




SHORT REPORT

Testing the mid-range model: Attachment in a high risk sample

Samantha G. Mitsven¹  | Emily B. Prince¹ | Daniel S. Messinger^{1,2,3} |
Elena J. Tenenbaum⁴ | Stephen J. Sheinkopf⁵ | Edward Z. Tronick⁶ | Ronald Seifer⁷ |
Barry M. Lester⁵

¹ Department of Psychology, University of Miami, Coral Gables, Florida, USA

² Department of Electrical and Computer Engineering, University of Miami, Coral Gables, Florida, USA

³ Department of Pediatrics, Department of Music Engineering, University of Miami, Coral Gables, Florida, USA

⁴ Department of Psychiatry and Behavioral Sciences, Duke University, Durham, North Carolina, USA

⁵ Department of Psychiatry & Human Behavior and Department of Pediatrics, Warren Alpert Medical School of Brown University, Providence, Rhode Island, USA

⁶ Department of Psychology, University of Massachusetts, Boston, Massachusetts, USA

⁷ Frank Porter Graham Child Development Institute University of North Carolina Chapel Hill, Chapel Hill, North Carolina, USA

Correspondence

Samantha G. Mitsven, Department of Psychology, University of Miami, 5665 Ponce de Leon Blvd, Coral Gables, FL 33146, USA.
Email: sxm1531@miami.edu

Samantha G. Mitsven and Emily B. Prince contributed equally to this work.

Funding information

National Institute of Child Health and Human Development, Grant/Award Numbers: U10 HD 21397, U10 HD 36790, U10 HD 27904, U10 HD 21385, U10 HD 21415, N01-HD-2-3159; Administration on Children, Youth, and Families; Center for Substance Abuse Treatment; National Institute on Drug Abuse

Abstract

Infant attachment is a key predictor of later socioemotional functioning, but it is not clear how parental responsiveness to infant expressive behavior is associated with attachment outcomes. A mid-range model of responsiveness holds that both unresponsive and highly reactive parental behaviors lead to insecure and disorganized attachment. We examined the relationship between maternal (and infant) contingent responsiveness and attachment in a high-risk sample. Participants were 625 infant-mother pairs from a longitudinal study of children with and without prenatal drug exposure and variable levels of associated social risks. Infant-mother pairs participated in the Face-to-Face/Still-Face paradigm (FFSF) at 4-months and in the Strange Situation Procedure (SSP) at 18-months. A model incorporating both linear and quadratic responsiveness effects indicated that mothers who were either very high (reactive) or very low (unresponsive) in responsiveness were more likely to have infants with disorganized attachment outcomes. While maternal responsiveness was associated with attachment disorganization, no associations between maternal responsiveness, and attachment security/insecurity were detected. Infant responsiveness to mother was not associated with attachment outcomes. The findings suggest the importance of mid-range levels of maternal responsiveness in the development of organized attachment among infants facing high levels of prenatal and social risk.

KEYWORDS

attachment, disorganization, face-to-face, high-risk infants, interaction

1 | INTRODUCTION

Infants who repeatedly experience responsive parenting may learn to expect that responsiveness and come to use the parent as a source of sup-

port for emotion regulation and expression. Early patterns of responsiveness contribute to the development of attachment security, an infant's expectations of a parent's availability particularly when stressed or distressed (Ainsworth et al., 1978; van IJzendoorn & Kroonenberg, 1990).

In this report, we investigate associations between maternal (and infant) contingent responsivity and later attachment in the largest sample yet examined.

The most consistent predictor of secure attachment is high levels of parental sensitive responsivity, a global measure of parental warmth and attentiveness to the child's needs (De Wolff & van IJzendoorn, 1997; Isabella & Belsky, 1991; Völker et al., 1999). Despite the similarity in terms, sensitive responsivity differs from contingent responsivity, a construct that describes moment-to-moment parental reactions to infant expressive actions. Contingent responsivity is typically measured via fine-grained sequential coding of infant and mother expressions during face-to-face interactions.

Face-to-face interactive behavior and attachment security are both key indices of early socioemotional functioning, but it is unclear how they are associated (Beebe et al., 2010; Jaffe et al., 2001; Mesman et al., 2009). A mid-range responsivity model holds that both higher and lower levels of contingent responsivity during face-to-face interaction are associated with insecure and disorganized attachment (Jaffe et al., 2001). High levels of maternal responsivity to infant facial expressions have been associated with later insecure attachment (Malatesta et al., 1989), and high levels of maternal vocal responding have been associated with attachment disorganization (Jaffe et al., 2001). However, lower levels of maternal responsivity to expressions of infant affective engagement have also been associated with later disorganized attachment (Beebe et al., 2010). A potential explanation for these findings is an "optimal mid-range model" in which both high and low levels of maternal contingent responsivity are not rated as optimally sensitive (Bornstein & Manian, 2013), and are associated with insecure attachment or disorganization (Jaffe et al., 2001). In this formulation, overly low levels of contingent responsivity may index disengagement while overly high levels may index reactivity. Both disengaged and reactive patterns, in different ways, may decrease infant opportunities to regulate their own behaviors during dyadic interaction. However, models have yet to formally test such curvilinear associations between maternal contingent responsivity and infant attachment.

