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UNDERSTANDING THE IMPACT OF PARENTAL NIGHTTIME RESPONSIVENESS ON CHILD SOCIOEMOTIONAL DEVELOPMENT: A STATE SPACE APPROACH

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Abstract

Infant sleep plays a crucial role in shaping the development of internalizing and externalizing behaviors and has been consistently linked with attachment, although the precise nature of this association is unclear. Parent responsiveness is believed to drive these outcomes, but what constitutes appropriate nighttime responsiveness, and particularly responsiveness to infant distress and non-distressed night wakings, remains a gap in the literature. State space analysis can be used to obtain measures of nighttime responsiveness which build upon those most commonly used in research on nighttime parenting and may help to fill this gap.

The current study employed state space-derived measures of nighttime responsiveness to distress and non-distress at 6 months to predict attachment quality, internalizing behaviors, and externalizing behaviors at 12 months in 50, full-term infants (50% male / female). It was hypothesized that higher responsiveness to distress would predict adaptive developmental outcomes (i.e., higher attachment quality, lower internalizing and externalizing behaviors), and higher responsiveness to non-distress would predict maladaptive self-regulatory outcomes (i.e., higher internalizing and externalizing behaviors). The association between responsiveness to non-distress and attachment and the interactions between distinct state space derived measures of responsiveness were also explored.

Findings provided mixed support for hypotheses. Responsiveness to distress was not found to be associated with attachment quality, nor was it consistently demonstrated to predict internalizing behaviors. However, responsiveness to non-distress was shown to predict higher internalizing behaviors as anticipated. Further, responsiveness to distress was unexpectedly associated with higher externalizing, though only when response duration was above average. Responsiveness to non-distress consistently predicted higher externalizing. Finally,

responsiveness to non-distress was found to have a complex, albeit marginally significant, association with attachment such that higher likelihood to respond to non-distress predicts stronger attachment when response durations are shorter.

These findings contribute to the existing literature exploring nighttime parenting behaviors, emphasizing the need for more sensitive measures of nighttime responsiveness contingent upon specific infant behaviors, highlighting the complexity of associations between parenting behaviors related to relative infant nighttime distress and infant developmental outcomes, and identifying important next steps to better understand these associations.

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Introduction

Infancy is a period characterized by rapid and significant changes across multiple domains of socioemotional development. During this period, the quality of infant sleep predicts both short- and long-term trajectories of internalizing and externalizing behaviors. Infant sleep quality has also been shown to have a close but not particularly well-understood association with the quality of parent-child attachment. How parents respond to their infants needs and behaviors during the night, and specifically responsiveness to infant distress and non-distressed wakings, is an important factor shaping both of these outcomes. However, little research has explicitly explored the differential effects of parent responsiveness to infant nighttime distress nighttime and responsiveness to infant non-distressed night wakings in shaping development. This may be due in part to the limitations of the measures commonly used to assess nighttime parenting behaviors. State space analysis may be able to provide the measures of responsiveness necessary to further our understanding of how nighttime responsiveness across these contexts may differentially predict developmental outcomes.

The current study will contribute to the literature by examining if state space derived measures of parent nighttime responsiveness can be used to gain insight into infant socioemotional development. Specifically, this study will explore the efficacy of these measures in predicting the development of attachment quality, internalizing behaviors, and externalizing behaviors. Further, this study will explore the extent to which responsiveness to infant distress and non-distress during the night differentially predict these socioemotional outcomes, and the extent to which different state space derived measures interact in predicting infant outcomes.

Infant Sleep and Development

Infancy, specifically the first year following birth, is a period of rapid growth across a variety of developmental domains, ranging from physical growth to motor-, cognitive-, social - and emotional – development, and beyond (Bornstein, 2014). These early patterns of development are foundational to the developmental trajectories and differentiation of function in these areas as children participate in interactions with the wider world (Fox & Calkins, 2003; Oakes & Rakison, 2020). As such, identifying the contexts and factors associated with early developmental trends may be key in predicting and shaping subsequent outcomes. While there is undoubtedly a myriad of these factors and contexts contributing to infant development, few have found to be as universal and impactful as infant sleep.

Sleep is a ubiquitous and vital process which influences nearly, if not all, domains of an individual's functioning (Assefa et al., 2015). During childhood, sleep disruptions and poor-quality sleep have been linked both negative short-term (e.g., heightened stress responses, depression, anxiety, decreased cognitive performance, and increased behavioral problems; Medic et al., 2017) and long-term (e.g., socioemotional, sensorimotor, and cognitive development; Spruyt, 2019) outcomes. The salience of sleep is especially in evidence during infancy, and perhaps most readily apparent is the proportion of time that infants spend sleeping. On average full-term newborn infants spend up to 16-17 hours a day asleep, which gradually decreases to around 13-14 hours per day by the age of 6 months (Ednick et al., 2009). This change in sleep over the first six months not only reflects a decrease in the total duration of sleep but increases in sleep consolidation, transitioning from shorter and more sporadic sleep bouts to the longer, cyclical sleep-wake patterns which comprise an infant's ability to sleep through the night. Sleep consolidation is a complicated process that requires the "capacity for i) a sustained period of unbroken sleep; ii) the ability to independently reinitiate sleep following nocturnal arousals (self-soothing), and iii) the consistent deployment of these skills during a culturally or family determined nocturnal period, ideally corresponding to the nocturnal period during which other family members sleep," (Henderson et al., 2011). This process sits at the nexus of many co-developing systems, including the maturation of the nervous system, physiological growth, changes in the need to feed, and cognitive development (Davis et al., 2004), with the development of self-regulatory and self-soothing capabilities playing a key role (Goodlin-Jones et al., 2001). Given the number of contributing factors, sleep consolidation (and by extension infant night wakings) can be amongst the most variable data of all sleep measures during childhood (Galland et al., 2012), however researchers generally agree that on average by about 6 months of age infants demonstrate consistently consolidated sleep (Ednick et al., 2009), and that the quality of this sleep influences a host of developmental outcomes.

Evidence has routinely demonstrated the role that infant sleep has in shaping child development. For example, cognitive development has been demonstrated to be closely tied to the quality of infant sleep, with higher sleep quality predicting increases in memory, language acquisition, and executive functioning, amongst other outcomes (Tham et al., 2017). Conversely, sleep problems and inadequate sleep during this period have been routinely linked with detrimental outcomes, both concurrently (e.g., increased communication problems and decreased motor skills; Hysing et al., 2016), and longitudinally (e.g., poor sleep quality at 4 and 6 months predicting increased crying, feeding difficulties, and sleep problems at 12 months; Sidor et al., 2013). Importantly, these detrimental trajectories may expand far beyond infancy. Inadequate and poor sleep during infancy has been shown to predict poorer attention regulation and increased behavior problems at 3-4 years old (Sadeh, 2015), lower emotion regulation capability and higher behavioral problems at 5 years old (Sivertsen et al., 2015), and even maternal reported behavior problems as far out as 14 years of age (Hyde et al., 2012).

Infant sleep has specifically been found to be closely associated with the development of self-regulation, and two detrimental outcomes routinely associated with child sleep are the development of internalizing and externalizing behaviors. Across childhood, decreases in sleep quantity and sleep quality are associated with increases in each of these behaviors (see Bagley & El-Sheikh, 2013 for review). While this association has been explored less in infancy specifically (see Field, 2017), evidence suggests that this association holds true during this period as well. Most of the research on this topic explores the long-term development of these behaviors, with findings indicating that poor sleep during infancy predicts increased internalizing and externalizing behaviors during toddlerhood (specifically as measured at 36 months; Beijers et al., 2011), and later during childhood (Cook et al., 2020, Hyde et al., 2012). However, some evidence does suggest that these patterns, and particularly the link between sleep problems and internalizing, are present across early to late infancy. A series of studies demonstrated that later bedtimes and lower total sleep duration at 6, 12, and 18 months predicted increases in both concurrent and longitudinal inhibition, separation distress, anxiety, and depression in infants (Mindell et al., 2016; Mindell et al., 2017). While the association between sleep and maladaptive socioemotional outcomes are due at least in some part to the negative short-term effects of poor sleep quality (i.e., those outlined in Medic et al., 2017), to truly understand the etiology of these behaviors one must also account for another factor closely associated with infant sleep and self-regulatory development: the parent-child relationship.

Attachment, Socioemotional Development, and Infant Sleep

The idea that the parent-child relationship is critical in shaping infant development is by no means a novel premise. During infancy, the motor and cognitive skills necessary for anything beyond basic orienting behaviors are still developing, and regulation in response to both internal and external stimuli is heavily reliant on caregiver intervention (Rothbart et al., 2011; Stifter & Augustine, 2019). The importance of the parent-child relationship is acknowledged across several theories of child development, such as Baumrind's parenting styles (Baumrind, 1967), behavioral learning theories such as those posited by B.F. Skinner (Gewirtz & Peláez-Nogueras, 1992; Skinner, 1975) and Albert Bandura (Bandura, 1973), attachment theory (Ainsworth et al., 1978; Bowlby, 1969), Eisenberg & colleagues heuristic model of parental socialization of emotion (Eisenberg et al., 1998), and many more, all of which emphasize the importance of the quality of the parent-child relationship in predicting adaptive developmental outcomes across all domains of life. Attachment theory (Ainsworth et al., 1978; Bowlby, 1969) is one of the most common frameworks used in exploring the parent child relationship during infancy and may be particularly relevant for investigating the associations among the parent-child relationship, infant socioemotional development, and sleep.

Attachment theory is predicated on the assumption that the quality of the emotional bond (or attachment security) between parents and children is key in shaping children's socioemotional development (Ainsworth et al.,1978; Bowlby, 1969). This bond is influenced by both parent and child characteristics and built over time through dyadic interaction (Coleman & Watson, 2000). A supportive parent-child relationship provides a sense of security through consistently responsive and sensitive caregiving in infancy and serves as the foundation for adaptive development across various domains from infancy to as far out as adulthood (Benoit, 2004; Goldberg, 2014; Sroufe, 2005). Attachment security is measured in a variety of ways, including the classification of infants into one of some number of attachment types (e.g., Secure, Anxious-Ambivalent, Avoidant, Disorganized; scored from behavior during the Strange Situation Ainsworth et al., 1978), or scored on a continuum from low to high attachment quality (e.g., -1 to 1, the Attachment Q-Sort; Waters et al., 2021), with higher security indicating a stronger emotional bond and better quality of relationship between parents and children. Meta-analytic evidence has demonstrated that attachment security is robustly linked with concurrent and longitudinal socioemotional development, predicting the development of general self-regulatory capabilities (Pallini et al., 2018) as well as specifically the development of internalizing and externalizing behaviors (Groh et al., 2017). However, the association between infant sleep and attachment is less clear.

Taking the literature as a whole, poor sleep and/or increased sleep problems have typically been associated with lower attachment security (Keller, 2011), and better sleep quality has been associated with higher attachment security (both concurrently and longitudinally; Adams et al., 2014; Simard et al., 2017). However, the bulk of research on this topic follows a narrow 'attachment-to-sleep' pathway, exploring the quality of infant sleep as a function of attachment security (see for example, comparisons of infant sleep disorder behaviors between insecure-avoidant, insecure-resistant, and securely attached infants; McNamara et al., 2003). Considering the association between sleep and attachment beyond this narrow lens, however, reveals that sleep quality and attachment may not be as consistently linked as the discussed findings may suggest (Sadeh et al., 2010). That is, while multiple studies have found converging evidence that less securely attached infants demonstrate more night wakings at 6 months (Beijers et al., 2011; Morrell & Steele, 2003), results from these same studies differ as to whether these effects on sleep in turn predict downstream developmental outcomes. Further, research comparing various measures of infant sleep (namely maternal reports compared to actigraphy data), has demonstrated that attachment may only significantly predict changes in parent perceptions of children's sleep, and not objective measures of sleep quality (Scher, 2001). By comparison, relatively little research has explored the extent to which infant sleep predicts the quality of infant attachment (see Tikotzky, 2017). Insofar as this association has been explored directly, findings are mixed. Some evidence suggests a direct association between attachment quality and sleep, with evidence that sleep problems at 12 and 24 months predict lower attachment security at 36 months (Pennestri et al., 2015). Conversely, other research finds that infants with sleep problems are just as likely to be securely attached as they are to be insecurely attached (Scher & Asher, 2004). Together, these findings indicate that the association between attachment and sleep is likely more complicated than has been addressed within the literature and that further research taking an approach outside of the more common attachment-to-sleep framework may help to clarify the interrelation between these constructs.

Examining the parenting behaviors associated with attachment security may provide the missing link in understanding the underlying associations between attachment, sleep, and self-regulatory development. As noted, the development of attachment, as well as the development of self-regulation, are dynamic processes which form through infants interacting with their environments, and specifically parents, over time (Coleman & Watson, 2000; Grolnick et al., 2019). Although several factors inform what these interactive patterns look like for each dyad (e.g., parent acceptance of infant needs, cooperation with infant behaviors, etc.; Ainsworth et al., 1974; Ainsworth, 2020), perhaps most relevant in the context of infant sleep and socioemotional development is that of parent responsiveness. As defined by Ainsworth and colleagues, responsiveness refers to the extent to which parents accurately perceive their children's emotional states and respond promptly and appropriately to their children's needs and behaviors (Ainsworth et al., 1974). Through these patterns parent of behavior, responsiveness shapes the parent-child dynamic in two key ways: fostering the development of a secure and healthy parent-child relationship (i.e., attachment;), and promoting the development of children's self-regulatory capabilities.

Across most contexts, higher parent responsiveness is associated with positive outcomes in both of these domains. For instance, higher responsiveness during infancy not only predicts attachment security concurrently but has been shown to predict attachment security into middle childhood and even adolescence (Beijersbergen et al., 2012; Fearon & Belsky, 2018; Kochanska, 1998; Kochanska & Kim, 2013; de Wolff & Ijzendoorn, 1997). Likewise, higher responsiveness is associated with adaptive cognitive development (Landry et al., 2001) as well as concurrent and longitudinal decreases in internalizing and externalizing behaviors (Bradley & Corwyn, 2007; 2008; Sadeh et al., 2010; van der Voort et al., 2014). However, increased responsiveness is not universally associated with adaptive outcomes.

In some contexts, increased responsiveness has been demonstrated to have detrimental effects on child socioemotional development. For example, increased responsiveness to child distress in low-threat contexts, or those in which the threats posed are developmentally appropriate for children to engage in self-regulatory behaviors, has been found to predict increased internalizing behaviors over time (Kiel & Buss, 2012). These findings, in line with the broader literature around over-protective and intrusive parenting predicting higher internalizing and externalizing behaviors across development (Jiang et al., 2023; Thomasgard & Metz, 1993), underscore the importance of 'contingency' in responsiveness. That is, whether parent behaviors are considered appropriately responsive is determined not only by how parents respond to specific child behaviors but also how parent and child behaviors are themselves framed by situational demands. Considering both of these elements is not only necessary in understanding what determines appropriate parent responses more generally but for understanding how nighttime responsiveness specifically may inform child development.

