Published in final edited form as:

Attach Hum Dev. 2017 February ; 19(1): 38–57. doi:10.1080/14616734.2016.1252780.

Trajectories of Mothers' Emotional Availability: Relations with Infant Temperament in Predicting Attachment Security

Bo-Ram Kim^a, Sy-Miin Chow^a, Bethany Bray^b, and Douglas M. Teti^a

^aDept of Human Development and Family Studies, The Pennsylvania State University, College of Health and Human Development, University Park, PA 16802

^bThe Methodology Center, College of Health and Human Development, The Pennsylvania State University, University Park, PA 16802

Abstract

The present study examined observations of parenting quality (mothers' emotional availability - EA) during infant bedtimes at 4 points across the infants' first year, assessing relations between levels and trajectories of emotional availability and infant attachment at 12 months and the role of infant temperament in moderating these associations. The sample (N = 128) was predominantly Euro-American (82.5%) and at low socioeconomic risk. Latent growth curve modeling with latent basis coefficients indicated substantial individual differences in initial levels and slopes in EA trajectories across the first year. Both levels of maternal EA and EA trajectories across the first year predicted 12-month infant attachment security. Although maternal EA tended to decrease across the first year in the full sample, EA trajectories that showed a “bounce-back” between 6 and 12 months, suggesting more successful maternal adaptation to an expanding infant developmental repertoire, predicted greater infant security at 12 months. In addition, linkages between latent EA trajectories and 12-month attachment were moderated by 3-month infant temperamental reactivity and regulation. These findings indicate that infant attachment security is sensitive to both static and dynamic aspects of parenting quality across the first year, and that infant temperament can interact with both in predicting infant attachment.

Keywords

Parenting Trajectories; Maternal Emotional Availability; Infant Temperament; Infant Attachment Security

A major tenet of attachment theory is that quality of parenting leads to secure attachments, and insensitive parenting leads to insecure attachments (Ainsworth, Blehar, Waters, & Wall, 1978; Biringen, 2000). Since Mary Ainsworth's seminal study documenting a strong link between maternal sensitivity and attachment security (Ainsworth et al., 1978), there have been many studies examining parental sensitivity as a predictor of attachment security. In contrast to Ainsworth et al.'s (1978) finding of a strong sensitivity-attachment link, subsequent studies have generally found small to medium effect sizes (Cassidy, Jones, &

Shaver, 2013), with some studies finding no association at all (e.g., Lohaus, Keller, Ball, Voelker, & Elben, 2004).

One possible explanation for these inconsistencies is that some studies sampled parenting inadequately, conducting single-point-in-time, relatively brief structured observations, or at most two such observations. Obtaining multiple and more naturalistic observations of mother-child interactions across time (akin to the lengthy observations undertaken by Ainsworth) may present a more representative picture of parenting during the first year and provide a more robust and reliable prediction of infant attachment security. In addition, particular trajectories of parental sensitivity across the infant's first year may reflect parents' capacity to adapt to the rapid changes in infant sleep consolidation that take place across the first year (Teti et al., 2015), and to significant developments in infants' cognitive (e.g., object permanence), socio-emotional (e.g., attachment behavior), and behavioral (e.g., crawling and walking) repertoires during this time (Bornstein, Arterberry, & Lamb, 2014). Trajectories of parenting sensitivity that are stably high or increase across the infant's first year may indicate more successful adaptation to an infant's rapidly changing set of developmental competencies than trajectories of sensitivity that are stably low or that decrease.

A second possible explanation for inconsistent linkages between parental sensitivity and infant attachment may be that this association depends on characteristics of the infant. Increasingly, emphasis is being placed on the role of infant temperament as a moderator of relations between parenting and infant attachment (Roisman et al., 2012). At least two theoretical models informed our approach to this question. One model, the “differential susceptibility” model (Belsky, 2005), posits that children who are more susceptible to environmental influence will react more strongly and more negatively to negative influences (e.g., insensitive parenting), and more strongly and more positively to positive influences (e.g., sensitive parenting) than children who are less susceptible. A second model, the “diathesis-stress” model (Heim & Nemeroff, 1999), views certain child characteristics (e.g., reactivity, negative affectivity) as vulnerabilities, such that children high on these characteristics would be differentially susceptible to poor parenting, compared to less reactive children, but that children with and without such vulnerabilities would respond similarly to parenting of good quality.

Both of these models posit that temperamentally reactive children are more susceptible to rearing influences than less reactive children, and evidence has accumulated in support of both, particularly when predicting from infancy to later childhood (Roisman et al., 2012). It is important to note, however, that the predictability of these models, and perhaps in particular the differential susceptibility model, may depend on the particular aspects of temperament that are considered to constitute “risk” or susceptibility and the specific outcome or phenotype under investigation (Anzman-Frasca, Stifter, Paul, & Birch, 2015; Cassidy, Woodhouse, Sherman, Stupica, & Lejuez, 2011). As van IJzendoorn and Bakermans-Kranenburg (2012) noted, additional work is needed to clarify the individual temperamental characteristics that function as susceptibility factors in response to particular rearing environments. We view the present study as a step in that direction.

Emotional Availability (EA) as an Index of Parenting Quality

In the present study, we drew from emotional availability (EA) theory to assess parenting quality. Parental EA is conceptualized as the parent's "affective attunement" to the child's emotions, needs, and goals (Biringen, 2000; Easterbrooks & Biringen, 2000). Biringen (2000) has conceptualized parental EA as incorporating constructs of sensitivity (awareness and responsiveness to child cues, with affective attunement), structuring (ability to follow child's lead but also scaffold child behavior as needed), non-intrusiveness (being available to the child without disrupting child activities), and non-hostility (the non-use of expressions of frustration, boredom, or anger during interactions with the child). Maternal EA has been found to be predictive of attachment security in infancy and middle childhood in both U.S. and non-U.S. samples (Easterbrooks, Biesecker, & Lyons-Ruth, 2000; Tomlinson et al., 2005; van Bakel and Riksen-Walraven, 2002; Ziv et al., 2000). In addition, studies examining the stability (i.e., consistency of individual differences) and continuity (i.e., consistency of mean levels) of EA across multiple time points during infancy and toddlerhood report moderate stability and continuity (Bornstein et al., 2006a, 2006b, 2010; Lovas, 2005). In addition, at least one study suggested that that improvements in parenting quality in infants' second year and beyond benefited infant attachment, whereas declines in parenting quality led to poorer attachment outcomes (NICHD Early Child Care Research Network (NICHD, 2006).

The present study examined mothers' EA during infants' bedtimes at four time points (3, 6, 9, and 12 months) across their infants' first year of life, independently and conjunction with infant temperamental reactivity, as a predictor of infant attachment security at 12 months. Individual differences in parental EA are quite evident at bedtime (Teti et al., 2010), a time when parents are tasked to promote the infant's ability to down-regulate and separate from the parent for a significant period of time. Although comparatively little is known about parenting during infant sleep contexts, prior work indicates that what parents do in these contexts, and how they do it, bears importantly on infant sleep quality and infant attachment (Anders, 1994). In their cross-sectional study, Teti et al. (2010) reported that individual differences in maternal bedtime EA significantly predicted infants' ability to settle to sleep and to sleep without crying out for the parent during the night among 1-to-24-month-old infants. In an important study, Higley and Dozier (2009) found that maternal responsiveness to infant nighttime distress was predictive of 12-month security of infant-mother attachment, although there is also evidence that benign neglect of infant distress is not necessarily predictive of insecurity (van IJzendoorn & Hubbard, 2000). Benoit, Zeanah, Boucher, and Minde (1992) found that insecure maternal state of mind with respect to attachment was strongly associated with disordered sleep in toddlers. Finally, infant attachment security may also be predictive of infant sleep quality, with at least one study linking insecure-ambivalent attachment in infancy with sleep problems (Morrell & Steele, 2003) and another demonstrating that more secure infants at 15 months of age enjoyed better quality sleep at 24 months than less secure infants (Bélanger, Bernier, Simard, Bordeleau, & Carrier, 2015).