Although attachment theory emphasizes the role of parental responsivity in the development of attachment, *infant* contingent responsivity to the parent may also be implicated. Infants with insecure or disorganized attachment exhibited higher levels of responsivity to mother affective engagement than future secure infants (Beebe et al., 2010). Likewise, infants who were highly responsive to maternal vocal pauses were more likely to be categorized as disorganized (Jaffe et al., 2001). Like maternal contingent responsivity, increased infant contingent responsivity may be associated with insecure or disorganized attachment. Thus the current project tests associations between attachment outcomes and both maternal and infant contingent responsivity assessed during a standardized face-to-face interaction. Specifically, the Face-to-Face/Still-Face paradigm (FFSF) provides a structured protocol to assess dyadic patterns of responsivity in the context of the infant's response to parental unavailability in the still-face episode (Chow et al., 2010; Cohn & Tronick, 1987).

During the Strange Situation Procedure (SSP), a gold standard measure of infant attachment, infants are classified as securely attached

RESEARCH HIGHLIGHTS

- Mid-range models, which suggest that extremely low and high levels of responsivity are associated with non-optimal outcomes, are rarely formally tested.
- We examined maternal (and infant) contingent responsivity in the Face-to-Face/Still-Face paradigm at 4 months and infant attachment outcomes at 18 months in a high-risk sample.
- Both mothers who were emotionally disengaged and mothers who were more reactive in the FFSF were more likely to have infants with disorganized attachment.
- Mid-range levels of maternal responsivity appear to be associated with organized patterns of attachment, which may contribute to infant resilience.

when they effectively use contact with their caregiver to regulate distress. By contrast, insecure-resistant infants engage in over-activation of attachment behaviors (e.g., seeking yet resisting contact) while insecure-avoidant infants engage in under-activation of attachment behaviors (e.g., little to no tendency to seek or maintain contact) in the parent's presence (Ainsworth, 1979; Ainsworth et al., 1978; Bretherton, 1992; Elliot & Reis, 2003). Children who engage in inconsistent or contradictory attachment strategies are orthogonally classified as disorganized (Carlson et al., 1989; Main & Solomon, 1986; van IJzendoorn et al., 1999). Meta-analyses indicate robust associations between secure attachment and later social competence, while insecure and disorganized attachments are associated with later externalizing problems (Fearon et al., 2010).

This project examines the association between early responsivity and later attachment in the Maternal Lifestyle Study (MLS), a large dataset that incorporated both the FFSF and SSP. The MLS (1993–2011) examined the effects of prenatal drug exposure on infant outcomes (Lester et al., 2001). Infants had high levels of prenatal cocaine, opiate, alcohol, tobacco and marijuana exposure, and high levels of social risk factors, including low maternal education and SES. An earlier MLS report indicated that prenatal cocaine exposure was associated with reductions in matched dyadic affective engagement during the FFSF (Tronick et al., 2005). Likewise, prenatal exposure to both cocaine and opiates was associated with a decrease in the proportion of securely attached infants at 18 months (Seifer et al., 2004). However, the association between dyadic responsivity in the FFSF and attachment outcomes in the MLS sample has not been examined.

1.1 | Current study

In the current study, we predicted a curvilinear association between maternal contingent responsivity during the FFSF and attachment outcomes. Specifically, we hypothesized that infants whose mothers were

either very low or very high in responsivity at 4 months would be more likely to have insecure and disorganized 18-month attachment outcomes. Likewise, we expected infants who exhibited high levels of interactive responsivity during the FFSF to be more likely to exhibit insecure and disorganized attachment outcomes.

2 | METHOD

2.1 | Sample

The sample was recruited from four sites (Brown University, University of Miami, Wayne State University, and the University of Tennessee at Memphis) whose institutional review boards approved study procedures. The original MLS design (Lester et al., 2001) compared prenatal cocaine and/or opiate (C/O) exposure (confirmed by maternal report or meconium toxicology) with C/O non-exposure. Infants were categorized as “exposed” if their mothers reported cocaine or opiate use during pregnancy in a hospital interview, or they tested positive on a meconium assay (Sheinkopf et al., 2007). The comparison group mothers denied use of cocaine or opiates during pregnancy and did not test positive on a meconium assay. The comparison group was matched to the exposure group on prematurity, race, and gender. Risk factors were present in both groups and higher in the C/O exposed group. Low birthweight infants (500–2500 g) were oversampled. Nurses and social workers who were certified to administer the structured maternal interview used a written script to ascertain prenatal exposure to alcohol, marijuana, and tobacco, and indicators of socioeconomic status (Lester et al., 2001).