Responsiveness in The Context of Infant Sleep

Under attachment theory, appropriate parenting behaviors are generally thought to be those which are consistent, temporally contingent to child behaviors, and act to promote adaptive developmental outcomes. As related to the former, per Ainsworth and colleagues' definition of responsiveness and much of the literature thereafter, temporal contingency (or the temporal association between parent and child behaviors, i.e., promptness, and the consistency of this prompt responses over time) serves as one of the core tenets of responsiveness research (Ainsworth et al., 1974; van Ijzendoorn & Sagi-Schwartz, 2008). As related to the latter, while multiple approaches purport specific aspects or characteristics of parent behaviors which are most beneficial in promoting adaptive outcomes (e.g., the rise of and subsequent debate surrounding warmth in responsiveness; Keller et al., 2018), most agree appropriate responsive behaviors are those which help to regulate children's affect through reducing child distress and/or promoting child positive affect. In line with the principles of behaviorism and operant conditioning (Skinner, 1975), these patterns of prompt, consistent, and adaptive responses serve to reinforce a child's perception that their behaviors yield predictable and dependable parental support and effective affect regulation, forming the foundation for both the development of a secure attachment bond and self-regulatory capability.

However, as seen in Kiel and Buss (2012), even when parents accurately assess their children's behaviors (i.e., fear), respond promptly to their children's behaviors, and ostensibly respond in an adaptive manner (i.e., promoting fear reduction), higher responsiveness can still be associated with detrimental long-term developmental outcomes (i.e., increased internalizing behaviors). This is likely because appropriate responsiveness is not solely contingent upon child behaviors, but how responses are informed by the interaction of child behaviors and contextual demands. In this example, parent protective behaviors in low-threat contexts may work to temporarily alleviate child fear but may also prevent children from engaging in and practicing the self-regulatory behaviors which are necessary to shape later developmental cascades in these processes Thus, it is necessary to consider how parents' responses to child behaviors are aligned with contextual demands in shaping both short- and long-term developmental outcomes. This understanding may prove particularly important in the exploration of nighttime responsiveness as not only are infant sleep, attachment, and self-regulatory outcomes heavily influenced by nighttime parenting behaviors (Sadeh et al., 2010), but also because this context brings with it a set of demands which may change what appropriate responsiveness looks like.

As related to attachment, theory suggests that "… since one of the major functions of the attachment system is to provide security and comfort at times of distress, sleep serves as a relevant stimulus to trigger the attachment system ... and waking in the middle of the night is an opportunity to obtain comfort … it is likely that nighttime experiences early in life most certainly influence the emergence of the developing attachment system." (p. 14, Anders, 1994). More directly, given that attachment theory is centered around the cyclical patterns of separation, reunion, and alleviating child distress (Bowlby, 1988), and that nighttime can be a significant source of distress (Anders, 1994), parent responsiveness during the night represents an opportunity for reunion and comfort (Goodlin-Jones et al., 1997) and thus the development of a stronger attachment bond. This may be why sleep quality and/or sleep problems at base have been inconsistently linked with attachment; it is not the quality of infant sleep alone which builds the attachment bond or vice versa, but instead how parents respond to infant night waking which drives both.

As related to self-regulation, though, both theory and evidence from the literature point to differential outcomes of parent nighttime responsiveness. For instance, some have argued that nighttime responsiveness is generally detrimental for infant development. Drawing from theories such as unmodified extinction (Etherton et al., 2016), it is posited that the sleep context prompts infants to engage in the rudimentary self-soothing behaviors necessary for development of sleep consolidation and self-regulation more generally (Bruni et al., 2014; Goodlin-Jones et al., 2001; Karraker, 2008; St. James-Roberts et al., 2015). Parent responsiveness during the night would prevent infants from engaging in these behaviors and, in turn, interfere with the natural development of self-regulatory processes. This interference would increase infant reliance on external regulation and in turn contribute to self-regulatory issues later in development (Etherton et al., 2016).

Other evidence, more in line with the understanding of appropriateness of response as a function of both contingency to child behavior and contextual demands, suggests that nighttime responsiveness is not in itself detrimental but that appropriate responsiveness is contingent upon only responding to specific infant behaviors; namely, responding to infant nighttime distress but not infant non-distressed night wakings (e.g., results from Voltaire & Teti, 2018). Under this framework, infant nighttime distress reflects contexts in which infants' self-regulatory capabilities have already been surpassed. Here, parents responses would not only achieve the short-term goals of alleviating distress and promoting sleep but also activate the distress reduction component of the attachment system and help to build upon infants' nascent self-regulatory capabilities, fostering adaptive long-term development across both of these systems.

By comparison, non-distressed night wakings reflect contexts in which infants have not yet surpassed their own self-regulatory capabilities and can still engage in the self-soothing behaviors which would reinforce self-regulatory development. As seen in Kiel and Buss (2012) and the overprotective literature, parent responsiveness contexts in which children can effectively self-regulate may prevent children from practicing these critical self-regulatory skills and interfere with the natural development of these processes. Moreover, the extent to which responsiveness to non-distress in the nighttime context would positively influence attachment is unclear, as while the patterns of separation and reunion inherent to attachment may still be present when responding to non-distress, critically the distress reduction component of attachment would not be present (Anders, 1994; Bowlby, 1988).

Considering these conflicting theoretical perspectives, it is evident that how parent responsiveness to infant distress and non-distress during the night shapes child development remains a gap in the literature. This gap becomes even more apparent when examining the empirical evidence and commonly held beliefs surrounding nighttime parenting practices.

Responsiveness to Nighttime Distress vs. Non-Distress

Exactly if, when, and how to respond to infants across relative levels of distress during the night remains a highly debated topic. As related to infant distress, across most other contexts higher responsiveness has been found to promote the development of secure attachment, potentially above and beyond responsiveness to non-distress (Leerkes & Zhou, 2018; McElwain & Booth-LaForce, 2006) and has also been demonstrated to predict better self-regulatory outcomes in preschool (Roberts & Strayer, 1987) and during middle childhood (Davidov & Grusec, 2006). However, multiple theories provide conflicting evidence and recommendations for parent responsiveness to infant distress during the night.

As mentioned, proponents of the unmodified extinction method suggest that parents should not respond to instances of distress during the night at all, or, if necessary, as little as possible (Etherton et al., 2016). Some evidence does suggest that higher rates of parental intervention at bedtime and during the night are associated with more sleep problems, although typically research on this method does not identify a causal relationship between limited responsiveness and infant development (Morrell & Cortina-Borja, 2002; Sadeh et al., 2010). Another approach, known as graduated extinction or more colloquially as the Ferber method (Ferber, 1985; Ferber, 2006), involves modifying the temporal contingency of parent response over time, gradually increasing the time to respond and decreasing overall frequency of response to nighttime distress (see Blunden et al., 2011). This method has been posited to be generally adaptive for development, balancing the promotion of attachment security through distress reduction and providing comfort with the development self-regulatory capability through providing early regulatory support and gradually increasing infant self-reliance on their own self-regulatory behaviors as they develop. In practice, while there is some empirical support for this method in a clinical setting (e.g., Lawton et al., 1991), evidence is at best mixed and may lean toward this method being ineffective for most families (Bruni & Novelli, 2010; Loutzenhiser et al., 2014). Finally, some researchers support consistent responsiveness (i.e., no extinction) to nighttime distress throughout infancy (Blunden et al., 2022). This practice stems from arguments around temporal contingency and consistency, positing that inconsistent parental responses to daytime crying but not nighttime crying may confuse infants, affecting the attachment relationship and making secure attachment less likely (Blunden et al., 2011). While there is some evidence to support consistent responsiveness to distress in at least the development of attachment (e.g., Higley & Dozier, 2009), little if any empirical research on the association between non-extinction methods and other socioemotional outcomes has been conducted. Taking these approaches together, while there remains some debate most theories appear to suggest that at least some level of responsiveness to infant nighttime distress promotes adaptive development.

By comparison, much less research has focused on parent responsiveness to non-distress during the night. Some evidence has shown that higher responsiveness to non-distressed infants has detrimental effects on infant sleep quality, increasing sleep fragmentation and night waking (Hazumi et al., 2021; Voltaire & Teti, 2018). In line with the summarized literature on sleep quality and socioemotional development, it is likely that these parent driven decreases in sleep quality would in turn contribute to infant dysregulation and increases in internalizing and externalizing behaviors across development (Mindell et al., 2017; Morales-Muñoz et al., 2020; Sadeh et al., 2010; Witte et al., 2021). However, there is limited research directly measuring the impact of responsiveness to non-distress on child socioemotional outcomes directly. Further, the potential acute and long-term effects of decreased sleep quality may negate or reverse any potentially positive effects on attachment security gained through separation and reunion as posited by Blunden and colleagues (2011).

In summary, evidence suggests that responsiveness to distress is generally considered to promote adaptive developmental outcomes for both attachment and self-regulation. Responsiveness to non-distressed night wakings has received less attention in the literature but is likely detrimental for the at least the development of infant self-regulation. No clear relationship between responsiveness to non-distress and attachment has been identified in either theory or the existing literature, leaving a notable gap that the current study seeks to address. However, many of the most commonly used measures of nighttime parenting may not be sufficiently equipped to address this gap in the literature.

Measuring Nighttime Responsiveness

The bulk of research on nighttime parenting has relied on parent reported measures of infant night waking and parental response, or some combination of parent-reported measures and actigraphy data (e.g., Tikotzky et al., 2015; see Tham et al., 2017, for review). These measures are informative but are largely unable to account for the dynamic processes which shape socioemotional development. Parent reports of infant night waking and subsequent responses are often assessed using sleep diaries (e.g., those outlined in Coons & Guilleminault, 1984, etc.) most commonly asking parents to report information such as sleep schedule, location, the frequency and/or the total duration of infant night waking. Notably, many of these measures do not actually assess parent behaviors during the night and may instead be more aligned with the constructs of infant sleep quality and/or sleep disturbances than they are with nighttime responsiveness. These limitations are compounded by evidence which suggests the validity of these measures tends to drop considerably when comparing parent-reported and observed instances of infant night waking (Sadeh, 2015). This is likely due to bias in reporting related to parent and child factors (e.g., parent negative affect and depression, Burdayron et al., 2021; attachment quality, Scher, 2001; see Sadeh et al., 2010 for review). Likewise, while actigraphy data does provide a more objective measure of night waking, actigraphy alone is not able to inform researchers on parental response behaviors or relative levels of infant distress.

Of parent-reported measures which do specifically account for parenting behaviors, most capture the overall frequency or total durations of nighttime parent-child interactions but do not account for the preceding infant behaviors upon which parent responses are contingent (i.e., relative infant distress; see, for example, the sleep diaries used in Beijers et al., 2011). To account for the interactive nature of nighttime responsiveness and infant distress, survey measures have been utilized to assess overarching patterns of infant sleep behaviors and parent responsiveness (e.g., the Brief Infant Sleep Questionnaire; Sadeh, 2004), however again these more summative measures may be unable to provide insight into the more nuanced patterns of dyadic behavior thought to shape development.

To overcome these limitations, researchers have incorporated video data and more complex behavioral coding to capture observed dyadic nighttime interactions. Thus far, most observational coding of nighttime responsiveness has either been operationalized through global coding of child behaviors and patterns of parent response (i.e., 'clear signalers' vs 'not clear signalers' infants, and 'no response/let cry' vs 'soothe in crib' parents; Higley & Dozier, 2009), or through more cumulative and/or summative measures of dyadic interaction (e.g., the total duration of distress, and total number of verbal and physical contacts between parents and children during the night following a threshold of non/distress; Voltaire & Teti, 2018). While these measures have expanded our understanding of and provided valuable insight into nighttime responsiveness and infant development, as with sleep diaries and survey measures their summative nature may prove insufficient in capturing the patterns of dyadic interaction driving developmental trajectories.

Importantly, while these video based observational measures have utilized coding schemes accounting for specific parenting behaviors in line with other measures of responsiveness used in similar contexts (e.g., those which account for discrete parent behaviors during at home interactions; Bornstein & Manian, 2013), most measures have operationalized responsiveness as ‘parent present with infant’ vs ‘parent absent’ during the night. Although this operationalization may not be as comprehensive as other, more thorough behavioral coding, these measures have been proven useful in assessing how parent responsiveness influences infant development and may be particularly well suited for exploring responsiveness in the context of solitary sleeping arrangements.

Amongst White, Educated, Industrialized, Rich, and Democratic populations (WEIRD), solitary sleeping arrangements during infancy has become the cultural norm (Mindell et al., 2010; Owens, 2004). Estimates of these populations reveal that roughly one quarter of infants consistently solo-sleep from the first month of life on, with most infants engaging in consistent solo-sleeping by 6 months of age (e.g., Morelli et al., 1992; Teti et al., 2016).

Compared to other dyadic contexts (e.g., feeding or free play) or other sleeping arrangements (e.g., room or bed sharing) in which parent responses to child behaviors may need more elaborate coding schemes and may still be limited in the extent they can capture parents’ decisions to respond to infants, solitary sleeping arrangements offer a distinct advantage in identifying and analyzing parental responsiveness. Specifically, since caregivers must physically relocate to the infant's room in order to respond to infant needs and behaviors, parent presence directly indicates parents’ perception of and subsequent response to their children’s behaviors during the night. While more complex behavioral coding could shed further light on the way that discrete parent behaviors promote adaptive developmental outcomes, given the noted gap in the literature around responsiveness to nighttime distress and non-distressed night wakings more generally, using more straightforward ‘parent presence’ based measures may help to lay the foundation and identify whether these proposed patterns of response actually differentially influence child development. However, in order to use ‘parent presence’ based measures to build upon the existing literature, newer methodologies must be utilized to better assess the dynamic patterns of interaction driving developmental trajectories.

State space analysis is one methodology which may be able to provide these measures. Rooted in Dynamic Systems Theory, state space analysis allows for the measurement of dynamic affective systems, in which multiple components (i.e., specific parenting behaviors or relative infant distress) of multiple entities (i.e., parents and infants) can be simultaneously explored over multiple time series (i.e., seconds to hours; Lodewyckx et al., 2011). One popular state space methodology known as state space grids (or SSG) has become prevalent over the past two decades in exploring parent-child interactions. SSG allow researchers to explore the contiguous associations between parent and child behaviors which drive the dynamic processes of development across a host of contexts (e.g., parent-child play, feeding, affective co-regulation, etc.) and in predicting numerous developmental outcomes, including attachment, internalizing, and externalizing, amongst many others (see for review, Grumi et al., 2022). Conceptually similar to other continuous time-event sequence approaches like time-series analysis (Velicer & Molenaar, 2012), at the core of SSG is tracking the duration within and transitions between key experimenter defined states over time (e.g., 'infant distressed - alone' and 'infant distressed – mother present') to explore observed and underlying dyadic processes. In the context of nighttime responsiveness, SSG measures can allow researchers to specifically explore the tangible influence of the theoretically derived patterns of dyadic behavior thought to shape attachment and self-regulatory development described thus far. Additionally, unlike other methods SSG may provide some unique benefits in exploring nighttime responsiveness to distress and non-distressed night wakings.