The present study makes use of repeated longitudinal observations of mothers' emotional availability at bedtime to predict infant attachment and examines whether initial levels and change across time in bedtime EA is predictive of infant attachment. As suggested by both

theory and empirical findings (Ainsworth et al., 1978; Teti & Kim, 2014), parenting quality that is consistently high across the first year may be most beneficial to infants in terms of their attachment security. In contrast, consistently low parenting quality was expected to lead to less secure attachment in infants. Further, increases in parenting quality across time were expected to be predictive of more secure attachment, and decreases predictive of less secure attachment, by 12 months. Such expectations are consistent with findings from the NICHD Early Child Care Research Network (NICHD, 2006).

Rothbart's Conceptualizations of Temperament

In the present study, we drew from Rothbart's conceptualization of temperament (Putnam, Ellis, & Rothbart, 2001), which defines temperament as emotional, motor, and attentional reactivity and self-regulation and identifies three higher-order factors of temperament, Surgency/Extraversion, Negative Affectivity, and Orienting/Regulation (Gartstein & Rothbart, 2003). Surgency/Extraversion is identified by high vocal reactivity, engaging with rather than withdrawing from novelty, impulsivity, and strong positive affect (Stifter & Dollar, 2016). Orienting/regulation is identified by the ability to focus attention and regulate behavior and is a developmental precursor to effortful control that first emerges in toddlerhood. Finally, negative affectivity is identified by sadness, fear, anger, distress to limitations, and reduced ability to soothe (Shiner et al., 2012; Stifter & Dollar, 2016). All three of these factors were examined in the present study as potential moderators of relations between mothers' bedtime EA with infants and security of infant-mother attachment at 12 months. Diathesis-stress and differential susceptibility models predict that more reactive, less well-regulated infants would be more susceptible to differential rearing. In terms of Rothbart's superfactors, we viewed high surgency and high negative reactivity to reflect high reactivity, and low orientation/regulation to reflect low regulatory capacity (Stifter & Dollar, 2016; van IJzendoorn & Bakermans-Kranenburg, 2012), and thus we expected that infants high in surgency and negative affectivity and low orientation/regulation would be more susceptible to differential rearing than infants low in surgency and negative affectivity and high in orientation/regulation.

The Present Study

The present study addressed three major questions:

Question 1: What are the patterns of change in maternal bedtime EA between 3 to 12 months of age?

We used a series of latent growth curve models (LGCs) with latent basis coefficients (McArdle, & Bell, 2000) to identify differential patterns of change in bedtime EA across the first year (i.e., no change, increasing, decreasing, or non-linear trajectories).

Question 2: How do between-family differences in maternal bedtime EA and longitudinal change in EA predict infant-mother attachment at 12 months?

Based on prior work, generally higher levels of EA were expected to predict more secure infant-mother attachment at 12 months. In addition, we hypothesized that increasing patterns

of bedtime EA during infants' first year, reflecting positive parental adaptation to the infant's expanding developmental repertoire, would predict more secure attachment, whereas decreasing patterns of bedtime EA, reflecting poorer adaptation, would predict less secure attachment.

Question 3: Does infant temperamental reactivity moderate linkages between first-year maternal bedtime EA and infant-mother attachment at 12 months of age?

We examined whether linkages between mothers' bedtime EA during the first year and 12-month infant-mother attachment would be stronger among highly surgent infants, infants low in orientation/regulation, and infants high in negative affectivity, than among infants low in surgency, low in orientation/regulation, and high in orientation/regulation.

Method

Participants

One hundred and twenty-eight mothers and their infants from a larger NIH-funded study of parenting, infant sleep, and infant development during the first two years of life (R01HD052809), awarded to the fourth author, were included in the present study. A total of 167 mothers were recruited in the larger study from the obstetric floors of the Mt. Nittany Medical Center Mother and Baby Clinic and the Milton S. Hershey Medical Center in central Pennsylvania. All mothers were 18 years or older, of any ethnic background, and fluent in English.

Of the original 167 families recruited, 22 families had dropped from the study between 1 and 12 months of infant age, and 16 families did not have at least two codable video recordings of mother-infant interactions at bedtime across the five assessment occasions (1, 3, 6, 9, and 12 months). Reasons for missing video data included (a) no consent for video recordings ($n = 3$), father-infant interaction only ($n = 2$), inability to complete the home visit protocol due to unspecified life events ($n = 1$), and too little or no mother-infant interaction during bedtime to assess parenting quality ($n = 10$). Finally, one family's data were excluded from model fitting because the mother's EA ratings showed lower EA with little variability across the 12 months compared to the EA ratings of other families in the sample. Comparisons between these 38 families and the 128 families included in the present study sample on sociodemographic variables indicated no significant differences.

In the final study sample, mothers' average age at recruitment was 29.49 years ($SD = 5.22$), 82.5% of mothers were married, 68.6% of mothers had college or graduate degrees, 62.0% of mothers were employed, and the average family income was \$69,827. The sample included 82.5% White, 3.6% African American, 3.6% Asian, 5.4% Latino, and 3.6% other families. Approximately half (53.0%) of the infants were female, and 36.7% were first-borns.

Measures

Socio-demographics—Parents at recruitment completed a socio-demographic questionnaire that inquired about educational attainment, yearly family income, parental age, partner status (live-in partner vs. no live-in partner) and family size.

Infant sleep arrangements—The Sleep Practices Questionnaire (SPQ) (Goldberg & Keller, 2007) was used at each age point to obtain information from parents about their infants' sleep arrangements. Mothers responded to the SPQ item: “Where does your baby usually sleep at night?” At each age point, four sleep arrangement categories were scored: Solitary sleep (infant slept in a separate room), room sharing (infant slept in the same room as parents, but on a separate sleeping surface), bed sharing (infant slept in the same bed as parents), and combination (infant's sleep arrangement varied across the night). Use of solitary sleep increased from 54% at 3 months to 74% by 12 months. Conversely, use of co-sleeping arrangements (room sharing, bed sharing, or combination) decreased from 46% at 3 months to 26% at 12 months.

Infant temperament (3 months)—Infant temperament was measured when infants were 3 months of age using the Infant Behavior Questionnaire–Revised (IBQ-R; Rothbart & Gartstein, 2000). Mothers rated each of the 191 items on a 7-point scale, in which 1 indicates their infant “never engages in the behavior”, and 7 indicates their infant “always engages in the behavior”. Three temperament factors can be obtained from 14 subscales: Surgency/extraversion is comprised of the subscales of approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level, and perceptual sensitivity ($\alpha = .80$); Orienting/regulation is the combination of the subscales of low intensity pleasure, cuddliness, duration of orienting, and soothability ($\alpha = .56$; Gartstein & Rothbart, 2003); and negative affectivity includes the subscales of sadness, distress to limitations, fear, and falling reactivity (reverse coded; $\alpha = .64$).