Of 1388 infant-mother dyads recruited (Lester et al., 2001), 625 dyads (333 male infants) were included in analyses. Only mother-infant dyads who contributed both 4 and 18-month data were included in the analyses. The dyads included in analyses exhibited lower drug risk scores, $M_{included} = 1.62$, $M_{notIncluded} = 2.11$, $t(1386) = -6.74$, $p < 0.001$, but not lower social risk scores, $M_{included} = 2.78$, $M_{notIncluded} = 2.86$, $t(1381) = -1.11$, $p = 0.266$, than excluded dyads. Sample demographics and risk factors are described in Table 1.

2.2 | Measures

2.2.1 | Face-to-face/still-face procedure

In three successive 2-min episodes, mothers were asked to “play with [baby’s name] as you would at home” (FF), to “maintain a still-face and look at the baby without talking, smiling, touching the baby or interacting in any way” (SF), and then to start “playing again with [baby’s name]” (RE). Separate video streams of the upper bodies and faces of the infant and mother were integrated into a split-screen display and synchronized. If infants cried for 30 s, the FFSF procedure was terminated. All 625 dyads completed the FF episode, 605 dyads completed the SF episode, and 576 dyads completed the RE episode (Table S1, Figure S1 for descriptive statistics).

TABLE 1 Descriptors and risk factors ($N = 625$)

Ethnicity	Hispanic	37 (6%)
	Non-Hispanic	588 (94%)
Race	Black	492 (79%)
	White	91 (15%)
	Other	5 (1%)
Perinatal status	Gestational age (weeks)	36.37 (4.01)
	Birth weight (g)	2662.58 (830.87)
Drug risk	Cocaine	196 (31%)
	Opiates	36 (6%)
	Alcohol	365 (58%)
	Marijuana	119 (19%)
	Tobacco	287 (46%)
Social risk	Mother single	493 (79%)
	Medicaid	497 (80%)
	Maternal Ed. ≤ 12 years	220 (35%)
	< Federal Poverty Line	394 (63%)

Note: Medicaid is a public health insurance program that provides health-care coverage to low-income individuals within the United States.

2.2.2 | FFSF coding

The infants’ and mothers’ behaviors were coded using the Infant and Caregiver Engagement Phases (ICEP). The ICEP system includes a set of mutually exclusive phases of interactive engagement that are coded separately for infant and adult (Table 2). The infant and adult behavioral interactive phases are configurations of facial expressions, direction of gaze, and vocalizations that form an ordinal pattern from negative to positive social engagement (Weinberg & Tronick, 1998; Weinberg et al., 1999). Infant and adult phases form a set of matched 4-point ordinal engagement codes from negative through neutral and positive (Table 2). Percent agreement assessed in a random 15% of dyads was high for infant engagement (85%, $k = 0.74$) and mother engagement (84%, $k = 0.76$).

2.2.3 | Strange situation procedure and attachment coding

The SSP (Ainsworth et al., 1978), a gold-standard attachment assessment, was used to assess attachment behavior at 18 months. The procedure consists of eight brief episodes that include two 3-min separations from the mother, each followed by a 3-min reunion. Children’s classifications were based on 7-point scales of infant (1) proximity seeking; (2) contact maintenance; (3) resistance to interaction; and (4) avoidance of contact/interaction in the two reunion episodes (Ainsworth et al., 1978). Children were classified as secure if the mother’s return reduced distress and facilitated play and secure base behavior. Insecure categories included avoidant (marked avoidance of mother, especially during reunions) and resistant (resistance to

**TABLE 2** Engagement codes and corresponding infant/caregiver engagement phases

Engagement	Infant	Mother
1	Protest	Hostile–Intrusive & Passive–Withdrawn
2	Passive–Withdrawn	Social Monitor without Vocalizing
3	Object–Environment & Social Monitor	Social Monitor w/ Positive Vocalizing
4	Social Positive Engagement	Social Positive Engagement

Note: Engagement codes were assigned on a second-to-second basis to infant behavior and, separately, to mother behavior.

mother's bids to soothe and contact, and failure to be comforted). Scores of 5 and higher on a 9-point disorganization scale indicated disorganized classification. The disorganized classification was assigned when both avoidant and resistant qualities, or other disorganized patterns including fearful behavior or unusual timing/sequence of behavior, were present (Main & Solomon, 1986). Attachment classification was done by trained raters who achieved and maintained a reliability criteria of kappa = 0.80 for both security (avoidant, secure, resistant) and the orthogonal disorganized (disorganized, non-disorganized) classifications.

Attachment security and disorganization were examined separately using two categorization methods. In the first, infants with a primary disorganization classification were sorted into a secondary category of secure, avoidant, or resistant (three-way analysis). In the total sample, 458 infants were securely attached, 93 were avoidant, and 74 were resistant. In the second, infants with a primary disorganization classification (57) were compared to infants with secure (433), avoidant (73), and resistant (62) classifications (four-way analysis). Gender, race, and ethnicity did not differ between the attachment categories in either the 3- or 4-way attachment categorizations ($ps > 0.30$).