For example, SSG may be better equipped to analyze the type of data provided by ecological nighttime dyadic data collection than other time-event sequence approaches. Other common methods such as time series analysis are often predicated on assumptions that data is ‘stationary’ over time (e.g., variable means and variance remain consistent across a time series) and maintains regular time intervals between transitions, and/or require imputation and interpolation to standardize time series data (Chatfield & Xing, 2019; Wei, 2013). These constraints may limit the ability of these methods to effectively model the rapid changes between states and presence of missing data which characterizes infant nighttime behavior, parent-infant interactions, and ecological data collection more generally (Burnham et al., 2002; Cerezo et al., 2017; Łopucki et al., 2022). SSG can offer a flexible alternative approach more compatible with these non-stable, non-regular, and rapidly shifting dyadic interactions (Hollenstein, 2013). Specifically, SSG based software such as Gridware™ (Hollenstein, 2013) can not only provide a convenient structure for data incorporation, analyses, and visualization, but can be used to produce several measures quantifying dyadic patterns of interaction which would build upon existing ‘parent-presence’ based measures of responsiveness.

For instance, researchers have calculated ‘regional duration’ scores, or the amount of time that dyads spend in specific behavior-matched states (for example, high parent affect – high child affect, vs reciprocal low affect states; Hollenstein et al., 2004). While the use of behavior matched duration scores is not explicitly unique to state space analyses (e.g., Voltaire & Teti, 2018), these measures have often been incorporated into SSG analyses and have been demonstrated to reliably assess dyadic traits across contexts (e.g., Sravish et al., 2013; Van der Giessen & Bögels, 2018) as well as how dyadic processes predict child outcomes such as internalizing and externalizing behaviors (Hollenstein et al., 2004). In the context of nighttime responsiveness these measures would be able to expand upon the more summative ‘total duration of’ and ‘total frequency of’ response measures commonly used in the literature, differentiating the amount of time that parents are present during distressed and non-distressed infant night wakings.

Beyond these more behaviorally contingent measures of duration, SSG can also be utilized to assess the likelihood that dyads will engage in theoretically derived patterns of behavior (i.e., transition between certain dyadic states over time), and the extent to which engaging in these behavior patterns influences developmental phenomena. As it stands, most studies utilizing SSG derived transitional measures have sought to assess more global ‘rates of change’ (sometimes called phase transitions; Hollenstein, 2013) and their associations with the developmental outcomes (e.g., transitions per second predicting attachment, Cerezo et al., 2017; transitions per minute predicting internalizing and externalizing, Van der Giessen et al., 2015). However, measures of transitional probability (referred to as transitional propensity within the Gridware™ system; Hollenstein, 2013) are also able to track the occurrences of transitions into and out of specific experimenter defined parent-child behavior states over time (e.g., Guo et al., 2015). Moreover, unlike other methods of calculating conditional probability scores which reflect the likelihood to shift between specific states as a function of total transitions (e.g., time series analysis), SSG derived measures of transitional probability are able to explicitly provide probabilities of transition which account for the duration of time spent in the origin state (Hollenstein, 2013). Recontextualized, this would allow researchers to create a single measure of nighttime responsiveness which accounts both for the likelihood to respond and for the temporal contingency of response to either distress or non-distress. For example, these measures would differentiate parents that respond with shorter durations of infant distress as more responsive than parents that allow infants to remain in a distressed state for longer periods of time, where measures which calculate transitional probability solely as a function of total transitions would not. Building upon these transitional probability measures, through the incorporation of lagged transitional probabilities (again, see Hollenstein, 2013), SSG can be used to explore the extent to which the theorized patterns of multistage dyadic interactions central to theories of attachment and self-regulatory development are actually predictive of subsequent child outcomes. That is, lagged transitional probabilities can be used to explore how the likelihood that dyadic interactions which lead to distress reduction and/or sleep promotion (e.g., transitions from 'infant distressed' and 'infant alone' to 'infant distressed' and 'infant present', and then finally to 'infant non-distressed' / 'infant asleep') predict developmental outcomes.

Individually, each of these measures may provide unique insight into distinct aspects of nighttime responsiveness and their association with the development of attachment, internalizing, and externalizing behaviors. However, it may be that taking them together can provide an even more comprehensive understanding of the processes of responsiveness. Namely, given that each measure may tap into the distinct aspects of responsiveness (time spent responding to infants in distress or non-distress, likelihood to respond to distress or non-distress while accounting for temporal contingency, and likelihood of dyadic behavior patterns to follow theoretically derived pathways in relation to distress and non-distress), together they may provide a more complete representation of nighttime responsiveness better able to address the current gaps in the literature than either existing measures or each SSG derived measure individually. However, to date no known study has utilized these measures in exploring parent nighttime responsiveness and predicting infant socioemotional development.

The Current Study

Infancy is a period characterized by rapid and significant changes across many domains of development setting the stage for short- and long-term developmental trajectories. Infant sleep has been found to be closely related to the development of internalizing and externalizing behaviors, as well as the development of attachment, likely through parent nighttime responsiveness. Higher responsiveness is generally associated with adaptive developmental outcomes, however the extent to which nighttime responsiveness, and particularly responsiveness to infant distress and non-distressed night wakings, predicts adaptive development is unclear. While some argue that any responsiveness during the night will lead to detrimental child outcomes, across theories most agree that responsiveness to distress predicts adaptive socioemotional development. Little research has explicitly explored responsiveness to non-distress during the night, however evidence suggests an association with decreased sleep quality which would in turn lead to detrimental self-regulatory outcomes. The relationship between nighttime responsiveness to non-distress and attachment is unclear. The current gaps in the literature around these topics may be due in part to the limitations of the measures which have been commonly used in research on nighttime parent-child interactions. State space derived measures may be able to provide the more nuanced assessments of responsiveness necessary for understanding how nighttime parenting behaviors shape infant development.

The current study seeks to fill these gaps in the literature, using state space derived measures of nighttime responsiveness to distress and non-distress in predicting infant socioemotional development. Specifically, the current study seeks to answer two research questions: R1) Can state space derived measures of nighttime responsiveness effectively predict subsequent infant attachment, internalizing, and externalizing outcomes, as has been seen when using more summative measures such as maternal reported infant night waking and overall frequency of parent-child nighttime interactions?; and R2) Does responsiveness to child distress and non-distress have distinct effects in the prediction of attachment, internalizing behaviors, and externalizing behaviors? To this end, the following hypotheses are proposed.

H1) Given that summative measures of responsiveness likely cannot sufficiently account for the dynamic, dyadic behaviors shaping the development of attachment, and that they may instead be more indicative of sleep disturbances which have been shown to negatively influence child self-regulatory development, it is hypothesized that H1a) maternal reported infant night waking at 6-months will not be associated with attachment at 12 months, H1b) higher maternal reported infant night waking at 6-months will predict higher internalizing behaviors at 12 months, and H1c) higher maternal reported infant night waking at 6-months will predict higher externalizing behaviors at 12 months. Similarly, it is predicted that H1d) total frequency of nighttime interactions at 6-months will not be associated with attachment at 12 months, H1e) higher total frequency of nighttime interactions at 6-months will predict higher internalizing behaviors at 12 months, and H1f) higher total frequency of nighttime interactions at 6-months will predict higher externalizing behaviors at 12 months.

Given that most theoretical perspectives generally support responsiveness to distress in predicting adaptive developmental outcomes, and what evidence exists suggests detrimental effects for responsiveness to non-distress in predicting self-regulatory development but not necessarily attachment, it is hypothesized that H2) State space derived measures of responsiveness at 6 months will predict attachment at 12 months such that higher responsiveness to nighttime distress as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to distress will predict higher attachment quality.

Additionally, it is hypothesized that H3) state space derived measures of responsiveness at 6 months will predict internalizing at 12 months such that H3a) higher responsiveness to nighttime distress as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to distress will predict lower internalizing behaviors, and H3b) higher responsiveness to nighttime non-distress as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to non-distress will predict higher internalizing behaviors.

Further, it is hypothesized H4) that state space derived measures of responsiveness at 6 months will predict externalizing behaviors at 12 months such that H4a) higher responsiveness to nighttime distress as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to distress will predict lower externalizing behaviors, and H4b) higher responsiveness to nighttime non-distress as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to non-distress will predict higher externalizing behaviors.

Finally, given the current theoretical and empirical gaps in the literature, two exploratory sets of analyses will be run. The first set of exploratory analyses will assess the association between responsiveness to non-distress, as measured through duration of response, transitional probability of response to, and lagged transitional probability of response to non-distress, at 6 months and attachment quality at 12 months. The second set of exploratory analyses will assess the potential interactive effects of duration of response, transitional probability of response to, and lagged transitional probability of response to both distress and non-distress in predicting attachment, internalizing, and externalizing as applicable for each of the aforementioned hypotheses.

Method

Participants

Data for the current study was collected from a subset of families that participated in Project SIESTA (Study of Infants' Emergent Sleep TrAjectories) II, a longitudinal study assessing parent and child contributions to the development of sleep patterns across the first two years of life. From a total sample of 167 families with full-term infants, 50 participating families with solitary sleeping arrangements (i.e., infants sleeping alone in a room without caregivers present) for their infants at 6 months of age were selected.

Participating families (50% male / female infants) were predominantly White (90% Mothers, 96% fathers), followed by Black / African American (4% Mothers, 2% Fathers), Asian American (2% Mothers), Latino (2% Fathers), or another race (4% Mothers), living in dual parent households (98% Living with Partner, 2% Mother living alone). Mothers average age was 30.64 (SD = 4.37 years) and fathers average age was 33.08 (SD = 5.60). Families reported an average of $76,00 total family income per year (SD = $42,000). 2% of mothers and 4% of fathers listed no education further than high school, 54% of mothers and 56% of fathers had some college education or their undergraduate degree, 8% of mothers and 6 % of fathers had some graduate education, 30% of Mothers and 23 % of Fathers had a master's degree, and 6% of mothers and 10% of fathers had a PhD or equivalent.

Procedures

As part of the larger longitudinal study, researchers periodically visited participant homes for approximately two hours per visit to obtain demographic, survey, sleep, and observational data over the first 18 months post-partum. Data for the current study was leveraged from the 6-month and 12-month visits. For one week prior to at home visits, participants were called each morning and asked to provide information on infant and parent sleep quality for the previous day, including the frequency of night wakings for infants, overall sleep quality, problems putting the baby to sleep, etc. (questions were in line with previous research, e.g., Burnham et al., 2002). During home visits, participants were provided with a series of questionnaires to complete and researchers set up video and audio recording equipment where parent-infant nighttime interactions would take place. Video and audio recording equipment made by Bosch Divar XF 8-Channel Digital Versatile Recorder was set up in the room where the infant slept, and where the infant was taken for any part of bedtime. The recording system included infrared security cameras made by ARM Electronics (Model No. C420BCVFIR) for video information, and Channel Vision microphones (Model No. 5104-MIC) for audio information. At least one camera was placed above the infant's sleep location (e.g., crib or bed). Up to three additional cameras were set up to capture areas such as chairs where infants were fed, infant changing tables, and/or an overview of infants' rooms, depending on the locations where the infant's bedtime and nighttime took place. In order to capture as much of the bedtime and nighttime routine as possible, parents were asked to turn on the cameras an hour before infants' bedtime began and turn off the system after the infant woke up in the morning. At age 12 months, researchers also separately visited participants for a roughly two-hour assessment of attachment quality, described below.

Measures

Maternal Reported Measures

Infant Internalizing and Externalizing

Infant internalizing and externalizing behaviors were measured through maternal reported values of the internalizing and externalizing subscales of the Infant-Toddler Social and Emotional Assessment (ITSEA; Carter et al., 1999) collected at the 12-month home visit. ITSEA items, e.g., “My child is withdrawn”, “Cries often”, “Hurts other children”, were answered on a three-point scale (0, reflecting “Rarely/Not True of My Child”; 1, reflecting “Sometimes/Somewhat True of My Child”; and 2, reflecting “Often/Very True of My Child”). Scores are calculated as sums, with Internalizing being comprised of subscales representing infant Depression/Withdrawal, General Anxiety, Separation Distress, and Inhibition to Novelty, and Externalizing being comprised of subscales representing Activity/Impulsivity, Aggression/Defiance, and Peer Aggression. Both the Internalizing ($M = 20.96$, SD = 8.67) and Externalizing ($M = 16.08$, SD = 8.02) scales were found to be reliable (Cronbach’s $\alpha = .849$, and $\alpha = .859$, respectively).

Maternal Reported Infant Night Waking.

Maternal report of infant night waking was measured as the total number of infant night wakings reported by mothers during daily phone interviews over the course of the week leading up the 6-month visit ($M = 8.14$, SD = 6.46).

Observational Measures

Attachment.

Infant attachment was measured using the Attachment Q-Set (AQS; Waters et al., 2021) completed at 12 months ($M = .47$, SD = .22). Scores were in line with typical distributions in relatively low risk samples (Waters et al., 2021). Trained observers visited the participants' homes to observe mother–infant interactions in an unstructured home setting for approximately 1.5 to 2 hours. Based on the infants' behavior observed with mothers during this interaction, the observers scored the 90 items in the AQS into nine categories, from very much unlike the child to very much like the child. Then, each infant's sorting was correlated with a security criterion sort (security score of the hypothetically most secure child, based on the Q-sorts of eight experts on attachment), and this correlation coefficient was used as a final security score ranging from between -1.0 to +1.0 for each infant. Examples of items include "If held in mother's arms, child stops crying and quickly recovers after being frightened or upset" (security criterion of 8.80) and "when something upsets the child, he stays where he is and cries" (security criterion of 1.20). Intraclass correlations (ICCs) for absolute agreement for rater pairs on the AQS for the larger sample (N = 167) were .86 to .96 based on 25% of observations across the three occasions.

Responsiveness.

Measures of responsiveness (namely, frequency of nighttime interactions, duration of parent response to distressed infants, duration of parents' response to non-distressed infants, transitional probability of response to distress, transitional probability of response to non-distress, lagged transitional probability of response to distress, and lagged transitional probability of response to non-distress) were obtained through behavioral coding of parent infant behaviors throughout the night. Video recordings collected at the 6-month at home visit were coded in 30 second epochs for both parent and infant behavior. Infant behavior was coded on a nominal scale such that 1 represents the infant being asleep, 2 represents the infant was awake but not distressed (e.g., eyes open, non-distressed vocalizations), 3 represents the infant was awake and distressed (e.g., crying / fussing), and 4 representing indeterminate infant state (i.e., the infant was out of frame). Parent behavior was coded as the presence of either or both parents in the same room as the child for more than half (15 seconds) of each epoch with 0 representing no parent present, 1 representing mothers attending to infant, 2 representing fathers attending to infant, 3 representing both mothers and fathers attending to infant, and 4 representing indeterminate parent state (i.e., parents out of frame but potentially present due to auditory / contextual evidence of interaction).

Frequency of Nighttime Interactions.