Maternal EA during infant bedtime (3, 6, 9, and 12 months)

The present study examined parenting quality during the less-studied naturalistic context of infant bedtimes. Home visits were conducted by project staff when infants were 3, 6, 9, and 12 months old to obtain video recordings of infant bedtime interactions. Although EA ratings were also available at 1 month, only EA data from 3 months and beyond were used for modeling purposes because the IBQ-R, used to assess infant temperament, is not designed to be used any earlier than 3 months of age. In addition, we wished to have our first assessment of EA to coincide with our measurement of infant temperament to enable clearer interpretation of our modeling analyses. The digital video recording system included a Bosch Divar XF digital video recorder, Infrared Color CCD night-vision cameras, Channel Vision 5104 microphones, and a portable DVD player. Up to four cameras were set up in the room where the infant slept, and another room (e.g., living room) if parents reported that they took the infant there for any part of bedtime. The cameras overlooked the infant's sleep location (e.g., bassinet, crib, or parents' bed), a chair/sofa used for bedtime activities such as feeding, and/or a changing table. Camera and microphone setup was done by project staff during the afternoon of the day of the recording but were not present during the recording itself. Parents were instructed to start the recording (turning on the switch on a surge strip)

approximately one hour before they began bedtime with their infant, and to end the recording when the infant woke up in the morning.

The four dimensions of EA – sensitivity, structuring, non-intrusiveness, and non-hostility – were used to score EA in the present study and were adapted according to criteria established in Teti et al. (2010) to code interactions during infant bedtime. Sensitivity, scored on a 9-point scale (9 = highly sensitive, 5 = inconsistently sensitive, 1 = highly insensitive) was scored highly if mothers responded accurately, appropriately, and promptly to their infants' emotional and behavioral cues during bedtime activities, but lower scores if mothers missed infant signals either to interact or signals indicating that the infant was drowsy, and if they responded non-contingently and/or inappropriately to infant cues. Structuring, scored on a 5-point scale (5 = optimal structuring, 3 = inconsistent structuring, 1 = inadequate structuring) received high scores if mothers used quiet and calming bedtime routines that gently guided infants toward sleep, but lower scores if mothers either showed repetitive attempts that were not successful in guiding their infants toward sleep, or left their infants unattended for longer than a few minutes. Non-intrusiveness, or the parent's availability to the child without being intrusive (5 = non-intrusive, 3 = inconsistently intrusive, 1 = highly intrusive), received high scores if mothers did not interfere with their infants as they settled to sleep, and lower scores if mothers initiated new interactions that disrupted the infant as s/he was falling asleep. Lastly, non-hostility, or the parent's non-use of hostility, either overtly or covertly, during interactions with the infant (5 = no hostility observed, 3 = covertly hostile, 1 = overtly hostile), received high scores if mothers never expressed frustration or hostility toward the infant during bedtimes, and lower scores displayed boredom, impatience, sarcasm, or anger in response to their infants.

The first and fourth authors who were certified to use the Emotional Availability Scales (Biringen, Robinson, & Emde, 1998) and blind to the other study variables coded the bedtime interactions. Adequate inter-rater reliability was established using sets of randomly-selected non-overlapping tapes at each time point (intraclass correlations ranged from .80 to 1.00). At each time point, composite EA scores were created by combining the standardized z-scores of the four EA dimensions (Cronbach's alphas ranged from .75 to .84).

Infant attachment security (12 months)—At the 12-month home visit, coders blind to all other observational data observed mothers and infants for 1.5 to 2 hours to assess infant attachment security using the Attachment Q-Set procedure (AQS; Waters, Vaughn, Posada, & Kondo-Ikemura, 1995). Coders sorted the 90 items of the Q-Set into nine stacks distributed from least (very much unlike the child) to most characteristic (very much like the child) of the infant. A security score for each infant was obtained by correlating the distribution of AQS scores for that infant with a security criterion sort for the hypothetically most secure child, provided by a variety of attachment experts. AQS scores ranged from $-.38$ to $.75$, with a sample mean of $.41$ ($SD = .22$, range: $-.38$ to $.75$), which is consistent with AQS distributions obtained from a variety of other relatively low-risk samples (Waters, Vaughn, & Teti, in press). The intraclass correlation (absolute agreement) for rater pairs on 145 observations in the larger study was $.95$.

Results

Descriptive Statistics

Table 1 presents descriptive statistics and zero-order correlations for all variables used in model fitting. Consistent with earlier work (Bornstein et al., 2006a, 2006b; Lovas, 2005), moderate-to-strong stability was found between mothers' EA from 3-to-12-months. The intraclass correlation (ICC) of EA (0.50) was obtained by computing the ratio between the intercept variance and the sum of intercept and measurement error variance in an intercept-only growth curve model (Streiner, & Norman, 1995), indicating substantial individual differences in EA scores across the infant's first year.

Surgency/extraversion at 3 months was negatively correlated with EA at all time points, $r_s = -.26$ to $-.43$, all $p_s < .05$; negative affectivity at 3 months showed non-significant negative correlations with EA at all time points, and regulation at 3 months showed non-significant correlations with EA at all time points except with EA at 12 months, $r = .25$, $p < .05$.

Independent t -tests indicated no significant gender differences in temperament at 3 months, attachment security, and mothers' EA across all months. In addition, there were no significant differences in attachment security between solitary-sleeping and co-sleeping infants at any age point. Of the temperament factors, only surgency/extraversion was significantly correlated, albeit weakly, with attachment security, $r = -.22$, $p < .05$. In addition, longer infant bedtime lengths at 3 months, defined as the interval of time parents began bedroom interactions to the time the infant was asleep without being held for at least 5 minutes (range = 1.17 to 319.47 minutes, $M = 71.11$, $SD = 65.62$), was negatively associated with infant attachment, $r(95) = -.26$, $p < .05$ and EA from 3 through 12 months ($r_s = -.24$ to $-.41$, $p_s < .05$) and positively associated with surgency at 3 months, $r(93) = .28$, $p < .05$. Thus, length of bedtime at 3 months was included in analyses predicting 12-month infant attachment.

Tests of Key Questions

A plot of the family-specific observed EA trajectories between 3 and 12 months (Figure 1A) confirmed the presence of substantial between-individual differences in the change trajectories of maternal EA during the infants' first year. The descriptive statistics in Table 1 further suggest that at the group level, the mean levels of EA had sustained declines between 3 and 9 months, followed by a slight increase (or stabilization) in EA from 9 to 12 months.

Question 1: What are the patterns of change in EA between 3 to 12 months of age?—We used a latent growth curve model (LGCM) with estimated slope or basis coefficients (McArdle, & Bell, 2000) to represent the families' trajectories of EA across the infant's first year. All model fitting was performed using Mplus version 7 (Muthén & Muthén, 1998-2012). The path diagram for the LGCM with latent basis coefficients, denoted below as *Model 1*, is shown in Figure 2. Observed variables are depicted as squares whereas latent variables are shown as circles. As depicted in Figure 2, the model adopted in the present study included the usual “*Intercept*” factor whose loadings on the manifest EA ratings were fixed at 1 as in standard linear growth curve models (e.g., Bryk, & Raudenbush,

1987). In contrast to linear growth curve models, only two of the four loadings for the latent “*Slope*” (or basis) factor were fixed for identification purposes (at 0 and 1, respectively, for loadings associated with the 3- and 12-month EA ratings, respectively). Freeing up the remaining loadings or basis coefficients as parameters allowed the estimated curves to better tailor to the nonlinear patterns of EA evidenced in Figure 1A and Table 2. We then proceeded to conduct a targeted test of whether EA demonstrated increasing, decreasing, or non-linear trajectories across age within families by examining the estimated values of the loadings, λ_2 and λ_3 . These loadings, together with the fixed loadings, depict the average within-family change patterns in EA.