2.2.4 | Risk

Cumulative risk models posit that combinations of risk factors are powerful predictors of developmental outcomes and combine multiple factors under one umbrella term (Sameroff et al., 1987; Sheinkopf et al., 2007). Two cumulative risk scores were calculated for each dyad. A composite drug risk score (range 0–5; $M = 1.62$; $SD = 1.35$) was calculated by summing dichotomized prenatal exposures to cocaine, opiates, alcohol, tobacco, and marijuana (yes = 1, no = 0 for each exposure). A social risk score (range 0–5; $M = 2.78$; $SD = 1.38$) was calculated by summing dichotomized social risks. One point was assigned for each of the following risks: having a single mother, receiving Medicaid, low maternal education (<12 years), low income (100% or more below the federal poverty line), and low socioeconomic status (using a modified Hollingshead score).

2.3 | Analytic approach

To measure responsivity in the FFSF, we estimated separate multilevel models in which mother and infant second-to-second affective engage-

ment was predicted by their partner's affective engagement. Modeling performed using HLM 8 for Windows employed restricted maximum likelihood estimation, which is robust to missing data (Bates et al., 2015; Enders, 2011). We first predicted maternal affective engagement from the mother's own previous behavior (auto-correlation), the infant's previous behavior (responsivity), FFSF episode contrasts, infant gender, drug risk score, and social risk score. The maternal auto-correlation parameter captured the effect of the mother's previous affective engagement 1- and 2-s prior on her current affective engagement. The FFSF episode effects contrasted maternal affective engagement during the SF with maternal engagement during the FF and RE, and contrasted maternal affective engagement during the FF and the RE. We next predicted infant affective engagement from the infant's own previous behavior measured at 1- and 2-s prior (auto-correlation), the mother's previous behavior (responsivity), FFSF episode contrasts, infant gender, drug risk score, and social risk score. Both maternal and infant models included random effects of auto-correlation and responsivity. For both maternal and infant models, the fixed effects of FFSF episode contrasts, auto-correlation, and responsivity were entered together, followed by subject-level (level-2) variables indexing infant gender, drug risk, and social risk scores. Variables were maintained in final models when their parameters were statistically significant (coefficient $p < 0.05$) and their presence improved model fit (nested chi-square comparison $p < 0.05$; Tables S2–S3).

Stepping out of the multilevel time series, we exported dyad-specific empirical Bayes estimates of responsivity and auto-correlation that incorporated both fixed and random effects from final models predicting mother and infant engagement. These estimates were used in multinomial logistic regressions predicting both three-way (security) and four-way (security and disorganized) attachment. Follow-up binary logistic regressions were planned for significant findings from the overall multinomial regression (i.e., secure vs. insecure). Logistic regressions were performed using SPSS Statistics for Macintosh version 26.0.

3 | RESULTS

3.1 | Affective engagement and responsivity

We first predicted second-to-second affective engagement during the FFSF at 4 months. Significant contingent responsivity parameters in both infant and mother models indicated that each partner adjusted their own affective engagement in response to their partner (Table 3).

TABLE 3 Multilevel models predicting affective engagement during the FFSF at 4 months

Maternal engagement ($Mother_{ikt}$)		Infant engagement ($Infant_{ikt}$)	
Parameter	B (SE)	Parameter	B (SE)
Intercept	0.96 (0.02)	Intercept	0.51 (0.02)
Still Face Effect (SFvsFF/RE $_{ikt}$)	-0.36 (0.01)	Still Face Effect (SFvsFF/RE $_{ikt}$)	-0.01 (0.01)
Reunion Effect (FFvsRE $_{ikt}$)	0.003 (0.00)	Reunion Effect (FFvsRE $_{ikt}$)	0.06 (0.01)
Responsivity (Infant $_{ikt-1}$)	0.06 (0.00)	Responsivity (Mother $_{ikt-1}$)	0.03 (0.00)
Auto-correlation t-1 (Mother $_{ikt-1}$)	0.64 (0.01)	Auto-correlation t-1 (Infant $_{ikt-1}$)	0.65 (0.01)
Social Risk Score (Social_Risk $_i$)	-0.01 (0.00)	Auto-correlation t-2 (Infant $_{ikt-2}$)	0.08 (0.00)

Note: The table reports unstandardized regression coefficients with standard errors in parentheses. The SF was coded 1 in SFvsFF/RE $_{ikt}$ and the FF was coded 1 in FFvsRE $_{ikt}$. Results reported here are from final models with only statistically significant predictors maintained (all p s < 0.001 with the exception of the SF effect for infant engagement where $p = 0.031$). Intercept, auto-correlation, and responsivity effects were allowed to vary randomly. Maternal engagement random effects: Intercept ($SD = 0.16$, $\sigma^2 = 0.03$), Auto-correlation t-1 ($SD = 0.07$, $\sigma^2 = 0.00$), Infant Responsivity ($SD = 0.04$, $\sigma^2 = 0.00$), and Level-1 residuals ($SD = 0.37$, $\sigma^2 = 0.13$). Infant Engagement random effects: Intercept ($SD = 0.33$, $\sigma^2 = 0.11$), Auto-correlation t-1 ($SD = 0.12$, $\sigma^2 = 0.01$), Auto-correlation t-2 ($SD = 0.07$, $\sigma^2 = 0.01$), Maternal Responsivity ($SD = 0.05$, $\sigma^2 = 0.00$), and Level-1 residuals ($SD = 0.42$, $\sigma^2 = 0.18$).