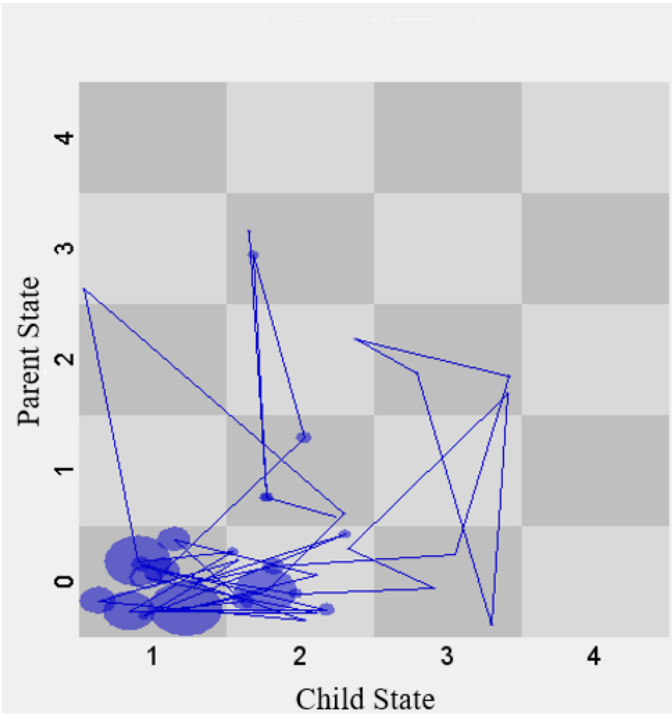
The total frequency of nighttime interactions was calculated as the total number of unique instances that either or both parents were recorded entering infants' rooms or otherwise interacting with infants during the night (*M* = 1.68, SD = 1.87).

State Space Derived Measures of Responsiveness.

State space derived measures of responsiveness were calculated from observational data using Gridware™ version 1.15a and SSG methodology (Hollenstein, 2013; see Figure 1). Specifically, the grid for the current study was defined as follows: Child State values (from left to right) were coded as 1) Infant Asleep, 2) Infant Awake Non-Distressed, 3) Infant Distressed, 4) Infant Indeterminate, and Parent State Values (from bottom to top) were coded as 0) Infant Alone, 1) Mother Present, 2) Father Present, 3) Both Parents Present, 4) Parent Indeterminate. These values resulted in a 4 x 5 grid in which each cell represents a distinct dyadic state (e.g., cell 1-0 represents 'infant asleep - infant alone', cell 3-3 represents 'infant distressed - both parents present'). From this grid, six measures of responsiveness were derived: duration of response to distress, duration of response to non-distress, transitional probability of response to distress, transitional probability of response to non-distress, lagged transitional probability of response to distress, and lagged transitional probability of response to non-distress.

Figure 1

Example State Space Grid



Note: Example state space grid used for data analyses. Blue nodes represent unique states between transitions, with larger nodes representing longer uninterrupted states. Blue lines reflect transitions between states.

Duration Of Response to Distress and Non-Distress.

First, mean duration of response was calculated for both infant distress and infant non-distress. On the current grid, Duration of Response to Distress scores were calculated as the mean number of 30 second epochs that dyads spent in an "infant distressed – mother present" (cell 3-1), "infant distressed - father present" (cell 3-2), or "infant distressed - both mother and father present" state (cell 3-3). Higher values reflect higher mean number of epochs of parent presence during infant distressed states, or more simply increased amount of time parents spent present with distressed infants.

Likewise, Duration of Response to Non-Distress scores represent the average number of 30 second epochs that dyads spend in an “infant awake and non-distressed – mother present” (cell 2-1), “infant awake and non-distressed - father present” (cell 2-2), or “infant awake and non-distressed - both parents present” state (cell 2-3). Higher values reflect higher mean number of epochs of parent presence during infant awake and non-distressed states, or again more simply increased amount of time parents spent present with non-distressed infants.

Transitional Probabilities.

Next, measures of transitional probability were calculated to capture the extent to which dyads shifted from infant alone to parent present across infant states. Similar to transitional probability measures from similar methodologies (e.g., sequential analysis, Gottman & Roy, 1990; time series analysis, Velicer & Molenaar, 2012, etc.), SSG derived transitional measures assess dyadic transitions as a function of the total number of transitions between key states, however unlike these other measures SSG derived transitional probability scores also account for the amount of time spent in ‘origin states’ in calculating these transitional probability scores. In the current study, these scores were calculated using the ‘Transitional Propensity’ function in Gridware™, as follows: “Using the shortest duration value found in any of the trajectories in the project to create equal-sized time bins, Transitional Propensity is a conditional probability of making the transition [between an origin and a destination] from time bin *t* to time bin *t*+1,” (p 48, Hollenstein, 2013) using the following formula:

$$\text{Transitional Propensity} = \frac{\#\ of\ transitions\ from\ Origin\ to\ Destination}{(Duration\ in\ Origin)/(Transitional\ Bin\ Size)}$$

Using this formula, the Transitional Probability of Response to Distress was calculated as the transitional propensity to move from the origin "infant distressed – infant alone" state (cell 3-0) to the destination "infant distressed – mother present" (cell 3-1), "infant distressed - father present" (cell 3-2), or "infant distressed - both parents present" (cell 3-3) state. As such, these scores reflected the likelihood that parents physically relocated to infant rooms in order to respond to infant distress over the course of the night while accounting for the total amount of time that infants spent in distressed states, with higher scores reflecting higher responsiveness to distress.

Similarly, Transitional Probability of Response to Non-Distress reflects the probability that a dyad shifted from the origin "infant awake and non-distressed – infant alone state" (cell 2-0) to the destination "infant awake and non-distressed – mother present" (cell 2-1), "infant awake and non-distressed - father present" (cell 2-2), or "infant awake and non-distressed - both parents present" (cell 2-3) state. As with Transitional Probability of Response to Distress, these scores reflect the likelihood that parents physically relocated to infant rooms in order to respond to infant non-distressed night wakings over the course of the night while accounting for the total amount of time that infants spent in non-distressed states, with higher scores representing higher responsiveness to non-distress.

Lagged Transitional Probabilities.

Finally, lagged transitional probabilities were calculated to assess the likelihood that dyads would follow the theoretically informed trajectories of behavior though to drive socioemotional development. Specifically, parent state data was lagged such that that child state at time t matched parent state at time $t + 1$, resulting in individual 'states' on the grid instead reflecting a single stage transition (i.e., infant state leading to parent state; per p 78-80, Hollenstein, 2013). Using the same transitional propensity formula as above, transitional propensities between these ‘states’ now reflected a two-stage transitions (i.e., child state leading to parent state leading to subsequent child state). These lagged transitional probabilities were calculated for several theoretically informed trajectories. Lagged Transitional Probability of Response to Distress – Non Distress was calculated as the likelihood to transition into a “infant distressed – parent present” state (cells 3-1, 3-2, 3-3) and then into a “infant awake and non-distressed – parent present” state (cells 2-1, 2-2, 2-3); Lagged Transitional Probability of Response to Distress – Sleep was calculated as the likelihood to transition into “infant distress – parent present” state (cells 3-1, 3-2, 3-3) and then into a “infant asleep –parent present” state (cells 1-1, 1-2, 1-3); and Lagged Transitional Probability of Response to Non-Distress - Sleep was calculated as the likelihood to transition into a “infant awake and non-distressed –parent present” state (cells 2-1, 2-2, 2-3) and then into or “infant asleep – parent present” state (cells 1-1, 1-2, 1-3). Across these scores, higher values represented a higher likelihood that dyads transitioned across these theoretically derived trajectories of behavior.

Results

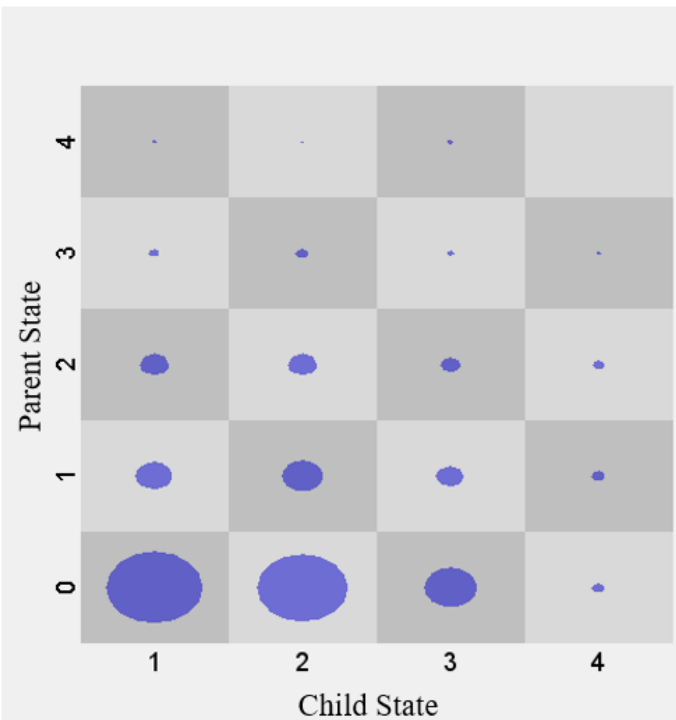
Preliminary Analysis

Mapping Visits, Patterns of Transition, and Data Reduction

Initially, parent state was coded to allow for potential post-hoc comparisons of patterns of responsiveness from mothers, fathers, and both parents together in predicting developmental outcomes. However, preliminary review of the data revealed that mothers alone made up the majority of observed parent responses compared to fathers alone or both parents together (see Figure 2). Specifically, calculating the average “visits” (or unique instances of a dyad entering a specific state on the grid) across infant distressed, non-distressed, and sleeping states revealed that mothers were present with infants during the night (*M* visits = 1. 786667) at nearly twice the rates of fathers (*M* visits = .966667), and over 10 times the rate of both parents together (*M* visits = .173333).

Figure 2

Summary Grid Depicting Mean Number of Visits per State



Note: Blue nodes represent the mean number of visits per state across dyads, with larger nodes representing higher number of average visits. Child state values: 1) Infant Asleep, 2) Infant Awake Non-Distressed, 3) Infant Distressed, 4) Infant Indeterminate. Parent state values: 0) Infant Alone, 1) Mother Present, 2) Father Present, 3) Both Parents Present, 4) Parent Indeterminate.

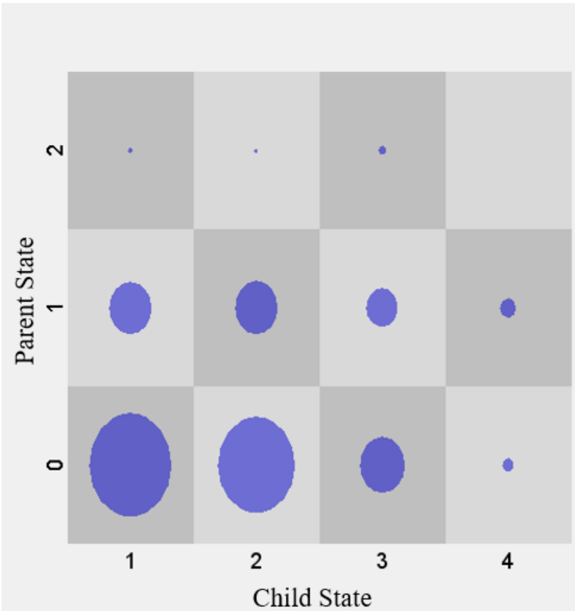
Further, exploring the transitional probability of response to distress and non-distress across parents demonstrated similar parental differences. Specifically, transitions from "infant distressed – infant alone" to "infant distressed – mother present" occurred in 38% of dyads, "infant awake and non-distressed – infant alone" to 'infant awake and non-distressed – mother present" occurred in 44% of dyads, "infant distressed – infant alone" to "infant distressed – father present" occurred in 26% of dyads, "infant awake and non-distressed – infant alone" to "infant awake and non-distressed – father present" occurred in 12% of dyads, and transitions from either "infant distressed – infant alone" or "infant awake and non-distressed – infant alone" to their respective "both parents present" state occurred in only 2% of dyads.

Finally, reviewing rates of two stage transitions across parents saw even lower occurrences of expected behavioral trajectories, with two stage transitions from 'child distress - mom present' to 'child awake and non-distressed – mother present' occurring in 18% of dyads, "infant distressed - father present" to "infant awake and non-distressed – father present" occurring in 14% of dyads, "infant distressed - mother present" to "infant asleep" occurring in 6% of dyads, "infant distress - father present" to "infant asleep" occurring in 8% of dyads, "infant awake and non-distressed - mother present" to "infant asleep" occurring in 28% of dyads, and "infant awake and non-distressed - father present" to "infant asleep" occurring in 14% of dyads.

Given that transitions between key states the relatively low frequency of these key transitions when coding parent presence separately across mothers, fathers, and both parents together, and that no hypotheses aimed at exploring between-parent differences in responsiveness in predicting developmental outcomes, parent states were collapsed such that 0 = Infant Alone, 1 = Any Parent Present, and 2 = Indeterminant (see Figure 3).

Figure 3

Collapsed Parent State Summary Grid Depicting Mean Number of Visits per State



Note: Blue nodes represent mean number of visits per state across dyads, with larger nodes representing higher average visits. Child state values: 1) Infant Asleep, 2) Infant Awake Non-Distressed, 3) Infant Distressed, 4) Infant Indeterminate. Parent state values: 0) Infant Alone, 1) Parent Present, 2) Parent Indeterminate.

Duration of Response to Distress scores now reflected the mean duration in cell 3-1 (M = 3.86, SD = 4.96). Likewise, Duration of Response to Non-Distress reflected the mean duration in cell 2-1 (M = 21.72, SD = 25.308).

Similarly, the Transitional Probability of Response to Distress now reflected the likelihood of transitioning from "infant distressed – infant alone" (cell 3-0) to "infant distressed – any parent present," (cell 3-1; M = 0.11, SD = 0.14), and occurred within 58% of dyads. Among the remaining 42% of dyads, 10% transitioned from “infant distressed – infant alone” into another parent-present or missing state (most frequently, ‘infant awake and non-distressed – any parent present'), 20% did not respond to observed infant distress, and 12% infants had no observed distress during the night.

Transitional Probability of Response to Non-Distress now reflected the likelihood of transitioning from "infant awake and non-distressed – infant alone" (cell 2-0) to "infant awake and non-distressed - any parent present," (cell 2-1; *M* = 0.02, SD = 0.03). This transition was observed in 56% of dyads. Among the 44% remaining dyads, 28% transitioned into 'infant awake and non-distressed - any parent present' from a state of 'infant distressed – any parent present', 10% demonstrated no response to observed non-distress, 4% transitioned into "infant awake and non-distressed – any parent present" from a "infant asleep – any parent present" state, and 2% of infants were observed to have no non-distressed night waking.