The fit indices for fitting Model 1 suggested a less than satisfactory fit to the data (χ^2 test of model fit = 22.25 with 6 degrees of freedom (dfs); RMSEA = .15 with 90% CI = [.08, .21]; CFI = .82; TLI = .82). The only statistically significant source of misfit stemmed from the need to allow the residual variance for 9-month EA ratings to differ from the residual variance characterizing other time points. Inspection of the observed EA ratings in Figure 1A confirmed the presence of notably greater between-family heterogeneities in EA level at 9 months compared to other months (including 12 months). The increased heterogeneity at 9 months may reflect the increased demands placed on parenting in response to a significant expansion of infants' behavioral repertoire at 9-months compared to earlier age-points, including enhanced attention and memory, and developments in motor (e.g. crawling), cognitive-linguistic (e.g., language and object permanence), and socio-emotional domains (e.g., separation and stranger anxiety (Bornstein et al., 2014). Allowing the residual variance at 9 months to differ from that associated with other time points led to a notable improvement in fit ($\chi^2 = 14.69$ with 1 df). The value of λ_3 and the covariance between the intercept and slope factors were not estimated to be significantly different from zero. Fixing these parameters to zero to improve model parsimony and aid model convergence led to a model with satisfactory fit ($\chi^2 = 8.36$ with 7 dfs; RMSEA = .04 with 90% CI = [.00, .12]; CFI = .99; TLI = .99). The value of λ_2 was estimated to be negative and significantly different from zero ($\hat{\lambda}_2 = -0.41$; $SE = 0.16$, $p < .05$). The remaining parameter estimates, as summarized in Table 2 in the column labeled Model 1, suggested that the estimated average EA intercept, $\hat{\mu}_I = 19.09$ ($SE = 0.22$, $p < .01$), but not the estimated average EA slope, $\hat{\mu}_S = -0.38$ ($SE = 0.27$, $p > .05$), was statistically significant from zero. Substantial between-family differences were found, as indicated by the statistically significant variances of the intercept as well as slope.

Collectively, these estimates produced the model-implied predicted trajectories shown in Figure 1B. With negative values of $\hat{\lambda}_2$ and $\hat{\mu}_S$, the average EA trajectory implied by Model 1 (see the thick solid line in Figure 1B) was estimated to be relatively flat, with slight increase at 6 months and a more noticeable drop at 12 months. If $\hat{\mu}_S$ was fixed to be exactly zero, the group-average EA trajectory would be completely flat, even though substantial between-family heterogeneities would still be present (as seen from differences in the family-specific trajectories). Based on the estimated loading values, the “*Slope*” factor implicated in Model 1 may be interpreted as a latent deviation or change factor summarizing the family-specific deviations in maternal EA at 6 and 12 months compared to the remaining months (3 and 9 months). Families with higher (i.e., more positive) estimated scores on this deviation factor would thus show decreases in EA ratings at 6 months relative to 3 and 9 months, followed

by substantial increases (or “bounce back”) in EA from 9 to 12 months (see e.g., the 3 lowest predicted trajectories in Figure 1B). In contrast, families with lower (i.e., more negative) estimated scores on this deviation factor would show increases in EA at 6 months relative to 3 and 9 months, followed by clear decreases in EA from 9 to 12 months (see e.g., the family whose predicted trajectory produced the lowest predicted EA score at 12 months in Figure 1B).

Question 2: How do between-family differences in EA and longitudinal change in EA predict infant-mother attachment at 12 months?—To address question 2, we

added the modifications enclosed in the dashed box in Figure 2 to Model 1 to yield Model 2. Specifically, we added attachment security as an outcome variable (shown as “*AQS 12 mo*” in Figure 2) and the length of infant bedtime (shown as “*Bedtime 3 mo*”) as another potential predictor of attachment security. Parameter estimates from fitting Model 2 are summarized in Table 2. Consistent with expectations, higher EA scores at 3 months of infant age were found to be related to higher AQS scores ($\hat{\beta}_{I \rightarrow AQS} = 0.04$, $SE = 0.01$, $p < .01$). Also consistent with expectations, greater positive deviations (i.e., “bounce back”) in EA at 12 months relative to the earlier months were associated with higher attachment security ($\hat{\beta}_{L \rightarrow AQS} = 0.05$, $SE = 0.01$, $p < .01$). Despite the significant negative correlation between infant bedtime at 3 months and attachment security at 12 months, the former was not found to be a significant predictor of the latter once the EA-related growth curve factors were included as predictors ($\hat{\beta}_{\text{Bedtime} \rightarrow AQS} = 0.00$, $SE = 0.00$, $p > .05$). Infant bedtime was thus omitted from our subsequent model for addressing question 3.

Question 3: Does infant temperamental reactivity moderate linkages between first-year maternal EA and infant-mother attachment at 12 months of age?—To

test whether infant temperamental reactivity moderated the relations between individual differences in EA-related growth curve factors and infant attachment security at 12 months, we included the temperament factors surgency/extraversion, negative affectivity and regulation as moderators. That is, in Model 3, we specified the regression paths, $\beta_{I \rightarrow AQS}$ and $\beta_{\text{Slope} \rightarrow AQS}$ from the intercept and deviation factors to AQS, respectively, to each be a function of the temperament subscales as:

$$\beta_{I \rightarrow AQS_i} = \beta_{I \rightarrow AQS,0} + \beta_{I \rightarrow AQS,1} \text{Surgency}_i + \beta_{I \rightarrow AQS,2} \text{Neg}_i + \beta_{I \rightarrow AQS,3} \text{Regulation}_i,$$

$$\beta_{\text{Slope} \rightarrow AQS_i} = \beta_{\text{Slope} \rightarrow AQS,0} + \beta_{\text{Slope} \rightarrow AQS,1} \text{Surgency}_i + \beta_{\text{Slope} \rightarrow AQS,2} \text{Neg}_i + \beta_{\text{Slope} \rightarrow AQS,3} \text{Regulation}_i,$$

where $\beta_{I \rightarrow AQS,0}$ is an intercept representing the predicted effect of the EA intercept on attachment security for individuals with average surgency, negative affectivity (*Neg*) and regulation; and $\beta_{\text{Slope} \rightarrow AQS,0}$ is an intercept representing the predicted effect of the EA “slope” (or more accurately, deviation factor) on attachment security for individuals with average scores on the three temperament dimensions. The remaining parameters in the equation, including $\beta_{I \rightarrow AQS,1}$ to $\beta_{\text{Slope} \rightarrow AQS,3}$, helped reveal the extent to which different temperament characteristics moderated the effects of the growth curve factors on AQS.

Based on the postulates of question 3, which suggested that families with more reactive and dysregulated infants would show disproportionately greater risks for lower attachment security when paired with mothers with lower initial EA and/or greater drop in EA, we expected the values of $\beta_{I \rightarrow AQS,1}$, $\beta_{I \rightarrow AQS,2}$, $\beta_{Slope \rightarrow AQS,1}$ and $\beta_{Slope \rightarrow AQS,2}$ to be positive and significantly different from zero, and the values of $\beta_{I \rightarrow AQS,3}$ and $\beta_{Slope \rightarrow AQS,3}$ to be negative and significantly different from zero.

