wakefulness: a longitudinal study comparing three sleep assessment methods. *Sleep,* (October), 1–12. https://doi.org/10.1093/sleep/zsy191.

Touchette, É., Petit, D., Paquet, J., Boivin, M., Japel, C., Tremblay, R. E., & Montplaisir, J. Y. (2005). Factors associated with fragmented sleep at night across early childhood. *Archives of Pediatrics & Adolescent Medicine, 159*(3), 242–249. https://doi.org/10.1001/archpedi.159.3.242.

Touchette, E., Petit, D., Séguin, J. R., Boivin, M., Tremblay, R. E., & Montplaisir, J. Y. (2007). Associations between sleep duration patterns and behavioral/cognitive functioning at school entry. Retrieved from *Sleep, 30*(9), 1213–1219. <http://www.ncbi.nlm.nih.gov/pubmed/17910393>.

Troese, M., Fukumizu, M., Sallinen, B. J., Gilles, A. A., Wellman, J. D., Paul, J. A., ... Hayes, M. J. (2008). Sleep fragmentation and evidence for sleep debt in alcohol-exposed infants. Retrieved from *Early Human Development, 84*, 577–585. <http://www.elsevier.com/copyright>.

Volkovich, E., Ben-Zion, H., Karny, D., Meiri, G., & Tikotzky, L. (2015). Sleep patterns of co-sleeping and solitary sleeping infants and mothers: A longitudinal study. *Sleep Medicine, 16*(11), 1305–1312. https://doi.org/10.1016/j.sleep.2015.08.016.

Voltaire, S. T., & Teti, D. M. (2018). Early nighttime parental interventions and infant sleep regulation across the first year. *Sleep Medicine, 52*, 107–115. https://doi.org/10.1016/j.sleep.2018.07.013.

Weinraub, M., Bender, R. H., Friedman, S. L., Susman, E. J., Knoke, B., Bradley, R., ... Williams, J. (2012). Patterns of developmental change in infants' nighttime sleep awakenings from 6 through 36 months of age. *Developmental Psychology, 48*(6), 1511–1528. https://doi.org/10.1037/a0027680.

Weissbluth, M. (1995). Naps in children: 6 months-7 years. *Sleep, 18*(2), 82–87. https://doi.org/10.1093/sleep/18.2.82.

Weissbluth, M. (2015). *Healthy sleep habits, happy child: A step-by-step program for a good night's sleep.* New York: Ballantine Books.

Zuckerman, B., Stevenson, J., & Bailey, V. (1987). Sleep problems in early childhood: Continuities, predictive factors, and behavioral correlates. *Pediatrics, 80*(5), 664–671.