Finally, Lagged Transitional Probabilities of Response to Distress represent the likelihood of transitioning through states such as "infant distressed – any parent present" (cell 3-1) into either "infant awake and non-distressed – any parent present" or "infant asleep – any parent present" (cell 1-1, or 2-1; *M* = 0.11, SD = 0.16). This transition occurred in 46% of dyads. Similarly, Lagged Transitional Probability of Response to Non-Distress remained the likelihood of transitioning through "infant awake and non-distressed – any parent present" (cell 2-1) to "infant asleep – any parent present" (cell 1-1; *M* = 0.01, SD = 0.02), and was observed in 42% of dyads.

Outlier Correction and Missing Data

Outliers were Windsorized to within two standard deviations of the mean for all variables. Data was determined to be missing completely at random (Chi-Square = 80.716, p = .364) and as such multiple imputation (MI) using Fully Conditional Specification (Van Buuren et al., 2006; Van Buuren, 2007) was conducted using version 28 of SPSS (IMB Corp., Released 2021). Following general guidelines used across the literature (e.g., Rubin, 2004) data was imputed a total of 10 times, and results discussed pertain to pooled findings from these imputed data sets. Multiple imputation, however, brings with it limitations in the statistical values which can be reported (see van Ginkel & Kroonenberg, 2014). Notably, SPSS precludes the pooling of degrees of freedom, F statistics, and R^2 estimates across imputations. For instances in which statistical procedures and subsequent values were not affected by MI (such as *df* for paired sample t-tests) these values were reported for pooled data sets. Otherwise, when possible the range of significance and error reduction across imputations was provided, however due to these methodological limitations it must be noted that these ranges are intended to simply give context to the pooled results and not intended for direct statistical interpretation.

Normality And Child Sex Differences

Skewness and kurtosis values were examined to assess the distributional characteristics of the data. Results indicated that total number of nighttime responses and all state space derived measures of responsiveness demonstrated significant positive skewness (see Table 1). To account for these issues all SSG derived measures were square root transformed in order to increase normality of variables.

No child sex differences were found for internalizing, externalizing, or AQS scores. Likewise, no child sex differences were found for non-distress duration, single stage transitional probabilities or lagged transitional probabilities. However, significant child sex differences for maternal reported infant night waking, $t(\text{pooled}) = 2.38$, $p = .02$, such that mothers reported male infants ($M = 10.24$) waking up more than female infants ($M = 6.04$). Likewise, significant child sex differences for frequency of nighttime interactions were present, $t(\text{pooled}) = 2.93$, $p < .01$, such that parents were more likely to interact with male children (*M* = 2.4) than female children (*M* = .96). Finally, child sex differences were also found in parent's likelihood to respond to distress, *t*(pooled) = 2.20, p = .02, such that parents were about twice as likely to respond to male distress (*M* = .15) than responding to female distress (*M* = .071). Models including these variables were run controlling for child sex, however this did not improve model fit. As such, models not including child sex will be discussed in this paper.

Analytic Plan

Correlations between variables were run. The association between measures of nighttime responsiveness and outcomes was assessed through a series of linear regressions on pooled MI data sets using SPSS. For summative measures, dependent variables (AQS, Internalizing, and Externalizing scores) were regressed upon each independent variable (Maternal Reported Night Waking and Frequency of Nighttime Interactions) independently. For SSG derived measures, dependent variables were first regressed upon each independent variable (Duration of Response to, Transitional Probability of Response, and Lagged Transitional Probability of Response to distress and non-distress separately) independently, then again with Duration of Response and either Transitional Probability of Response or Lagged Transitional Probability of Response, and then finally with Duration of Response, Transitional Probability of Response or Lagged Transitional Probability of Response, and their respective interactions.

Correlations

Findings indicate measures of responsiveness were largely positively correlated. Internalizing and externalizing behaviors were significantly positively correlated with one another as well as with measures of responsiveness to non-distress. Attachment was not significantly correlated with any other variables (see Table 2 for summary).

H1) Summative Measures of Nighttime Responsiveness Predicting Socioemotional Development

As anticipated, (H1a and H1d) neither maternal reported infant night waking (β = .002, *p* = .73) nor total frequency of nighttime interactions (β = .013, *p* = .45) at 6 months were associated with attachment at 12 months. Contrary to hypotheses, however, maternal reported infant night waking H1b) was not associated with internalizing behaviors (β = .16, *p* = .80) and H1c) was not associated with externalizing behaviors (β = .28, *p* = .12). Similarly, total frequency of nighttime interactions was H1e) not associated with internalizing behaviors (β = .33, *p* = .63), and H1f) was not associated with externalizing behaviors (β = .83, *p* = .19; see Table 3).

H2) SSG Derived Measures of Responsiveness Predicting Attachment

H2) Responsiveness to Distress

Contrary to hypotheses, no SSG derived measures of responsiveness to distress at 6 months were significantly associated with attachment quality at 12 months (see Table 4).

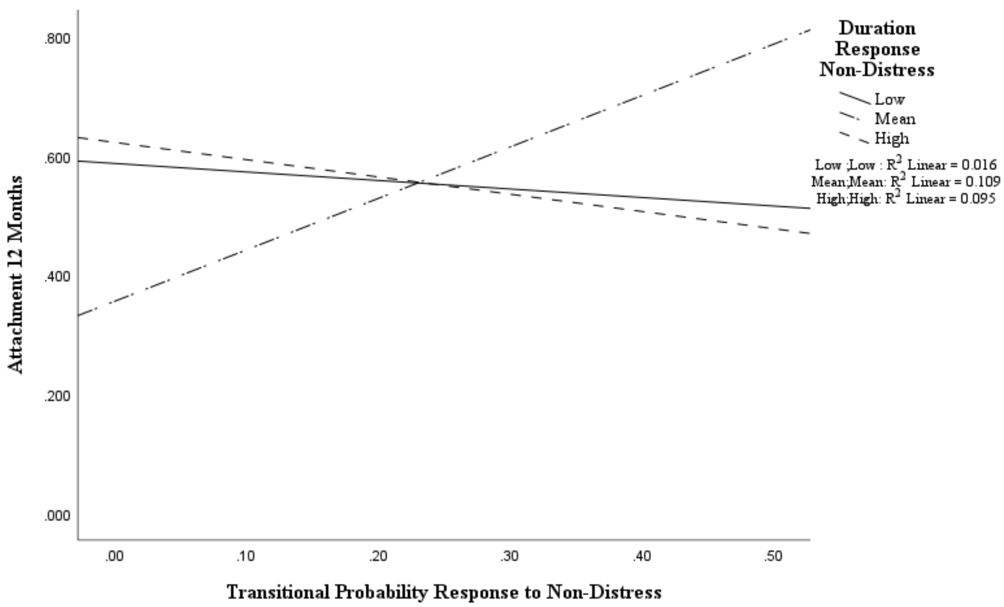
Responsiveness to Non-Distress

Results indicated that higher transitional probability of response to non-distress significantly (β = 1.06, *p* = .05) and duration of response to non-distress marginally (β = .028, *p* = .07) predicted higher attachment scores, and that the interaction between these two marginally predicted lower attachment scores (β = -0.14, *p* = .08). No other significant associations between responsiveness to non-distress and attachment were found (see Table 5). While only marginally significant, given these findings were in part aligned with expectations from the literature and exploring this association was a goal of the current study this interaction was probed at +/- 1 SD of duration of response to non-distress.

Probing Responsiveness to Non-Distress Attachment Interaction.

Figure 4

Probing the Interaction Between Duration of Response to Non-Distress and Transitional Probability of Response to Non-Distress at 6 Months Predicting Attachment Security at 12 Months.



Note: Figure reflects data from one of 10 imputations, and while representative of overall findings is not explicitly representative of pooled results. Low duration of response to non-distress reflects scores 1 *SD* below mean. High duration response to non-distress reflects scores 1 *SD* above mean.

Probing this interaction revealed that when coupled with lower durations of response, the transitional probability of response to non-distress was associated with higher attachment scores (β = 1.47, p = .047) than when coupled with higher durations of response (β = .67, p = .072) (see Table 6). However, graphing this interaction revealed that mean response duration was associated with higher attachment quality than either high or low response duration (see Figure 2 above).

H3) SSG Derived Measures of Responsiveness Predicting Internalizing

H3a) Responsiveness to Distress

Results did not indicate a robust association between responsiveness to distress and internalizing behaviors. While some models indicated a marginally significant association between responsiveness to distress and internalizing behaviors (i.e., duration of response when controlling for transitional probability to respond to distress, $\beta = -3.51$, $p = .07$); lagged transitional probability of response to distress, $\beta = 9.49$, $p = .09$) results were not consistent in direction and did not reach significance at $p = .05$. Only the duration of response to distress, and again only when modeled with the transitional probability of response to distress and their interaction, was found to be significantly associated with internalizing such that higher duration of response predicted lower internalizing behaviors ($\beta = -3.31$, $p = .03$; see Table 7).

H3b) Responsiveness to Non-Distress

Results indicated that responsiveness to non-distress, as measured through both duration of response to non-distress and the transitional probability of response to non-distress, significantly predicted higher internalizing behaviors across models (see Table 8). Specifically, the duration of response to non-distress significantly predicted higher internalizing behaviors when modeled alone ($\beta = 1.25$, $p = < .01$), with transitional probability of response to non-distress ($\beta = 1.03$, $p = .02$), with both transitional probability of response to non-distress and their interaction ($\beta = 1.43$, $p = .01$), with lagged transitional probability of response to non-distress ($\beta = 1.32$, $p < .01$), and with lagged transitional probability of response to distress and their interaction ($\beta = 1.46$, $p = .01$). Transitional probability of response to non-distress predicted higher internalizing behaviors when modeled alone ($\beta = 24.14$, $p = .03$), and marginally predicted higher internalizing behaviors when modeled with duration of response to non-distress and their interaction (β = 33.72, p = .09).

H4) SSG Derived Measures of Responsiveness Predicting Externalizing

H4a) Responsiveness to Distress

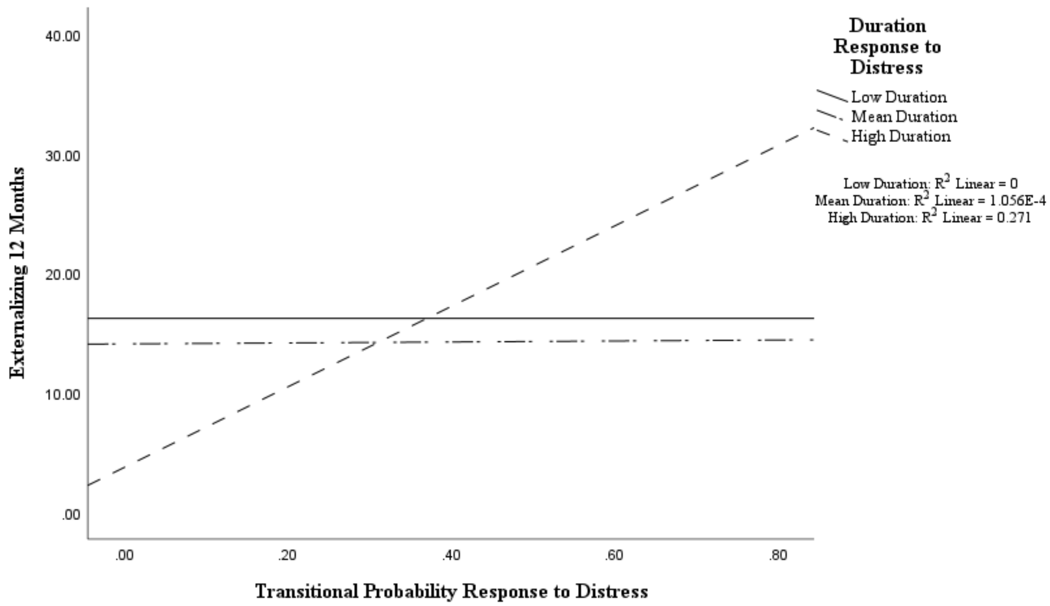
Contrary to hypotheses, results indicated that the interaction between duration of response to distress and the transitional probability of response to distress, but neither independently predicted higher externalizing behaviors (β = 9.36, p = .04). Additionally, lagged transitional probability of response to distress predicted higher externalizing behaviors alone (β = 11.01, p = .02) and when controlling for duration of response to distress (β = 10.49, p = .04; see Table 9).

H4a) Probing Responsiveness to Distress Externalizing Interaction.

The significant interaction between transitional probability to respond to distress, duration of response, and their interaction in predicting externalizing behaviors was probed at +/- 1 SD of duration of response to distress (see Table 10, Figure 3). Results indicated that when coupled with lower durations of response transitional probability of response to distress was found to be associated with lower externalizing behaviors (β = -26.85, p = .09) than when coupled with high duration of response (β =-2.04, p = .79). Graphing this interaction revealed that higher durations of response to distress were associated with higher levels of externalizing than mean or low durations of response.

Figure 5

Probing the Interaction Between Duration of Response to Distress and Transitional Probability of Response to Distress at 6 Months Predicting Externalizing Behaviors at 12 Months.



Note: Figure reflects data from one of 10 imputations, and while representative of overall findings is not explicitly representative of pooled results. Low duration response to distress reflects scores 1 *SD* below mean. High duration response to distress reflects scores 1 *SD* above mean.

H4b) Responsiveness to Non-Distress.

Results indicated that while when modeled alone higher transitional probability to respond to non-distress predicted higher externalizing behaviors ($\beta = 21.74$, $p = .03$), across models only higher duration of response to non-distress was consistently significantly associated with significantly higher externalizing behaviors (see Table 11). Specifically, duration of response to non-distress predicted higher internalizing when modeled alone ($\beta = 1.08$, $p < .01$), with the transitional probability of response to non-distress (β = .88, p = .03), with the lagged transitional probability of response to non-distress (β = .98, p = .02), and with lagged transitional probability of response to non-distress and their respective interaction (β = 1.133, p = .04).

Discussion

Summary of Findings

The current study investigated the relationship between nighttime responsiveness at 6 months and socioemotional developmental outcomes in infants at 12 months. Regarding summative measures of responsiveness (H1), findings supported the hypotheses that neither maternal reported infant night waking (H1a) nor the total frequency of nighttime interactions (H1d) were associated with attachment. However, hypotheses suggesting that higher maternal night waking would predict higher internalizing (H1b) and externalizing (H1c) behaviors were not supported. Similarly, hypotheses that higher total frequency of nighttime interactions would predict higher internalizing (H1e) and externalizing (H1f) behaviors were not supported.

Findings showed mixed support for hypotheses regarding SSG derived measures of responsiveness predicting developmental outcomes. Regarding attachment (H2), the current findings did not support the association between responsiveness to distress and attachment quality. The association between responsiveness to non-distress and attachment was more complex, with duration of response to non-distress, the transitional probability of response to non-distress, and their interaction predicting differential attachment outcomes (discussed below). For internalizing behaviors (H3), the hypothesis that higher responsiveness to distress would predict lower internalizing behaviors (H3a) was partially supported, although the findings were not consistent across models. However, the hypothesis that higher responsiveness to non-distress would predict higher internalizing behaviors (H3b) was supported across models, with both higher duration of response and higher transitional probability of response to non-distress predicting higher internalizing behaviors. Finally, regarding externalizing behaviors findings did support an association between responsiveness to distress and externalizing (H4a), however the interaction of duration of response and transitional probability of response to distress predicted higher, not lower, externalizing behaviors, particularly when the duration of response is higher than average. Findings more robustly supported the hypothesized association between responsiveness to non-distress and externalizing (H4b), with both higher duration of response and transitional probability of response to non-distress predicting higher externalizing across models.