Results from fitting Model 3 (see Table 2) indicated that none of the temperament subscales were significant moderators of the effect of EA intercept on attachment security. However, surgency was found to be a significant positive moderator of the effect of the deviation factor on attachment security ($\beta_{Slope \rightarrow AQS,1} = 0.044$; $SE = 0.020$; $p < .05$). That is, a low score on the EA slope or deviation factor – corresponding to a low “bounce back” or sharp decline in maternal EA at later months -- would put highly surgent infants at disproportionately higher risks for lower attachment security compared to infants with low surgency. In contrast, in cases with high EA slope or deviation factor scores (corresponding to high “bounce back” or gain in EA at later months), highly surgent infants were predicted to have higher attachment security than low-surgency infants (see Figure 3A). Tests of significant differences between the data points could not be done, however, because the standard error of this difference contained variability from multiple sources, including SEs in the intercept and deviation factor score estimates, SEs of other pertinent parameter estimates, as well as their multiplicative effects.

Similarly, we found a significant negative effect of regulation in moderating the influence of the deviation factor on attachment security ($\beta_{Slope \rightarrow AQS,3} = -0.068$; $SE = 0.033$; $p < .05$). Specifically, highly dysregulated infants (i.e., those with low scores on the regulation subscale of the IBQ) – just as infants with high surgency – appeared to benefit more from greater “bounce back” in maternal EA at later months but showed disproportionately higher risk for low security if paired with mothers who showed a low “bounce back” or sharp decline in maternal EA at later months (see Figure 3C).

Finally, contrary to our expectation, we found a marginally significant negative moderating effect of negativity affectivity ($\beta_{Slope \rightarrow AQS,2} = -0.059$; $SE = 0.031$; $p < .06$). Specifically, we found that infants with high negative affectivity did not appear to benefit from higher scores on the EA deviation factor (i.e., greater “bounce back” or gain in maternity EA): infants with low – as opposed to high – negative affectivity were the ones predicted to have disproportionately higher attachment security when paired with higher scores on the EA deviation factor (see Figure 3B).

Discussion

In the present study, we identified substantial variability in overall levels of EA and in longitudinal patterns of EA, and that these patterns were meaningfully predictive of 12-month attachment security. We also found evidence of moderation of EA-attachment linkages by broad-based dimensions of temperament derived from Rothbart's temperament model.

Question 1: What are the patterns of change in EA between 3 to 12 months of age?—We identified substantial individual differences both in level of bedtime EA, significant stability of EA from 3 to 12 months, and individual differences in longitudinal trajectories of EA across the first year. The plot of raw EA scores from 3 to 12 months (Figure 1A) indicated that, for the sample as a whole, maternal bedtime EA decreased on average across the first year. This finding is consistent with an earlier report, based on cross-sectional sample of infants from 1 to 24 months, that infant age related inversely to mothers' bedtime EA (Teti et al., 2010). We believe the downward trend of bedtime EA across the first year is normative and can be explained by the increasing demands placed on parenting by an ever-expanding infant behavioral repertoire across the first year. Particular developments emerge between 6 and 9 months of age (e.g., mobility, separation and stranger distress) (Bornstein et al., 2014) that may require new adaptations on the part of the parent that may or may not proceed smoothly. Indeed, there was increased variability in maternal bedtime EA observed in 9-month EA in the present study, relative to other infant age-points, and this increase needed to be taken into account to improve model fit for the longitudinal trajectories of maternal EA. We believe this increased variation in mothers' 9-month bedtime EA is a reflection of mothers' differential adaptation to emergent developmental capacities in infants between 6 and 9 months.

It is important to note, however, that longitudinal trajectories of EA were quite variable and suggested differential maternal adaptation to infants' emerging developmental competencies across the first year. The individual differences in these curvilinear trends proved to be important in predicting infant attachment security at 12 months.

Question 2: How do between-family differences in EA and longitudinal change in EA predict infant-mother attachment at 12 months?—Latent growth curve analyses revealed that, as expected, mothers' overall levels of EA at bedtime were positively predictive of infant-mother attachment security at 12 months. This finding is consistent with a plethora of studies identifying maternal EA, and maternal sensitivity more generally, as a significant predictor of quality of attachment in infancy (Ainsworth et al., 1978; Cassibba, van IJzendoorn, & Coppola, 2012; Weinfield, Sroufe, Egeland, & Carlson, 2008). Of special interest in this study were the findings that infants of mothers' whose EA increased between 6 and 12 months (i.e., a “bounce-back” between 6 and 12 months) were significantly more likely to be more securely attached at 12 months, compared to infants of mothers whose EA did not bounce back. These findings supported our belief that (a) developmental trajectories of parenting competence contribute uniquely to the prediction of children's developmental outcomes, and (b) these trajectories provide insights into individual patterns of parental adaptation across the infants' first year. Our data suggest that a mother's ability to adapt to emergent developmental capacities in infants between 6 and 12 months may be an important predictor of infant socio-emotional development by the end of the first year.

Question 3: Does infant temperamental reactivity moderate linkages between first-year maternal EA and infant-mother attachment at 12 months of age?—A final set of latent growth curve analyses revealed that, whereas infant temperament dimensions of surgency/extraversion, orientation/regulation, and negative affectivity did not

moderate linkages between level of EA and 12-month infant attachment, all three of these dimensions were found to moderate relations between *longitudinal trajectories* of EA and attachment. The fact that moderation by infant temperamental characteristics was obtained with trajectories of parenting, but not initial levels of parenting, lends further support to the need to study parenting dynamically to gain a better understanding of how parenting impacts child development uniquely and in interaction with child characteristics. The nature of the moderation supported the hypothesis that more reactive infants (i.e., high in surgency/extraversion) and less well-regulated infants (i.e., low in orientation/regulation) would be more responsive to parenting differences than less reactive infants. Among infants high in surgency/extraversion and infants low in orientation/regulation, greater bounce back in mothers' bedtime EA in later months was predictive of high AQS scores at 12 months, whereas less bounce back in mothers' bedtime EA across this same time period was predictive of low 12-month AQS scores (Figures 3A and 3C). However, because significance tests were not possible our observed patterns of mean differences did not definitively clarify whether the differential susceptibility or the diathesis-stress theory was a better description of the data. According to differential susceptibility, highly reactive (high surgency, high negative affectivity, low regulation) infants would show substantially higher attachment security than less reactive infants under the care of parents with high EA. This would be reflected in patterns of mean differences similar to what are shown in Figures 3A and 3C, except that larger reversal in mean difference might be expected between highly reactive and less reactive infants with greater increase in EA in later months. By contrast, the diathesis-stress hypothesis would predict no difference in attachment security between highly reactive and low reactive infants in the presence of large increases in EA in later months. From visual inspection, it was clear that larger predicted mean differences in AQS scores were found between infants high vs. low in surgency/extraversion and between infants high vs. low in orientation/regulation when mothers were low in bedtime EA, compared to corresponding mean differences when maternal bedtime EA was high. Our patterns of mean differences were in line with those predicted by the differential susceptibility theory; but one might also argue that the mean differences were not salient enough to completely negate the diathesis-stress theory. The plots in Figures 3A and 3C appeared to correspond well to what Roisman et al. (2012) characterized as “visually ambiguous” (p. 391).