Significant auto-correlation effects parameterized the degree to which each partner's affective engagement was predicted by past engagement (lag 1 was significant for mother; lags 1 and 2 were significant for infants). There were significant effects of the FFSF episodes for both mothers and infants such that both partners had higher affective engagement during the FF and RE than during the SF, and had higher engagement during the FF than during the RE. For mothers, affective engagement varied by level of social risk, with mothers who faced more risk factors being less positively engaged with the infant throughout the FFSF. Drug exposure was not a significant predictor of FFSF engagement for either the infant or the mother, nor did affective engagement differ by infant gender.

3.2 | Predicting infant attachment

To determine whether parent or infant responsivity predicted attachment security or disorganization, empirical Bayes estimates of infant and maternal responsivity and auto-correlation were acquired from the final models of affective engagement. Responsivity and auto-correlation parameters in the final models of affective engagement reflected maternal and infant behavior across all three episodes of the FFSF. As both lags t-1 and t-2 were significant predictors of infant affective engagement, these parameters were summed to create a single infant auto-correlation variable. Both maternal responsivity estimates and the squared value of maternal responsivity were included in analyses in order to examine both linear and curvilinear effects. Z-score transformations were conducted on the responsivity and auto-correlation variables to check for outliers. Reported results include all participants; the pattern of results was identical after removing dyads with scores greater than three standard deviations from the mean on responsivity or auto-correlation ($n = 16$, Table S4, Figure S2).

A multinomial logistic regression of three-way attachment security did not yield significant differences in maternal responsivity, infant responsivity, or auto-correlation effects between secure, avoidant, and resistant infants, nor did a binary logistic regression comparing

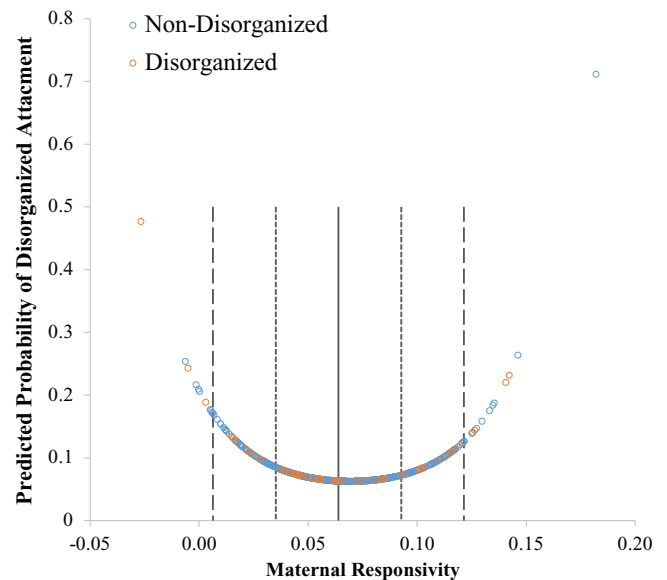


FIGURE 1 Disorganized attachment and maternal responsivity. Each dot represents an infant's probability of disorganized attachment based on the combined linear and quadratic effect of maternal responsivity coefficients ($N = 625$). Orange dots indicate Disorganized outcomes and blue dots indicate Non-Disorganized outcomes. The solid line indicates the mean value of maternal responsivity ($M = 0.06$) while the dotted and dashed lines represent maternal responsivity values within 1 (± 0.03) and 2 (± 0.06) standard deviations of the mean, respectively

secure/non-secure infants (Table S5). However, in the four-way analysis, disorganized infants, differed from the other three groups of infants on maternal responsivity, $\chi^2(3) = 8.51$, $p = 0.037$, and quadratic levels of maternal responsivity, $\chi^2(3) = 9.72$, $p = 0.021$. A follow-up binary logistic regression comparing disorganized/non-disorganized infants revealed a curvilinear relationship with maternal responsivity. Mothers who exhibited very low (unresponsive) or very high (reactive) responsivity at 4 months were more likely to have infants with disorganized attachment at 18 months (Figure 1, Table 4; Table S6 for a replication among low-risk dyads).