Predicting Infant Development: Summative Measures

Importantly, the current study found that the summative measures of parent child nighttime interaction used frequently across the literature did not significantly predict any developmental outcomes. As related to attachment, these findings were not unexpected. Considering attachment as a dynamic system (per Coleman & Watson, 2000), results supported expectations that these broad summary measures may not be sufficiently able to tap into the moment-to-moment patterns of parent-child interaction in a way which meaningfully informs the development of the attachment bond.

As related to internalizing and externalizing behaviors, however, these results were more surprising. Maternal reports of infant night waking and/or sleep disturbances are amongst the most common measures used across the literature (Tham et al., 2017; Tikotzky et al., 2015), and have consistently been associated with internalizing and externalizing behaviors across childhood (see Bagley & El-Sheikh, 2013), and specifically during the 6-to-24-month period of infancy (Mindell et al., 2016). The frequency of parent-child interactions during the night, as measured through both parent report and observation, has also long been utilized in studies of infant sleep and development (e.g., Goodlin-Jones et al., 2001). Less research has directly assessed the association between the frequency of nighttime interaction and child socioemotional outcomes, but as noted evidence from the literature does at least support increased nighttime interactions leading to decreased sleep quality (Sadeh et al., 2009), which in itself is strongly associated with increased internalizing and externalizing behaviors (Mindell et al., 2017; Morales-Muñoz et al., 2020; Sadeh et al., 2010; Witte et al., 2021). Importantly, while studies have raised concerns regarding the validity of parent reports of infant night waking as well as other sleep characteristic data (e.g., biases in report due to attachment quality; Scher, 2001; Quante et al., 2021), in the current study frequency of nighttime interactions was observed and not subject to these potential biases. Moreover, both measures were positively correlated with other SSG derived measures of responsiveness which did significantly predict these outcomes. Together, the results of the current study may indicate that these summative measures of nighttime responsiveness may not be as robust as they appear given their prevalence in the literature, and further highlights the value of incorporating more nuanced and measures of parent child interaction in improving our understanding of how nighttime parenting shapes child development.

Measuring Nighttime Responsiveness Using State Space Methodologies

The significant positive correlations across measures of nighttime responsiveness and child outcomes observed in the current study provide support for the use of SSG derived measures in capturing important dimensions of dyadic nighttime interaction, infant sleep, and child development. SSG derived measures were not only correlated with one another but were generally significantly correlated with both summative measures of responsiveness as well as with child internalizing and externalizing behaviors. Taken with the results as a whole, these findings indicate that SSG derived measures of responsiveness can be used to predict infant socioemotional development, potentially above and beyond the measures most commonly used in the literature. Further, these measures can capture meaningful differences in parent nighttime responsiveness to infant distress and non-distress to better understand how each may influence infant development. When coupled with the other significant and near significant findings of the current study, these differences highlight the value of these various SSG derived measures and provide evidence for the theoretical support of their use psychological research (e.g., Hollenstein, 2013).

Of SSG derived measures, the likelihood to respond to non-distress demonstrated the lowest correlation with other measures of responsiveness and was not significantly correlated with maternal reported night waking, duration of response to distress, or the likelihood to respond to distress. However, responsiveness to infant non-distress (as measured through both duration and likelihood to respond to non-distress) at 6 months was positively correlated with both internalizing and externalizing behaviors at 12 months which was not seen with most measures of responsiveness to distress (save for lagged probabilities of response to distress and externalizing). These initial correlations lend support to the idea that responsiveness to distress and non-distress are indeed differentially associated with trajectories of infant socioemotional development. More specifically, in line with the theoretical assumptions derived from studies such as Voltaire & Teti (2018) these results may suggest that, in general, responsiveness to distress, but perhaps not responsiveness to non-distress, promotes adaptive infant socioemotional development.

These results may also suggest that for families with solitary sleeping arrangements for infants, the factors which influence responsiveness to distress are different from those which influence responsiveness to non-distress. For example, responsiveness to distress may be more closely associated with infant behaviors such as bids for attention (e.g., crying) which may be easier for parents to accurately perceive and interpret from another room during the night. This would not only drive heightened responsiveness to distress but would also likely drive parent reports of infant night waking and frequency of nighttime interactions as non-distressed night wakings may be more likely to go unnoticed. Conversely, parent responsiveness to non-distress may be instead driven by factors internal to the parent such as their own internalizing characteristics. This interpretation would not only be in line with evidence in the literature demonstrating maternal depression and anxiety promotes parent initiated infant night wakings (Teti & Crosby, 2012), but may also help to explain the significant differences in patterns of responsiveness to distress and non-distressed night wakings demonstrated in the current data.

Post-hoc analyses of SSG derived measures of responsiveness indicate that responsiveness to distress and non-distress were significantly and substantially different from one another. Paired sample t-tests indicate that the likelihood to respond to non-distress (M = .02) was on average .08 lower than the likelihood to respond to distress (M = .10; t(49) = -4.27, SD = .13, $p < .001$). Conversely, durations of response to non-distress (M = 21.72) were on average 17.86 30-second epochs (or 8.93 minutes) longer than responses to distress (M = 3.86; t(49) = 5.28, SD = 23.909, p = < .001). Together, these results add to the literature though empirically characterizing what typical patterns of dyadic nighttime interaction may look like for populations represented by the current sample: namely, parents are far more likely to respond to infant distress than non-distressed night wakings, however the majority of the time spent in nighttime dyadic interactions are during infant non-distressed states.

Association Between SSG Derived Measures of Responsiveness and Infant Outcomes

As related to predicting infant developmental outcomes, generally (but as will be discussed in more detail), the duration of response as related to both distress and non-distress was the most significantly predictive SSG derived measure of responsiveness. This was followed by the transitional probability of response to both distress and non-distress, and importantly, their respective interactions.

For duration of response measures, this may be due to durations of response tapping into multiple latent and/or unmeasured aspects of the parent child dynamic outside of responsiveness explicitly. For example, child characteristics such as Soothability have not only been associated with sleep problems and difficulty with nighttime parenting interventions infancy (Keener, Zeanah, & Anders, 1988; Molfese et al., 2015) but also longitudinally influence the trajectories of attachment (Mills-Koonce, Propper, & Barnett, 2012), internalizing, and externalizing (Mäntymaa et al., 2012). Likewise, parent characteristics (e.g., anxiety/depression; Teti & Crosby, 2012) and/or specific parenting behaviors (as will be discussed in the limitations below) likely influence durations of response to distress and non-distress during the night as well as longitudinal infant outcomes (Sadeh, 2010). These individual differences were not accounted for in the current study, and as such act as both a limitation in our ability to interpret durations of response as a measure of responsiveness as well as a future direction for further research in disentangling the associations between individual characteristics, nighttime parenting behaviors, and infant socioemotional development.

However, the patterns of significance demonstrated in the current study related to the likelihood to respond to infants during the night and, perhaps more importantly, findings from the exploratory analyses related to the interaction between durations of response and likelihood to respond in predicting infant developmental outcomes significantly expands upon existing measures and contributes to our understanding of nighttime responsiveness. While each result will be discussed in more detail, in sum results of the current study emphasize that in the case of nighttime responsiveness it is not simply if parents respond to infants during the night or for how long parents are present with infants, but a combination of these factors which drives infant development.

Of note, lagged transitional probabilities of response demonstrated the least predictive power of all SSG derived measures. As they were defined and calculated in the current study, these measures were intended to reflect the theoretically informed trajectories of dyadic behavior sitting at the core of most theories of parenting (i.e., infant behavior leading to parent response, in turn leading to modified infant behaviors / affect; Ainsworth et al., 1974; Anders, 1994; Bowlby, 1988; Skinner, 1975). Reviewing the data of individual dyads across the night, these measures were indeed capturing these specific transitions across states. However, in practice, dyadic interactions are rarely as clean-cut as a direct transition across three dyadic states. Instead of the 'child distress' to 'parent present' to 'child soothed' pathway that forms the backbone of responsiveness in theory, real moment-to-moment nighttime interactions see infants shifting back and forth between distress, non-distress, sleep, etc., as they react to parenting behaviors and parents in turn react to changes in their infants. While lagged transitional probabilities did show some ability to predict infant outcomes, it appears they were not sufficiently able to capture the intricate behavior patterns which characterize dyadic nighttime interaction. Future research should seek to employ methods that may better account for these intricacies to improve our understanding of and ability to comprehensively measure dyadic nighttime interactions (for example, adapting more global rate of change measures utilized by researchers such as Cerezo et al., 2017, to fit rates of change across distress and non-distress states during parent-child nighttime interactions).

Predicting Infant Development: SSG Derived Measures and Attachment Outcomes

Overall, findings did suggest an association between SSG derived measures of responsiveness and attachment quality, however this association was not entirely in line with expectations. Contrary to hypotheses, there were no significant associations between any measures of responsiveness to distress and attachment. These findings were unexpected given that "one of the major functions of the attachment system is to provide security and comfort at times of distress …," (Anders, 1994), as well as the well-established links between general responsiveness to distress and higher quality attachment (Leerkes & Zhou, 2018; McElwain & Booth-LaForce, 2006).

It may be the case that this sample is simply more securely attached than would be representative of the overall population, as average AQS scores were within normative ranges but somewhat high (M = .47), and as such they may have been less subject to the influence of responsiveness to distress than would otherwise be expected. However, given that average night wakings in the current sample were in line with normative patterns of development outlined in the literature (i.e., mothers reported infants waking up about once per night; see Ednick et al., 2009) and that total frequency of parent interventions were in line with this average (M frequency of nighttime interactions = 1.68), it may instead be the case that the current sample simply did not vary enough from normative patterns of development to identify any significant associations. Namely, if responding to distress is a normative process in the development of attachment security, and the current sample demonstrated normative patterns of night waking, infant distress, parent responsiveness, and attachment quality, then the lack of significant associations observed may mean that these patterns of behavior reflect normative and appropriate patterns of responsiveness associated with adaptive attachment outcomes. In order to truly understand the association between responsiveness to distress and attachment, future research should seek to target more diverse samples such as those with lower average rates of attachment security and/or amongst infants demonstrating increased sleep disturbances and nighttime distress.

Conversely, the current study did reveal a potentially complex and nuanced association between responsiveness to non-distress and attachment. Initial hypotheses posited that increased responsiveness to non-distress would generally be associated with detrimental self-regulatory outcomes (i.e., higher internalizing and externalizing behaviors), however review of the literature revealed no such clear directional hypothesis for attachment. This directional association was supported when predicting internalizing and externalizing behaviors, however pertaining to attachment results were more complicated.

Before further discussion, it is important to acknowledge that the association between responsiveness to non-distress at 6 months and attachment at 12 months was largely only marginally significant. This limited significance constrains interpretation and generalization of these results beyond the current sample. However, given these results did approach significance and the that current the study specifically aimed to explore the gap in our current understanding of the association between these constructs, it is worthwhile to discuss these findings as they relate to the broader literature and theory.

In line with expectations derived from attachment theory, both the duration of response (marginally) and the likelihood to respond to non-distress (significantly) independently predicted higher infant attachment quality. However, the interaction between the duration of response and likelihood to respond to non-distress instead predicted lower attachment quality ($\beta = -0.14$, $p = .082$), suggesting that the association between responsiveness to non-distress and attachment is more complex than simply interacting more with non-distressed infants during the night. Probing this interaction revealed that the likelihood to respond to non-distress was associated with higher attachment scores when paired with shorter durations of response ($\beta = 1.47$, $p < .05$), as opposed to longer durations ($\beta = .65$, $p = .07$). However, graphing the association between these variables revealed that both high and low durations were associated with decreases in attachment (with steeper decreases for high duration compared to low), and mean durations of response predicted higher attachment scores.

These results could have several implications for understanding how parent responsiveness shapes the development of the attachment bond. At minimum, results once again highlight the value that incorporating various SSG derived measures of responsiveness can provide in exploring infant development; emphasizing that it is not only the duration of responses nor the likelihood to respond to infants but how these characteristics of responsiveness work together that shapes development. Insofar as these findings can be interpreted, results suggest the association between responsiveness to non-distress and attachment may be closer to an inverted U-shaped curve, where average levels of responsiveness to non-distress promotes the development of higher quality attachment. When responsiveness is too high (i.e., no longer appropriate and potentially introducing detrimental effects on sleep quality) or too low (insufficiently responsive to gain the benefits of aspects of attachment like separation and reunion which strengthen the attachment bond), attachment quality may suffer.

These results are intriguing and support continued research into a potential curvilinear relationship between nighttime responsiveness to non-distress and attachment. However, considering these results largely were not statistically significant, substantive interpretation is limited until future research can be conducted. For example, it may also be a possibility that these results instead point to a suppression effect and that other factors (e.g., specific parenting behaviors) may instead be driving this association.

Predicting Infant Development: SSG Derived Measures and Internalizing Outcomes

Results of the current study did not support a robust association between responsiveness to distress and internalizing behaviors. Results did indicate marginal support that the lagged transitional probability of response to distress was associated with internalizing behaviors, however these findings were not significant, not consistent across models, and were at times in the opposite direction from what was anticipated (i.e., higher responsiveness predicts higher internalizing behaviors; $\beta = 9.49$, $p = .09$). Responsiveness to distress as measured through duration of response technically was more frequently associated with internalizing behaviors and associated in the expected direction ($\beta = -3.51$, $p = .06$), however again results were not consistent across models and did not always reach significance. The only significant association between responsiveness to distress and internalizing behaviors was observed in higher duration of response to distress predicting lower levels of internalizing behaviors while controlling for lagged transitional probabilities of response and their interaction, ($\beta = -3.31$, $p = .03$). In contrast, and as expected, higher responsiveness to non-distress was found to significantly predict increased internalizing behaviors across the various models. This was most frequently seen in the duration of response to non-distress, which was significantly positively associated with internalizing behaviors regardless of what other variables were included in the models (see Table 7). This was followed by the likelihood to respond to non-distress which was significantly and positively associated with internalizing on its own ($\beta = 24.14$, $p < .01$), and marginally positively associated with internalizing when accounting for both the duration of response to non-distress and their interaction ($\beta = 33.72$, $p = .09$).

Together these results generally support the hypothesized association between nighttime responsiveness and the development of internalizing behaviors. That is, findings may support the general consensus across theories that responsiveness to nighttime distress is adaptive (or perhaps more accurately, was at least not found to be maladaptive) as related to the development of internalizing behaviors. Further, in line with the ideas of limited responsiveness from graduated extinction theories and evidence on the effects of responsiveness to non-distress impacting sleep quality (Voltaire & Teti, 2018), these results indicate that routine responsiveness to non-distress (i.e., those contexts in which infant's capacity for self-regulation has yet to be surpassed) may indeed hinder infants' self-regulatory development over time. Coupled with the overarching pattern of results in the current study, these findings may help to elucidate where to draw the proverbial line in terms of appropriate nighttime responsiveness to best foster infant self-regulatory development and promote adaptive developmental outcomes.