Moderation patterns obtained for infant negative affectivity approached but did not exceed conventional levels of significance ($p = .06$), and thus they must be interpreted with caution. As seen in Figure 3B, infants low in negative affectivity seemed more strongly affected by differential change in maternal EA over time than infants high in negative affectivity, with positive change in EA associated with higher AQS scores and negative change in EA associated with lower EA scores. As with moderation analyses involving surgency/extraversion and orientation/regulation, pairwise tests of significance could not be performed, and the plot in Figure 3B again appeared to be visually ambiguous. It may be the case that infant negative affectivity is not a susceptibility factor in response to individual differences in level or change in bedtime parenting quality but may become a susceptibility factor in response to parenting quality in other contexts. Regardless, these findings appear to be consistent with Conradt, Measelle, & Ablow (2013) premise that, in some cases, individuals who can engage effectively with the environment can in some circumstances be

more susceptible to rearing influences than individuals who cannot. We echo van IJzendoorn and Bakerman-Kranenburg's (2012) call for more research to identify specific environmental-susceptibility factor pairings in infancy and subsequent developmental periods.

Limitations

The findings of the present study are based on a largely homogenous sample of low-risk, middle-class families, and thus generalizability to more diverse populations is limited. In addition, it is possible that the roles of temperament would continue to evolve and change during the first year of an infant's life, and we did not consider such longitudinal changes and possible interactive relations with parenting. Despite these limitations, strengths of the study include naturalistic observations of parenting quality obtained at multiple times during the infant's first year during the less-studied context of infant bedtime.

Conclusions and Future Directions

The present study is the first to demonstrate that trajectories of parenting quality at bedtime across the first year of life predict infant attachment security at 12 months. Both the mean levels and changes in emotionally available parenting at bedtime predicted more secure attachment, and linkages between change trajectories in maternal EA and infant attachment were moderated by infant temperamental characteristics. Additional work is needed to identify susceptibilities in infancy, in combination with specific rearing environments and longitudinal changes in these environments in predicting infant and child outcomes.

Acknowledgments

This paper was supported by a grant from the National Institute of Health and Human Development, R01 HD052809, awarded to the 4th author. We thank Corey Whitesell, Cori Reed, and Renee Stewart for their hard work in coordinating this project. Special thanks are given to the participating families.

References

- Ainsworth, M., Blehar, MC., Waters, E., Wall, S. Patterns of attachment: A psychological study of the strange situation. Hillsdale, NJ: Erlbaum; 1978.
- Anders TF. Infant sleep, nighttime relationships, and attachment. *Psychiatry*. 1994; 57:11–21. [PubMed: 8190824]
- Anzman-Frasca S, Stifter CA, Paul IM, Birch LL. Negative temperament as a moderator of intervention effects in infancy: Testing a differential susceptibility model. *Prevention Science*. 2014; 15(5):643–653. DOI: 10.1007/s11121-013-0408-4 [PubMed: 23832637]
- Belsky, J. Differential susceptibility to rearing influences: An evolutionary hypothesis and some evidence. In: Ellis, B., Bjorklund, D., editors. *Origins of the social mind: Evolutionary psychology and child development*. New York: Guildford; 2005. p. 139-163.
- Benoit D, Zeanah CH, Boucher C, Minde KK. Sleep disorders in early childhood: Association with insecure maternal attachment. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1992; 31(1):86–93. [PubMed: 1537786]
- Biringen Z. Emotional availability: Conceptualization and research findings. *American Journal of Orthopsychiatry*. 2000; 70:104–114. DOI: 10.1037/h0087711 [PubMed: 10702855]
- Biringen Z, Emde RN, Brown D, Lowe L, Myers S, Nelson D. Emotional availability and emotional communication in naturalistic mother–infant interactions: Evidence for gender relations. *Journal of Social Behavior & Personality*. 1999; 14(4):463–478.

- Biringen, Z., Robinson, J., Emde, RN. Emotional availability scales. 3rd. Department of Human Development and Family Studies, Colorado State University; Fort Collins, CO: 1998. Unpublished manual
- Bornstein, MH., Arterberry, ME., Lamb, M. Development in infancy: A contemporary introduction. 5th. New York, NY, US: Psychology Press; 2014.
- Bornstein MH, Gini M, Putnick DL, Haynes OM, Painter KM, Suwalsky JTD. Short-term reliability and continuity of emotional availability in mother-child dyads across contexts of observation. *Infancy*. 2006a; 10:1–16. DOI: 10.1207/s15327078in1001_1
- Bornstein MH, Gini M, Suwalsky JTD, Putnick DL, Haynes OM. Emotional availability in mother-child dyads: Short-term stability and continuity from variable-centered and person-centered perspectives. *Merrill-Palmer Quarterly*. 2006b; 52(3):547–571. DOI: 10.1353/mpq.2006.0024
- Bornstein MH, Suwalsky JTD, Putnick DL, Gini M, Venuti P, de Falco S, Zingman de Galperin C. Developmental continuity and stability of emotional availability in the family: Two ages and two genders in child-mother dyads from two regions in three countries. *International Journal of Behavioral Development*. 2010; 34(5):385–397. DOI: 10.1177/0165025409339080 [PubMed: 20824179]
- Bryk AS, Raudenbush SW. Application of hierarchical linear models to assessing change. *Psychological Bulletin*. 1987; 101:147–158. doi:apa.org/journals/bul/101/1/147.pdf.
- Cassibba R, van IJzendoorn MH, Coppola G. Emotional availability and attachment across generations: Variations in patterns associated with infant health risk status. *Child: Care, Health and Development*. 2012; 38(4):538–544. doi:http://dx.doi.org/10.1111/j.1365-2214.2011.01274.x.
- Cassidy J, Jones JD, Shaver PR. Contributions of attachment theory and research: A framework for future research, translation, and policy. *Development and Psychopathology*. 2013; 25(4):1415–1434. doi:http://dx.doi.org.ezaccess.libraries.psu.edu/10.1017/S0954579413000692. [PubMed: 24342848]
- Cassidy J, Woodhouse SS, Sherman LJ, Stupica B. Enhancing infant attachment security: An examination of treatment efficacy and differential susceptibility. *Development and Psychopathology*. 2011; 23:131–148. DOI: 10.1017/S0954579410000696 [PubMed: 21262044]
- Conradt E, Measelle J, Ablow JC. Poverty, problem behavior, and promise: Differential susceptibility among infants reared in poverty. *Psychological Science*. 24(3):235–242. DOI: 10.1177/0956797612457381
- Easterbrooks MA, Biesecker G, Lyons-Ruth K. Infancy predictors of emotional availability in middle childhood: The roles of attachment security and maternal depressive symptomatology. *Attachment and Human Development*. 2000; 2(2):170–187. DOI: 10.1080/14616730050085545 [PubMed: 11707909]
- Easterbrooks MA, Biringen Z. Guest editors' introduction to the special issue: Mapping the terrain of emotional availability and attachment. *Attachment and Human Development*. 2000; 2(2):123–129. DOI: 10.1080/14616730050085518 [PubMed: 11707906]
- Emde, R. Emotional availability: A reciprocal reward system for infants and parents with implications for prevention of psychosocial disorders. In: Taylor, PM., editor. *Parent-infant relationships*. Orlando, FL: Grune & Stratton; 1980. p. 87–115.
- Emde, RN., Easterbrooks, MA. Assessing emotional availability in early development. In: Frankenburg, WK.Emde, RN., Sullivan, JW., editors. *Early identification of children at risk: An international perspective*. New York: Plenum Press; 1985. p. 79–101.
- Gartstein MA, Bateman AE. Early manifestations of childhood depression: Influences of infant temperament and parental depressive symptoms. *Infant and Child Development*. 2008; 17(3):223–248. doi:http://dx.doi.org.ezaccess.libraries.psu.edu/10.1002/icd.549.
- Gartstein MA, Rothbart MK. Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*. 2003; 26:64–86. DOI: 10.1016/S0163-6383(02)00169-8
- Goldberg WA, Keller MA. Co-sleeping during infancy and early childhood: Key findings and future directions. *Infant and Child Development*. 2007; 16:457–469. DOI: 10.1002/icd.522
- Heim C, Nemeroff CB. The impact of early adverse experiences on brain systems involved in the pathophysiology of anxiety and affective disorders. *Biological Psychiatry*. 1999; 46(11):1509–