TABLE 4 Binary logistic regression predicting disorganized attachment

Predictors	B (SE)	p-value	Exp (B)	95% CI for Exp (B)
Constant	-1.35 (2.13)	0.527	0.26	—
Maternal responsivity (linear)	-39.28 (13.04)	0.003	0.00	0.00, 0.00
Maternal responsivity (quadratic)	283.50 (89.95)	0.002	2.1325E+123	3.640E+46, 4.824E+199
Maternal auto-correlation	-0.79 (2.43)	0.745	0.45	0.00, 53.42
Infant responsivity	-0.61 (3.65)	0.867	0.54	0.00, 689.65
Infant auto-correlation	0.85 (1.35)	0.528	2.34	0.17, 32.92

Note: The table reports unstandardized regression coefficients with standard errors in parentheses. Maternal responsivity is included as both a linear and quadratic variable. Disorganized attachment was coded as 1, and non-disorganized attachment was coded as 0.

4 | DISCUSSION

This large-scale investigation utilized a unitary index of affective engagement encompassing both emotional valence and attention to the interactive partner in the FFSF to test for hypothesized associations with attachment outcomes in a high-risk sample. Infants whose mothers were either very high (reactive) or very low (disengaged) in responsivity at 4 months were more likely to have disorganized attachment outcomes at 18 months. These mothers tended to respond to changes in infant affective engagement to a greater or lower extent than other mothers. Although maternal responsivity was associated with infant disorganized attachment, there were no associations between maternal responsivity and infant attachment security. Likewise, infant responsivity to mother was not associated with attachment outcomes. These findings partially support and help refine an optimal mid-range model of parental responsivity (Bornstein & Manian, 2013; Jaffe et al., 2001). Specifically, departures from a normative range of parental responsivity (in the direction of both disengagement and reactivity) may be associated with disorganized attachment.

Attachment theory suggests that high levels of sensitive responsivity leads to secure attachment. The mid-range model poses a potential solution to this contradiction by proposing that contingent responsivity at either extreme constitutes less sensitive parenting and is associated with subsequent insecure or disorganized outcomes (Jaffe et al., 2001). Home observations, for example, indicate that mid-range levels of maternal behavioral responsivity are associated with maximal levels of maternal sensitivity (Bornstein & Manian, 2013). Previous micro-coding of contingent responsivity during face-to-face interactions suggested that both high and low levels of maternal responsivity to infant expressive behavior in the first year of life were associated with later insecurity and disorganization (Beebe et al., 2010; Jaffe et al., 2001). Crucially, there was no direct test of the curvilinear association between responsivity and attachment such as that conducted here. In support of the mid-range model, we found that mothers who were either extremely responsive or unresponsive to their infants during the FFSF were more likely to have infants with disorganized attachment at 18 months.

There was no evidence that maternal responsivity differed between secure and insecure infants. In a previous sample of 58 infants, heightened maternal affective responsivity was associated with insecure

attachment at 30 months, but the study did not incorporate coding of disorganization (Malatesta et al., 1989). Beebe et al. (2010) found lower levels of maternal responsivity in the affective engagement domain (a composite of visual attention to the interactive partner and facial affect) among disorganized versus secure infants. However, they did not report differences between secure and insecure (insecure-resistant and insecure-avoidant) infants. No differences in maternal contingent responsivity to infant affective engagement were found when contrasting secure infants to a combined group of insecure and disorganized infants (Beebe et al., 2010). This pattern of findings suggests that extreme levels of contingent parental responsivity may contribute to disorganized attachment. Mid-range levels of contingent parental responsivity were associated with non-disorganized attachment categories (both secure and insecure). One possibility is that mid-range levels of maternal responsivity provide infants with opportunities to regulate their own engagement in the course of dyadic interaction. Specifically, mid-range responsivity levels may allow infants to generate expectable patterns of maternal availability that are associated with organized patterns of attachment, be they secure or insecure.

Beebe et al. (2010) found that a combined group of insecure and disorganized infants exhibited higher levels of contingent responsivity to maternal affective engagement than secure infants but did not report disorganized versus non-disorganized (secure, insecure-resistant, insecure-avoidant infants) or secure versus insecure (insecure-resistant and insecure-avoidant infants) differences. The current large-scale investigation yielded no evidence that infant responsivity to maternal affective engagement differed between disorganized and non-disorganized infants, or between securely and insecurely attached infants. Instead, the results highlight the importance of extreme levels of maternal responsivity in the emergence of disorganized attachment.

Understanding the protective factors associated with resilience in the MLS sample provides insight into parenting behavior that may be optimal in high-risk contexts. Multilevel models indicated that mothers with high levels of social risk exhibited lower levels of affective engagement (less positive, more negative) with their infants, a pattern seen in other large samples (NICHD_ECRN, 2005). Drug exposure was not associated with affective engagement for either member of the dyad. Previous research with the MLS sample indicated that cocaine exposure was associated with increased maternal but not infant negativity

in univariate analyses (Tronick et al., 2005). By contrast, the current study's risk score gave equal weight to multiple in utero drug exposures and examined overall levels of affective engagement rather than negativity per se. The current results, then, underline the role of social risk rather than drug exposure in predicting maternal responsivity.