Predicting Infant Development: SSG Derived Measures and Externalizing Outcomes

Finally, results of the current study indicate that responsiveness to non-distress, most consistently as measured through the duration of response to non-distress as well as the likelihood to respond to non-distress when considered alone, significantly predicted higher externalizing behaviors (see Table 10).

However, as was seen with the development of internalizing behaviors, the association between responsiveness to distress and externalizing was not particularly robust, and what findings were significant were in the opposite direction as was hypothesized. Specifically, the interaction between the duration of response and likelihood to respond to distress, but neither measure independently, predicted higher externalizing behaviors ($\beta = 9.36$, $p = .04$). Probing this interaction revealed that the likelihood to respond to distress was associated with lower levels of externalizing behaviors when paired with shorter durations of response ($\beta = -26.85$, $p = .09$) compared to higher durations of response ($\beta = -2.04$, $p = .79$). Graphing these results further supported this association demonstrating that higher responsiveness to distress, and particularly when paired with longer durations of response, is associated with higher levels of externalizing behaviors. Similarly, lagged transitional probabilities of responsiveness to distress were found to predict externalizing behaviors alone ($\beta = 11.01$, $p = .02$) and when accounting for the duration of response to distress ($\beta = 10.49$, $p = .04$), but not when accounting for the interaction between these variables. Interestingly, and contrary to hypotheses, these lagged transitional probabilities scores also predicted higher, rather than lower, levels of externalizing behaviors.

Given that responsiveness to both distress and non-distress predicted higher externalizing behaviors these findings could support the arguments proposed by extinction / graduated extinction theories (Bruni et al., 2014; Goodlin-Jones et al., 2001; Karraker, 2008; St. James-Roberts et al., 2015) suggesting that parent responsiveness during the night may inadvertently hinder self-regulatory development though promoting infant externalizing behaviors. As related to responsiveness to non-distress, this may reflect an indirect pathway as over time infants turn to externalizing behaviors to elicit previously unprompted parental intervention. As related to responsiveness to distress, these associations may be more complicated. While higher durations of time spent with non-distressed infants during the night predicted increased externalizing behaviors across most models, as related to distress specifically this was only significant in two contexts: the interaction between duration of response and the transitional probability of response, but not either independently, and lagged transitional probabilities of response reflecting parents responding to and soothing distressed infants. Instead of the more direct pathway posited in extinction and graduated extinction theories (i.e., parent responses reinforce infants engaging in externalizing behaviors as a successful regulatory strategy), these results may suggest instead that it is dragging out response times longer than necessary when soothing infant distress which leads to the development externalizing problems. That is, longer response times to infant distress and continued responsive behaviors after infants have been sufficiently soothed may function the same way as responding to non-distress in shaping infant externalizing outcomes. When taken together with the similar patterns of findings demonstrated in predicting attachment quality and internalizing behaviors, these findings emphasize that, generally, shorter durations of parent-child nighttime interactions seem to be associated with more adaptive infant socioemotional outcomes.

However, it is important to note that the association between these variables in the current study is not necessarily causal. Instead, these findings may reflect that infants naturally higher in externalizing behaviors at 6 months simply elicit more responsiveness in general (manifesting as higher responsiveness across contexts during the night) and also may be more likely to exhibit subsequent externalizing behaviors at 12 months. There may also be potentially bidirectional effects driving this association, such that higher general externalizing manifesting higher general rates of nighttime responsiveness compounds natural maladaptive trajectories of developing externalizing behaviors (as has been seen with the development of internalizing behaviors in particularly fearful children other early childhood contexts; Kiel & Buss, 2012). Testing for these effect was outside of the scope of the current study and moreover would likely not be possible using measures such as the ITSEA, as externalizing behaviors during this period of development are difficult to define and this specific scale is only recommended for use in samples between 12 and 36 months (Community-University Partnership for the Study of Children, Youth, and Families, 2011). Future research could instead explore similar, developmentally appropriate measures such as negative affectivity and surgency from the temperament literature, which have been shown to predict internalizing and externalizing behaviors from infancy into toddlerhood (e.g., Gartstein et al., 2012), to assess the extent to which infant characteristics contribute to these dyadic processes.

Additional Limitations

Beyond those mentioned thus far, the current study was subject to a number of limitations. First, it is important to note that all observational measures of responsiveness included in the current study exhibited moderate to heavy skewness (see Table 1), and that not responding or low levels of responsiveness to both distress and non-distress were more common than responses to either. This was particularly true for responsiveness to non-distress, which demonstrated the highest skew and kurtosis of all observed variables. It is unlikely that this was due to any inherent differences in sleep characteristics between the current sample and general population. As noted, estimates of naturalistic patterns of sleep consolidation predict that at this stage in development infants would typically only wake up about once per night (Ednick et al., 2009), and while the current sample was found to actually be slightly higher than that average (e.g., maternal reported night waking over 7 days prior to the study $M = 8.14$), given that night waking is amongst the most variable sleep measures across infancy and early childhood (Galland et al., 2012) the current sample was not significantly outside of expectations. It may instead be the case that these lower levels of responsiveness were driven by parent characteristics and/or beliefs and predispositions towards nighttime responsiveness. As discussed, explicitly not responding to infants during the night comprises a major component of several popular sleep training methods that parents, and particularly parents transitioning into solitary sleeping arrangements for young infants, may engage in (e.g., extinction and graduated extinction; Blunden & Dawson, 2011; Etherton et al., 2016). These parenting beliefs were not controlled for in the current study, however again average responsiveness was generally in line with estimated and demonstrated patterns of sleep consolidation and night waking (*M* frequency of nighttime interactions = 1.68). While steps were taken to account for this skewness, it is unknown the extent to which the current findings were driven by a subset of particularly responsive or otherwise uncharacteristic dyads as opposed to reflecting the general population. Future research should seek to explore the use of these measures in predicting infant development amongst populations with more variability in both night waking and parental responsiveness.

Another limitation of the current study is that the SSG derived measures were based on a single video assessment at one timepoint. This approach may not fully capture the variability of parent responsiveness to infant distress and non-distress during the night, which not only changes discretely from day to day but may change characteristically as children age and the parent-child relationship develops. Further, parent nighttime behaviors including sleep and nighttime responsiveness can be influenced by a factors such as parent stress, parental functioning, and coparenting quality (Kang et al., 2020; Teti, 2017), amongst others, which were not controlled for in the current study. Future research should aim to assess the association between responsiveness and socioemotional development across other, wider periods of child development and should account for other parental factors which may provide a more comprehensive understanding of parent-child nighttime interactions.

Notably, many of the findings discussed thus far approached significance but did not meet the conventional threshold of $p <= .05$. Although the majority of these effects were in line with theoretical predictions, and the scarcity of direct research on these topics underscores the importance of reporting and acknowledging even marginally significant findings to prevent potential file drawer effects, it should be explicitly stated that interpretation of the current findings is limited until replication studies have been conducted. Similarly limiting the generalizability of these findings is the relatively small and homogenous sample included in the current study. Participants predominantly consisted of white, middle-class families with solitary sleeping arrangements for infants specifically at 6 months of age, which may not reflect universal norms. While an effort was made to limit the interpretation and discussion of the current findings to what is supported in the literature, future research is necessary to determine if these patterns of results would replicate in the general population.

Additionally, while most responsiveness measures and attachment quality were assessed through experimenter observation, internalizing and externalizing outcomes were only assessed through maternal report on the ITSEA. Parent reports on these outcomes, and particularly internalizing due to the relative ambiguity of these inward-directed behaviors, have been found to be subject to bias when reported for older children (Kroes et al., 2003), and similar biases have been shown in reporting other emotionally salient information in younger children (Durbin & Wilson. 2012). Moreover, in the current sample internalizing and externalizing were found to be highly correlated with one another ($r = .68$, $p < .001$) and may have been better assessed as a composite ‘behavior problems’ variable than as separate developmental outcomes. Future research on this topic should seek to use alternative, and potentially observational measures of infant self-regulatory outcomes in order to overcome these limitations.

Finally, operationalizing responsiveness solely as parent presence may have been justified for the current study as a first foray into using SSG measures to explore responsiveness to distress and non-distress, but it must be acknowledged that these measures are far from comprehensive. ‘Parent presence’ does not account for the differences between specific parenting behaviors, such as soothing, feeding, attending to infants physically vs non-physically, etc. Accounting for these behaviors would not only provide more insight into the specific processes which drive infant development but may also have helped to clarify the patterns of significance (or lack thereof) demonstrated in the current results. For example, in the case of duration of response and likelihood to respond to distress interacting to predict higher externalizing behaviors it may be that specific parenting behaviors were associated with both increased duration of response and subsequent infant externalizing. As such, next steps in this line of research should be to differentiate specific nighttime parenting behaviors and adapt the current methodology to assess how each may be associated with developmental outcomes as related to responsiveness to infant distress and non-distress. These expansions would not only contribute to our understanding of development and the existing literature but also could generate more detailed evidence-based recommendations for parents and other caregivers than can be provided by the current study.

Conclusion

SSG-derived measures of nighttime responsiveness offer valuable insight into the processes that shape infant socioemotional development, potentially above and beyond the commonly used summative measures of nighttime interaction. Further, nighttime responsiveness to distress and non-distress were found to differentially affect important developmental outcomes. When comparing SSG derived measures of responsiveness, the duration of response, and particularly duration of response to non-distress, emerged as the most consistently influential factor predicting child development, both independently and in interaction with other measures. Results also indicate that transitional probability measures of nighttime responsiveness can be utilized as predictive indicators of developmental outcomes. Lagged transitional probabilities of response aligned with theoretically informed pathways of three-stage dyadic interactions demonstrated some predictive ability, however these measures were not robustly associated with most outcomes and may fail to account for the intricate patterns of behavior which comprise typical parent-child interactions. Together, the current study supports the theoretical assumptions that it is not simply if parents are responsive to infants during the night that shapes longitudinal attachment, internalizing and externalizing outcomes, but when and how parents respond to infant nighttime behaviors. Specifically, responding to distress and not-non distress, and when responding to infants keeping responses short and/or not responding longer than is necessary, may be best for predicting adaptive child outcomes. However, drawing substantive conclusions requires further research using more diverse and non-normative samples, accounting other factors which may influence parent and infant nighttime behaviors, and employing more comprehensive measures of responsiveness which can account for distinct parenting behaviors and more complex trajectories of dyadic behaviors over time.

Appendix

Table 1

Variable Skewness and Kurtosis

Variable	*M*	*SD*	Min	Max	Skewness	Kurtosis
AQS	0.467	0.218	-.085	.751	-0.837	0.126
Externalizing	16.082	8.022	3.09	31.27	0.198	-1.048
Internalizing	20.964	8.673	5.50	39.25	0.075	-0.714
Maternal Reported Infant Night Waking	8.141	6.456	0	25.67	0.816	0.11
Total Frequency of Nighttime Response	1.68	1.867	0	7	1.625	2.292
Duration of Response to Distress	3.86	4.961	0	16	1.341	0.564
Duration of Response to Non-Distress	21.72	25.308	0	85	1.112	0.215
TP Distress	0.112	0.139	0	.5	1.129	0.184
TP Non-Distress	0.019	0.028	0	.25	2.061	4.173
LTP Distress	0.105	0.157	0	.5	1.621	1.666
LTP Non-Distress	0.014	0.022	0	.062	1.423	0.627

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to

Table 2

Imputed Means and Correlations Between Variables

Variable	*Imputed M*	1	2	3	4	5	6	7	8	9	10	11	12
1. Child Sex	NA	1											
2. AQS	.46	0.054	1										
3. Externalizing	16.11	-0.144	0.161	1									
4. Internalizing	20.75	0.103	0.201	0.678**	1								
5. Maternal Reported Night Waking	8.14	-0.329*	0.051	0.22	0.115	1							
6. Total Frequency of Nighttime Response	1.68	-0.389**	0.11	0.188	0.07	0.704**	1						
7. Response to Distress Duration	3.86	-0.385**	-0.017	0.179	-0.156	0.611**	0.521**	1					
8. Response to Non-Distress Duration	21.72	-0.126	0.2	0.376**	0.401*	0.524**	0.441**	0.378**	1				
9. TP Distress	.11	-0.303*	-0.001	0.157	-0.085	0.453**	0.471**	0.748**	0.222	1			
10. TP Non-Distress	.02	0.037	0.208	0.31*	0.316*	0.218	0.379**	0.044	0.351*	-0.005	1		
11. LTP Distress	.11	-0.041	0.067	0.337*	0.144	0.432**	0.369**	0.449**	0.53**	0.307*	0.286*	1	
12. LTP Non-Distress	.01	-0.044	-0.007	0.228	0.039	0.345*	0.411**	0.325*	0.279*	0.164	0.481**	0.551**	1

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, * = p value < .05, ** = p value < .01

Table 3

Summary of Regression Analyses: Summative Measures of Responsiveness at 6 Months Predicting Attachment, Internalizing, and Externalizing at 12 Months

	Regression Summary							
AQS	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.448	0.053	8.446	<.001	.03 - .25	.54 - .93	.00 - .01
	Maternal Reported Infant Night Waking	0.002	0.005	0.342	0.732			
	Intercept	0.44	0.044	9.935	<.001	.32 - .72	.52 - .40	.01 - .02
	Total Frequency of Night Interactions	0.013	0.017	0.762	0.446			
Internalizing	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	19.461	2.072	9.392	<.001	.42 - 1	.32 - .52	.01 - .02
	Maternal Reported Infant Night Waking	0.159	0.2	0.795	0.427			
	Intercept	20.192	1.747	11.555	<.001	.14 - .32	.57 - .72	.00 - .01
	Total Frequency of Night Interactions	0.334	0.69	0.485	0.628			
Externalizing	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	13.813	1.891	7.306	<.001	1.61 – 2.79	.10 - .21	.03 - .06
	Maternal Reported Infant Night Waking	0.282	0.183	1.546	0.122			
	Intercept	14.724	1.601	9.196	<.001	1.16- 2.08	.17 - .29	.02 - .04
	Total Frequency of Night Interactions	0.826	0.632	1.307	0.191			

Note: F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 4

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Distress at 6 Months Predicting Attachment Quality at 12 Months