1522. [http://dx.doi.org.ezaccess.libraries.psu.edu/10.1016/S0006-3223\(99\)00224-3](http://dx.doi.org.ezaccess.libraries.psu.edu/10.1016/S0006-3223(99)00224-3). [PubMed: 10599479]

Higley E, Dozier M. Nighttime maternal responsiveness and infant attachment at one year. *Attachment & Human Development*. 2009; 11(4):347–363. DOI: 10.1080/14616730903016979 [PubMed: 19603300]

Klein Velderman M, Bakermans-Kranenburg MJ, Juffer F, van IJzendoorn MH. Effects of attachment-based interventions on maternal sensitivity and infant attachment: differential susceptibility of highly reactive infants. *Journal of Family Psychology*. 2006; 20(2):266–274. DOI: 10.1037/0893-3200.20.2.266 [PubMed: 16756402]

Lohaus A, Keller H, Ball J, Voelker S, Elben C. Maternal sensitivity in interactions with three- and 12-month-old infants: Stability, structural composition, and developmental consequences. *Infant and Child Development*. 2004; 13(3):235–252. DOI: 10.1002/icd.351

Lovas GS. Gender and patterns of emotional availability in mother-toddler and father toddler dyads. *Infant Mental Health Journal*. 2005; 26(4):327–353. DOI: 10.1002/imhj.20056 [PubMed: 28682464]

McArdle, John J., Bell, RQ. An introduction to latent growth models for developmental data analysis. In: Little, TD, Schnabel, KU., Baumert, J., editors. *Modeling longitudinal and multilevel data*. Mahwah, NJ: Lawrence Erlbaum; 2000. p. 139-175.

McArdle JJ, Epstein DB. Latent growth curves within developmental structural equation models. *Child Development*. 1987; 58(1):110–133. DOI: 10.2307/1130295 [PubMed: 3816341]

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

Muthén, LK., Muthén, BO. *Mplus user's guide*. Seventh. Los Angeles, CA: Muthén & Muthén; 1998-2012.

NICHD Early Child Care Research Network. Infant-mother attachment classification: Risk and protection in relation to changing maternal caregiving quality. *Developmental Psychology*. 2006; 42:38–58. DOI: 10.1037/0012-1649.42.1.38 [PubMed: 16420117]

Putnam, SP., Ellis, LK., Rothbart, MK. The structure of temperament from infancy through adolescence. In: Elias, A., Angleitner, A., editors. *Advances/proceedings in research on temperament*. Germany: Pabst Scientist Publisher; 2001. p. 165-182.

Roisman GI, Newman DA, Fraley C, Haltigan JD, Groh AM, Haydon KC. Distinguishing differential susceptibility from diathesis–stress: Recommendations for evaluating interaction effects. *Development and Psychopathology*. 2012; 24:389–409. DOI: 10.1017/S0954579412000065 [PubMed: 22559121]

Rothbart, MK., Gartstein, MA. *Infant Behavior Questionnaire – Revised: Items by Scale*. University of Oregon; 2000.

Shiner RL, Buss KA, McClowry SG, Putnam SP, Saudino KJ, Zenter M. What is temperament now? Assessing progress in temperament research on the twenty-Fifth anniversary of Goldsmith et al. (1987). *Child Development Perspectives*. 2012; 0(0):1–9.

Spruyt K, Aitken RJ, So K, Charlton M, Adamson TM, Horne RSC. Relationship between sleep/wake patterns, temperament and overall development in term infants over the first year of life. *Early human development*. 2008; 84(5):289–96. DOI: 10.1016/j.earlhumdev.2007.07.002 [PubMed: 17707119]

Stifter, C., Dollar, J. Temperament and developmental psychopathology. In: Cicchetti, D., Cohen, D., editors. *Developmental Psychopathology*. 3rd. Vol. IV. New York: Wiley; 2016. p. 546-607. *Genes and Environment*

Zentner, Shiner, RL. *Handbook of temperament*. Guilford Press;

Streiner, DL., Norman, GR. *Health measurement scales: A practical guide to their development and use*. New York: Oxford University Press; 1995.

Teti, DM., Kim, BR. Infants and pre-school children: Observational assessments of attachment, a review and discussion of clinical applications. In: Farnfield, S., Holmes, P., editors. *The Routledge Handbook of Attachment: Assessment*. London: Routledge; 2014. p. 53-80.

- Teti DM, Kim BR, Mayer G, Countermine M. Maternal emotional availability at bedtime predicts infant sleep quality. *Journal of Family Psychology*. 2010; 24(3):307–315. DOI: 10.1037/a0019306 [PubMed: 20545404]
- Teti, DM., Philbrook, L., Shimizu, M., Reader, J., Rhee, HY., McDaniel, B., Crosby, B., Kim, BK., Jian, N. The social ecology of infant sleep: Structural and qualitative features of bedtime and nighttime parenting and infant sleep in the first year. In: Calkins, S., editor. *Handbook of infant biopsychosocial development*. Guilford Press; 2015. p. 359-391.
- Tomlinson M, Cooper P, Murray L. The mother-infant relationship and infant attachment in a South African peri-urban settlement. *Child Development*. 2005; 76(5):1044–1054. DOI: 10.1111/j.1467-8624.2005.00896.x [PubMed: 16150001]
- van Bakel HJA, Riksen-Walraven JM. Parenting and development of one-year-olds: Links with parental, contextual, and child characteristics. *Child Development*. 2002; 73:256–273. DOI: 10.1111/1467-8624.00404 [PubMed: 14717256]
- van IJzendoorn, MH., Bakermans-Kranenburg, MJ. Integrating temperament and attachment: The differential susceptibility paradigm. In: Zentner, M., Shiner, RL., editors. *Handbook of temperament*. New York: Guilford; 2012. p. 403-424.
- van IJzendoorn MH, Hubbard OA. Are infant crying and maternal responsiveness during the first year related to infant–mother attachment at 15 months? *Attachment & Human Development*. 2000; 2(3):371–391. DOI: 10.1080/14616730010001596 [PubMed: 11708224]
- van IJzendoorn MH, Vereijken CMJL, Bakermans-Kranenburg MJ, Riksen-Walraven JM. Assessing attachment security with the Attachment Q-Sort: Meta-analytic evidence for the validity of the observer AQS. *Child Development*. 2004; 75(4):1188–1213. DOI: 10.1111/j.1467-8624.2004.00733.x [PubMed: 15260872]
- Waters E, Vaughn B, Posada G, Kondo-Ikemura K. Appendix A: The Attachment Q-Set. *Monographs of the Society for Research in Child Development*. 1995; 60(2-3):234–246. DOI: 10.2307/1166181
- Waters, E., Vaughn, B., Teti, DM. Assessing secure base behavior in naturalistic environments: The Attachment Q-set. In: Waters, E. Vaughn, B., Waters, H., editors. *Measuring Attachment*. New York: Guilford Press; (in press)
- Weinfield, NS., Sroufe, LA., Egeland, B., Carlson, E. *Handbook of attachment: Theory, research, and clinical applications*. 2nd. Guilford Press; New York, NY: 2008. Individual differences in infant-caregiver attachment: Conceptual and empirical aspects of security; p. 78-101.doi:http://search.proquest.com/docview/621559998?accountid=13158
- Ziv Y, Aviezer O, Gini M, Sagi A, Koren-Karie N. Emotional availability in the mother-infant dyad as related to the quality of infant-mother attachment relationship. *Attachment and Human Development*. 2000; 2(2):149–169. DOI: 10.1080/14616730050085536 [PubMed: 11707908]

Figure 1.