A limitation is that the current use of overall ratings of affective engagement did not indicate how dyad specific behaviors such as smiling or vocalizing during the FFSF were associated with attachment outcome. This curtails our ability to pinpoint specific patterns of maladaptive behaviors that disengaged and reactive mothers demonstrated during the FFSF. Risk exposure may be parameterized in multiple ways. Here we created cumulative risk indices in which infants received one point for each prenatal drug exposure measured, a procedure designed to efficiently characterize polydrug exposure (Conradt et al., 2014; Fisher et al., 2011; Sheinkopf et al., 2007), and one point for each social risk measured. It is possible, however, that this dichotomization and aggregation of individual exposures, which did not account for the level or duration of drug exposure or social risk, may have underestimated their impact, a limitation.

Overall, findings from this large, longitudinal sample of high-risk infants and their mothers suggest that early patterns of maternal responsivity can set the stage for the formation of an organized system of attachment behaviors. That is, mid-range levels of maternal responsivity were not associated with disorganized attachment outcomes. These results are noteworthy because disorganized attachment is associated with later externalizing problems (Madigan et al., 2016), particularly for children in high-risk home environments (Fearon & Belsky, 2011). Thus, mid-range levels of maternal responsivity appear to be associated with the emergence of organized patterns of attachment that may help set infants on a resilient trajectory into childhood and beyond.

ACKNOWLEDGMENTS

This study was supported by the National Institute of Child Health and Human Development through cooperative agreements U10 HD 21397, U10 HD 36790, U10 HD 27904, U10 HD 21385, and U10 HD 21415; contract N01-HD-2-3159; and interagency agreements with the National Institute on Drug Abuse, Administration on Children, Youth, and Families, and the Center for Substance Abuse Treatment.

CONFLICT OF INTEREST

The authors have no conflicts of interest.

AUTHOR CONTRIBUTIONS

Barry M. Lester developed the original study concept. Emily B. Prince, Daniel S. Messinger, Barry M. Lester, Stephen J. Sheinkopf, and Edward Z. Tronick developed the current study design. Elena J. Tenenbaum and Ronald Seifer were involved in data management. Ronald Seifer was responsible for data processing and supervising the attachment coding of the Strange Situation Procedure (SSP). Edward Z. Tronick and Daniel S. Messinger were responsible for supervising the behavioral coding of the Face-to-Face/Still-Face (FFSF) paradigm. Emily B. Prince and Samantha G. Mitsven performed data analysis and interpretation

under the supervision of Daniel S. Messinger. Daniel S. Messinger, Emily B. Prince, and Samantha G. Mitsven wrote the manuscript. Stephen J. Sheinkopf provided critical revisions. This manuscript is based on the dissertation of Emily B. Prince. All authors approved the final version of the manuscript for submission.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available on the Open Science Framework (<https://osf.io/46327/>).

ORCID

Samantha G. Mitsven  <https://orcid.org/0000-0002-0151-560X>

REFERENCES

- Ainsworth, M. S. (1979). Infant-mother attachment. *American Psychologist*, 34(10), 932.
- Ainsworth, M. S., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the strange situation*. Lawrence Erlbaum.
- Bates, D., Machler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1-48.
- Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., Bahrack, L., Andrews, H., & Feldstein, S. (2010). The origins of 12-month attachment: A microanalysis of 4-month mother-infant interaction. *Attachment & Human Development*, 12(1), 3-141. <http://www.informaworld.com/10.1080/14616730903338985>
- Bornstein, M. H., & Manian, N. (2013). Maternal responsiveness and sensitivity reconsidered: Some is more. *Development and Psychopathology*, 25(4 Pt 1), 957-971. <https://doi.org/10.1017/s0954579413000308>
- Bretherton, I. (1992). The origins of attachment theory: John Bowlby and Mary Ainsworth. *Developmental Psychology*, 28(5), 759.
- Carlson, V., Cicchetti, D., Barnett, D., & Braunwald, K. (1989). Disorganized/disoriented attachment relationships in maltreated infants. *Developmental Psychology*, 25(4), 525-531. <https://doi.org/10.1037/0012-1649.25.4.525>
- Chow, S., Haltigan, J. D., & Messinger, D. S. (2010). Dynamic infant-parent affect coupling during the Face-to-Face/Still-Face. *Emotion (Washington, D.C.)*, 10, 101-114.
- Cohn, J., & Tronick, E. (1987). Mother-infant face-to-face interaction: The sequence of dyadic states at 3, 6, and 9 months. *Developmental Psychology*, 23(1), 68-77.
- Conradt, E., Abar, B., Sheinkopf, S., Lester, B., Lagasse, L., Seifer, R., Shankaran, S., Bada-Ellzey, H., Bauer, C., Whitaker, T., Hinckley, M., Hammond, J., & Higgins, R. (2014). The role of prenatal substance exposure and early adversity on parasympathetic functioning from 3 to 6 years of age. *Developmental Psychobiology*, 56(4), 821-835. <https://doi.org/10.1002/dev.21155>
- De Wolff, M. S., & van IJzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development*, 68(4), 571-591.
- Elliot, A. J., & Reis, H. T. (2003). Attachment and exploration in adulthood. *Journal of Personality and Social Psychology*, 85(2), 317.
- Enders, C. K. (2011). Analyzing longitudinal data with missing values. *Rehabilitation Psychology*, 56(4), 267-288.
- Fearon, P., & Belsky, J. (2011). Infant-mother attachment and the growth of externalizing problems across the primary-school years. *Journal of Child Psychology and Psychiatry*, 52(7), 782-791.
- Fearon, R. P., Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., Lapsley, A.-M., & Roisman, G. I. (2010). The significance of insecure attachment and disorganization in the development of children's externalizing behavior: A meta-analytic study. *Child Development*, 81(2), 435-456. <https://doi.org/10.1111/j.1467-8624.2009.01405.x>