	Regression Summary							
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.467	0.05	9.406	<.001	.00- 1.02	.32 - .98	.00 - .02
	Response to Distress Duration	-0.003	0.028	-0.119	0.905			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.463	0.046	10.031	<.001	.00 - .317	.58 - .99	.00 - .01
	TP Distress	-0.003	0.147	-0.022	0.982			
	Intercept	0.466	0.051	9.191	<.001	.01 - .54	.59-.99	.00 - .02
	Response to Distress Duration	-0.007	0.041	-0.163	0.871			
	TP Distress	0.025	0.211	0.118	0.906			
	Intercept	0.472	0.057	8.334	<.001	.03 - .44	.73 - .99	.00 - .03
	Response to Distress Duration	-0.014	0.05	-0.279	0.78			
	TP Distress	-0.023	0.318	-0.071	0.943			
	Response to Distress Duration * TP Distress	0.027	0.131	0.21	0.834			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.45	0.042	10.612	<.001	.01 – .57	.46 - .92	.00 - .01
	LTP Distress	0.059	0.132	0.448	0.654			
	Intercept	0.46	0.051	8.976	<.001	.17 - .70	.51 - .85	.01 - .03
	Response to Distress Duration	-0.011	0.032	-0.333	0.739			
	LTP Distress	0.084	0.147	0.574	0.566			
	Intercept	0.468	0.055	8.502	<.001	.17 - .55	.65 - .91	.01 - .04
	Response to Distress Duration	-0.02	0.04	-0.514	0.608			
	LTP Distress	0.007	0.277	0.025	0.98			
	Response to Distress Duration* LTP Distress	0.051	0.151	0.336	0.737			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 5

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Non-Distress at 6 Months Predicting Attachment Quality at 12 Months

	Regression Summary							
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.403	0.054	7.443	<.001	1.54 – 2.16	.15 - .22	.03 - .04
	Response to Non-Distress Duration	0.016	0.011	1.402	0.161			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.422	0.045	9.31	<.001	1.06 – 2.78	.10 - .31	.02 - .05
	TP Non-Distress	0.404	0.284	1.424	0.155			
	Intercept	0.389	0.057	6.849	<.001	.96 – 1.80	.18 - .39	.04 - .07
	Response to Non-Distress Duration	0.011	0.012	0.955	0.339			
	TP Non-Distress	0.306	0.302	1.013	0.311			
	Intercept	0.324	0.068	4.76	<.001	1.44 – 2.33	.09 - .24	.09 - .13
	Response to Non-Distress Duration	**0.028**	0.015	1.841	**0.066**			
	TP Response to Non-Distress	**1.058**	0.531	1.992	**0.047**			
	Response to Non-Distress Duration *TP Non-Distress	**-0.144**	0.083	-1.737	**0.082**			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	0.464	0.041	11.236	<.001	.00 - .83	.37 - .96	.00 - .02
	LTP Non-Distress	-0.024	0.392	-0.061	0.952			
	Intercept	0.41	0.055	7.493	<.001	.88 – 1.84	.17 - .42	.04 - .07
	Response to Non-Distress Duration	0.017	0.012	1.432	0.152			
	LTP Non-Distress	-0.169	0.413	-0.409	0.683			
	Intercept	0.432	0.064	6.766	<.001	.58 - 1.63	.20 - .63	.04 - .10
	Response to Non-Distress Duration	0.01	0.016	0.64	0.522			
	LTP Non-Distress	-0.52	0.742	-0.701	0.485			
	Response to Non-Distress Duration* LTP Non-Distress	0.089	0.14	0.637	0.524			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 6

Probing the Interaction Between Duration of Response to Non-Distress and Transitional Probability of Response to Non-Distress at 6 Months Predicting Attachment Security at 12 Months.

	Regression Summary							
Low Response to Non-Distress Duration	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	.246	.104	2.368	.018	1.43 – 2.23	.09 - .24	.09 - .13
	Response to Non-Distress Duration	.028	.015	1.841	.066			
	TP Response to Non-Distress	1.470	.740	1.986	.047			
	Response to Non-Distress Duration * TP Response to Non-Distress	-.144	.083	-1.737	.082			
High Response to Non-Distress Duration	Variable	*B*	σ	*t*	*p*	*F* range	*Sig range*	R^2 range
	Intercept	.403	.046	8.699	<.001	1.43 – 2.23	.09 - .24	.09 - .13
	Response to Non-Distress Duration	.028	.015	1.841	.066			
	TP Response to Non-Distress	.647	.360	1.798	.072			
	Response to Non-Distress Duration * TP Response to Non-Distress	-.144	.083	-1.737	.082			

Note: TP = Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R2 range = range of regression R2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 7

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Distress at 6 Months Predicting Internalizing at 12 Months

	Regression Summary							
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	22.301	1.937	11.513	<.001	.01- .3.29	.076-.95	.00 - .06
	Response to Distress Duration	-1.058	1.102	-0.96	0.339			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	21.52	1.817	11.846	<.001	.001 – 1.11	.40 - .98	.00 - .02
	TP Response to Distress	-3.223	5.74	-0.561	0.575			
	Intercept	22.185	1.977	11.223	<.001	.008 - 1.71	.99 -.19	.00 - .07
	Response to Distress Duration	-1.424	1.601	-0.889	0.374			
	TP Response to Distress	2.741	8.21	0.334	0.738			
	Intercept	23.922	2.134	11.208	<.001	1.40 – 1.88	.15 - .26	.08 - .11
	Response to Distress Duration	**-3.512**	1.872	-1.876	**0.061**			
	TP Response to Distress	-11.272	11.998	-0.94	0.348			
	Response to Distress Duration * TP Response to Distress	8.044	4.944	1.627	0.104			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	19.694	1.656	11.893	<.001	.46 – 1.77	.24 - .50	.01 - .04
	LTP Response to Distress	5.081	5.151	0.986	0.324			
	Intercept	21.505	1.947	11.047	<.001	1.15 – 3.20	.05 - .22	.05 - .12
	Response to Distress Duration	-1.866	1.204	-1.55	0.123			
	LTP Response to Distress	**9.489**	5.566	1.705	**0.088**			
	Intercept	22.623	2.044	11.067	<.001	2.13 – 2.28	.09 - .11	.12 - .13
	Response to Distress Duration	**-3.312**	1.474	-2.247	**0.025**			
	LTP Response to Distress	-1.904	10.377	-0.183	0.855			
	Response to Distress Duration* LTP Response to Distress	7.47	5.646	1.323	0.186			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R2 range = range of regression R2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 8

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Non-Distress at 6 Months Predicting Internalizing at 12 Months

		Regression summary						
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	16.111	2.003	8.044	<.001	7.67	< .01	.14-.18
	Response to Non-Distress Duration	**1.251**	0.419	2.99	**0.003**			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	18.33	1.726	10.62	<.001	2.89 – 6.58	.01 - .10	.06 - .12
	TP Non-Distress	**24.135**	10.831	2.228	**0.026**			
	Intercept	15.391	2.079	7.403	<.001	5.28 – 6.34	< .01 - .02	.15 - .21
	Response to Non-Distress Duration	**1.032**	0.441	2.342	**0.019**			
	TP Non-Distress	15.294	11.053	1.384	0.167			
	Intercept	13.803	2.539	5.436	<.001	3.06 – 4.68	< .01 - .04	.17 - .24
	Response to Non-Distress Duration	**1.425**	0.561	2.542	**0.011**			
	TP Non-Distress	**33.72**	19.757	1.707	**0.088**			
	Response to Non-Distress Duration * TP Non-Distress	-3.536	3.099	-1.141	0.254			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	20.501	1.635	12.538	<.001	.00 – 1.41	.46 - .93	.46 - .93
	LTP Response to Non-Distress	3.409	15.373	0.222	0.825			
	Intercept	16.411	2.014	8.147	<.001	3.90 – 5.50	.01 - .02	.11 - .16
	Response to Non-Distress Duration	**1.322**	0.453	2.92	**0.004**			
	LTP Non-Distress	-7.603	15.473	-0.491	0.624			
	Intercept	16.003	2.358	6.788	<.001	2.91 – 3.60	.02 - .04	.16 - .19
	Response to Non-Distress Duration	**1.458**	0.595	2.45	**0.014**			
	LTP Non-Distress	-0.999	27.553	-0.036	0.971			
	Response to Non-Distress Duration* LTP Non-Distress	-1.673	5.164	-0.324	0.746			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 9

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Distress at 6 Months Predicting Externalizing at 12 Months

	Regression Summary							
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	14.483	1.784	8.118	<.001	.01 - 4.83	.03 - .94	.00 - .09
	Response to Distress Duration	1.113	1.043	1.067	0.288			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	14.807	1.666	8.888	<.001	.129 – 2.62	.11 - .72	.00 - .05
	TP Distress	5.48	5.324	1.029	0.304			
	Intercept	14.405	1.821	7.912	<.001	.10 – 2.37	.11 - .90	.00 - .09
	Response to Distress Duration	0.864	1.508	0.573	0.567			
	TP Distress	1.863	7.585	0.246	0.806			
	Intercept	16.427	1.93	8.512	<.001	.73 – 3.94	.01 - .54	.05- .20
	Response to Distress Duration	-1.566	1.712	-0.915	0.36			
	TP Distress	-14.446	10.864	-1.33	0.184			
	Response to Distress Duration * TP Distress	**9.361**	4.457	2.101	**0.036**			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	13.817	1.463	9.444	<.001	3.61 – 7.85	.01 - .06	.07 - .13
	LTP Distress	**11.01**	4.605	2.391	**0.017**			
	Intercept	13.604	1.772	7.679	<.001	2.17 – 3.69	.02 - .13	.08 - .16
	Response to Distress Duration	0.219	1.118	0.196	0.845			
	LTP Distress	**10.492**	5.054	2.076	**0.038**			
	Intercept	14.485	1.866	7.762	<.001	1.48 – 4.25	.01 - .23	.09 – .22
	Response to Distress Duration	-0.92	1.349	-0.683	0.495			
	LTP Distress	1.512	9.507	0.159	0.874			
	Response to Distress Duration* LTP Distress	5.887	5.213	1.129	0.259			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 10

Probing Interaction Between Duration of Response to Distress and Transitional Probability of Response to Distress at 6 Months Predicting Externalizing at 12 Months.

	Regression Summary							
Low Response to Distress Duration	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	18.502	3.676	5.033	<.001	.73 – 3.94	.01 - .15	.05 - .20
	Response to Distress Duration	-1.566	1.712	-.915	.360			
	TP Distress	-26.849	15.757	-1.704	.089			
	Response to Distress Duration * TP Distress	9.361	4.457	2.101	.036			
High Response to Distress Duration	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	14.352	2.055	6.984	<.001	.73 – 3.94	.01 - .15	.05 - .20
	Response to Distress Duration	-1.566	1.712	-.915	.360			
	TP Distress	-2.042	7.584	-.269	.788			
	Response to Distress Duration * TP Distress	9.361	4.457	2.101	.036			

Note: TP = Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

Table 11

Summary of Regression Analyses: SSG Derived Measures of Responsiveness to Non-Distress at 6 Months Predicting Externalizing at 12 Months

	Regression Summary							
Duration Only	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	12.091	1.907	6.341	<.001	5.54 – 9.76	< .01 - .02	.10 - .17
	Response to Non-Distress Duration	**1.084**	0.393	2.754	**0.006**			
Duration and Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	13.929	1.666	8.363	<.001	3.41 – 7.59	.01 - .16	.04 - .14
	TP Non-Distress	**21.738**	10.237	2.123	**0.034**			
	Intercept	11.423	1.994	5.727	<.001	2.98 – 6.40	< .01 - .03	.11 - .22
	Response to Non-Distress Duration	**0.88**	0.414	2.125	**0.034**			
	TP Non-Distress	14.2	10.544	1.347	0.178			
	Intercept	11.736	2.467	4.758	<.001	2.01 – 4.26	.01 - .13	.12 - .22
	Response to Non-Distress Duration	0.802	0.535	1.499	0.134			
	TP Non-Distress	10.557	18.983	0.556	0.578			
	Response to Non-Distress Duration * TP Non-Distress	0.699	2.952	0.237	0.813			
Duration and Lagged Transitional Probability	Variable	*B*	σ	*t*	*p*	*F* range	*Sig* range	R^2 range
	Intercept	14.659	1.477	9.924	<.001	.13 – 7.10	.01 - .72	.00 - .13
	LTP Non-Distress	19.61	14.558	1.347	0.181			
	Intercept	11.639	1.879	6.194	<.001	3.66 – 5.24	.01 - .03	.14 - .18
	Response to Non-Distress Duration	**0.977**	0.428	2.282	**0.023**			
	LTP Non-Distress	11.476	15.153	0.757	0.452			
	Intercept	11.167	2.195	5.087	<.001	2.50 – 4.11	.01 - .08	.14 - .21
	Response to Non-Distress Duration	**1.133**	0.555	2.042	**0.041**			
	LTP Non-Distress	19.124	27.612	0.693	0.491			
	Response to Non-Distress Duration* LTP Non-Distress	-1.937	4.999	-0.387	0.699			

Note: TP = Transitional Probability of Response to, LTP = Lagged Transitional Probability of Response to, F range = range of lowest to highest regression F-values across imputations, Sig range = range of regression p values from lowest to highest across imputations, R^2 range = range of regression R^2 values across imputations. Range values provided to give context to regression coefficients but not intended for direct interpretation.

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Curriculum Vita

EDUCATION

PhD. Developmental Psychology
The Pennsylvania State University — 2023 (Expected)
Adviser: Kristin Buss, PhD

Master of Science, Psychology
The Pennsylvania State University — 2020
Adviser: Kristin Buss

B.A Psychology
University of California, Riverside — 2016

TEACHING EXPERIENCE

Instructor, "Basic Research Methods in Psychology"
World Campus — 2022-2023

RELEVANT EXPERIENCE

The Pennsylvania State University
Research Assistant, Human Development and Family Studies Department
Adviser: Douglas Teti, PhD — Apr 2021 - Present

The Pennsylvania State University
Research Assistant, Psychology
Adviser: Kristin Buss, PhD — Aug 2018 - Present

PUBLICATIONS

Zhou, A.M., **Trainer, A.,** Vallorani, A., Fu, K., & Buss, K.A., (2022). Are Fearful Boys at Higher Risk for Anxiety? Person-Centered Profiles of Toddler Fearful Behavior Predict Anxious Behaviors at Age 6. *Frontiers in Psychology, section Personality and Social Psychology 13,* 911913.

Buss, K.A., Zhou, A.M., & **Trainer, A.** (2021). Bidirectional effects of toddler temperament and maternal overprotection on maternal and child anxiety symptoms across preschool. *Depression and Anxiety, 38,* 1201 - 1210.

SELECT PRESENTATIONS

Austen Trainer, Myruski, S., Perez-Edgar, K., Buss, K. A., "*Measuring Attention Bias: Predicting Anxiety in Adolescents Using Eye Tracking, Reaction Time, and EEG Measures.*" Poster Session at the 2023 Society for Research in Child Development Biennial Meeting, Salt Lake City, Utah

Austen Trainer, Buss, K., "*Temperamental Differences in Emotion Regulation: The Role of Maternal Accuracy.*" Poster Session at the 2021 Society for Research in Child Development Biennial Meeting, Virtual, https://www.srcd.org/event/srcd-2021-biennial-meeting

Austen Trainer, Buss, K., "*Maternal Parenting Practices in Toddlerhood Predict Anxiety Symptoms in Early Childhood.*" Poster Session at the 2019 Association for Psychological Science Convention, Washington D.C.