(A) A plot of each family's trajectory of maternal emotional availability (EA) across four time points (3, 6, 9, 12 months) during the infant's first year. The thick solid line indicates the average across-family EA at each time point. (B) Predicted trajectories obtained from fitting Model 2 for each family. The thick solid line represents the sample's average predicted trajectory, obtained as $\hat{\mu}_I + \hat{\mu}_S * \lambda_t$ for $t = 1, 2, 3, 4$ (corresponding to the 4 measured age points), where $\lambda_1 = 0$ (fixed for identification), $\hat{\lambda}_2 = -0.41$, $\lambda_3 = 0$ (*n.s.* and fixed to zero) and $\lambda_4 = 1$ (fixed for identification).

Figure 2.

A path diagram showing Models 1 and 2. Model 1: a LGCM with intercept and slope with estimated basis coefficients (λ_2 and λ_3) of maternal EA (at 3, 6, 9, 12 months). Loadings of the intercept on EA from 3 to 12 months were all constrained to unity. σ_e^2 = residual error variance, constrained to be invariant across the four time points; μ_I = average intercept of EA at 3 months; μ_S = average basis/slope of change in EA from 3 to 12 months; σ_I^2 = inter-family variance in the intercept factor; σ_S^2 = inter-family variance in the latent slope factor;

$\sigma_{I,S}$ = covariance between the intercept and slope factors. Model 2: adding elements enclosed in the dashed box, with infant attachment security at 12 months (AQS12) as an outcome variable. The loading λ_3 of the “Slope” factor on the observed EA ratings at 9 months was set to zero in this model, as shown enclosed in parentheses. The “Slope” factor now represents a latent deviation or change factor summarizing the family-specific deviations in maternal EA at 6 and 12 months compared to the remaining months (3 and 9 months) The intercept and deviation factors in EA were used to predict infant attachment security at 12 months after controlling for the effect of infant length of bedtime on attachment security.

Figure 3.

Predicted levels of attachment security at 12 months for infants subjected to low vs. high maternal EA, as moderated by the levels of (A) surgency, (B) negative affectivity and (C) regulation. High (low) maternal EA was defined as an EA score that was predicted to start at 3 months at the sample average, but changed at a level that was 1SD above (below) the sample average deviation (i.e., “slope”) factor score. High and low scores on a temperament subscale was defined as 1SD above and below the sample average on that subscale, respectively.

Table 1

Descriptive statistics and correlations among all variables used in model fitting (n = 128).

	<i>M</i>	<i>SD</i>	<i>SE</i>	<i>α</i>						
Emotional Availability (EA)										
3 months	19.65	2.53	0.26	.75						
6 months	19.06	3.00	0.30	.75						
9 months	18.79	3.51	0.35	.84						
12 months	18.86	3.33	0.33	.79						
Infant Temperament (3 months)										
Surgency/Extraversion (surg)	4.03	0.83	0.07	.81						
Negative Affectivity (neg)	2.76	0.54	0.05	.61						
Regulation (reg)	5.05	0.58	0.05	.68						
12-month infant attachment (AQS)										
	.41	.22	.02	-						

	EA_3 mos	EA_6 mos	EA_9 mos	EA 12 mos	Surgency	Neg	Reg	AQS	Bedtime
Emotional availability									
3 mos									
6 mos	<u>0.59</u>								
9 mos	<u>0.50</u>	<u>0.56</u>							
12mos	<u>0.42</u>	<u>0.32</u>	<u>0.40</u>						
Infant temperament (3 mos)									
Surgency	<u>-0.26</u>	<u>-0.27</u>	<u>-0.43</u>	<u>-0.28</u>					
Neg	-0.12	-0.18	-0.18	-0.01	0.09				
Reg	0.08	-0.02	-0.13	<u>-0.25</u>	<u>0.62</u>	<u>-0.27</u>			
12 month AQS	<u>0.31</u>	<u>0.19</u>	<u>0.27</u>	<u>0.42</u>	<u>-0.22</u>	-0.08	<u>-0.03</u>		
3 mos Bedtime	<u>-0.41</u>	<u>-0.24</u>	<u>-0.25</u>	<u>-0.36</u>	<u>0.28</u>	0.16	0.15	<u>-0.25</u>	

SE = Standard error of the mean, obtained as $SD/\sqrt{n}$. Statistically significant correlations ($p < .05$) are underlined and bolded.

Table 2

Parameter Estimates from Fitting Models 1-3 to the Data.

Parameters	Model 1 estimates (SEs)	Model 2 estimates (SEs)	Model 3 estimates (SEs)
λ_1	= 0	= 0	= 0
λ_2	-0.41 (0.16) *	-0.35 (0.14) *	-0.36 (0.16) *
λ_3	= 0 ^{ns}	= 0 ^{ns}	= 0 ^{ns}
λ_4	= 1	= 1	= 1
μ_I	19.08 (0.22) *	19.37 (0.23) *	19.12 (0.23)
μ_S	-0.38 (0.27)	-0.39 (0.31)	-0.60 (0.27) *
μ_{AQS}	--	-0.34 (0.23)	= 0 ^{ns}
$\beta_{I \rightarrow AQS}$	--	0.04 (0.01) *	0.02 (0.001) *
$\beta_{Slope \rightarrow AQS}$ (in Model 2) or $\beta_{Slope \rightarrow AQS,0}$ (in Model 3)	--	0.05 (0.01) *	0.05 (0.02) *
$\beta_{Slope \rightarrow AQS,1}$			0.044 (0.020) *, ^a
$\beta_{Slope \rightarrow AQS,2}$			-0.059 (0.031) [≈]
$\beta_{Slope \rightarrow AQS,3}$			-0.068 (0.033) *
$\beta_{Bedtime \rightarrow AQS}$	--	0.00 (0.00)	--
σ_I^2	4.86 (0.80) *	3.93 (0.72) *	5.07 (0.84) *
σ_S^2	4.47 (1.27) *	5.27 (1.46) *	4.19 (1.32) *
$\sigma_{I,S}$	= 0 ^{ns}	= 0 ^{ns}	= 0 ^{ns}
σ_e^2 (residual variance for all other time points)	2.64 (0.44) *	2.56 (0.41) *	2.72 (2.52) *
$\sigma_{e,9}^2$ (residual variance at 9 months)	6.87 (1.13) *	6.66 (1.22) *	6.58 (1.12) *
$\sigma_{e,AQS}^2$	--	0.03 (0.01) *	0.03 (0.01) *

* $p < .05$;[≈] $p < .06$;^{ns} Not statistically significant when freed up in earlier iterations.

^aThe parameters $\beta_{I \rightarrow AQS,1}$, $\beta_{I \rightarrow AQS,2}$ and $\beta_{I \rightarrow AQS,3}$ were fixed at 0 in the final Model 3 because these parameters were not estimated to be statistically significant in an earlier model in which these parameters but not $\beta_{Slope \rightarrow AQS,1}$, $\beta_{Slope \rightarrow AQS,2}$ and $\beta_{Slope \rightarrow AQS,3}$ were estimated. Including these two sets of parameters simultaneously in the model led to convergence problems and these moderating effects-related parameters were thus included and evaluated for statistical significance successively.