- Fisher, P. A., Lester, B. M., DeGarmo, D. S., Lagasse, L. L., Lin, H., Shankaran, S., Bada, H. S., Bauer, C. R., Hammond, J., Whitaker, T., & Higgins, R. (2011). The combined effects of prenatal drug exposure and early adversity on neurobehavioral disinhibition in childhood and adolescence. *Development and Psychopathology*, 23(3), 777–788. <https://doi.org/10.1017/S0954579411000290>
- Isabella, R. A., & Belsky, J. (1991). Interactional synchrony and the origins of infant-mother attachment: A replication study. *Child Development*, 62(2), 373–384.
- Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of The Society for Research in Child Development*, 66, i-149.
- Lester, B. M., ElSohly, M., Wright, L., Smeriglio, V., Verter, J., Bauer, C., Shankaran, S., Bada, H. S., Walls, C., Huestis, M. A., Finnegan, L. P., & Maza, P. M. (2001). The Maternal Lifestyles Study (MLS): Drug use by meconium toxicology and maternal self-report. *Pediatrics*, 107, 309–317.
- Madigan, S., Brumariu, L. E., Villani, V., Atkinson, L., & Lyons-Ruth, K. (2016). Representational and questionnaire measures of attachment: A meta-analysis of relations to child internalizing and externalizing problems. *Psychological Bulletin*, 142(4), 367.
- Main, M., & Solomon, J. (1986). Discovery of an insecure-disorganized/disoriented attachment pattern. In T. B. Brazelton & M. W. Yogman (Eds.), *Affective development in infancy* (pp. 95–124). Ablex Publishing.
- Malatesta, C. Z., Culver, C., Tesman, J. R., Shepard, B., Fogel, A., Reimers, M., & Zivin, G. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development*, 54(1-2), 1-104.
- Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the still-face paradigm: A review and meta-analysis. *Developmental Review*, 29(2), 120–162. <http://www.sciencedirect.com/science/article/B6WDH-4VTJVJK-1/2/c139034406571965d5d77d3a6b62e351>
- NICHD_ECRN. (2005). Duration and developmental timing of poverty and children's cognitive and social development from birth through third grade. *Child Development*, 76(4), 795–810.
- Sameroff, A. J., Seifer, R., Barocas, R., Zax, M., & Greenspan, S. (1987). Intelligence quotient scores of 4-year-old children: Social-environmental risk factors. *Pediatrics*, 79(3), 343–350.
- Seifer, R., LaGasse, L. L., Lester, B. M., Bauer, C. R., Shankaran, S., Bada, H. S., Wright, L. L., Smeriglio, V. L., & Liu, J. (2004). Attachment status in children prenatally exposed to cocaine and other substances. *Child Development*, 75(3), 850–868.
- Sheinkopf, S. J., Lagasse, L. L., Lester, B. M., Liu, J., Seifer, R., Bauer, C. R., Shankaran, S., Bada, H., & Das, A. (2007). Vagal tone as a resilience factor in children with prenatal cocaine exposure. *Development and Psychopathology*, 19(3), 649–673. <https://doi.org/10.1017/S0954579407000338>
- Tronick, E. Z., Messinger, D. S., Weinberg, K., Lester, B. M., LaGasse, L. L., Seifer, R., Bauer, C. R., Shankaran, S., Bada, H. S., & Wright, L. L. (2005). Cocaine exposure compromises infant and caregiver social emotional behavior and dyadic interactive features in the face-to-face still-face paradigm. *Developmental Psychology*, 41(5), 711–722.
- van IJzendoorn, M. H., & Kroonenberg, P. M. (1990). Cross-cultural consistency of coding the strange situation. *Infant Behavior and Development*, 13(4), 469–485.
- van IJzendoorn, M. H., Schuengel, C., & Bakermans-Kranenburg, M. J. (1999). Disorganized attachment in early childhood: Meta-analysis of precursors, concomitants, and sequelae. *Development and Psychopathology*, 11(2), 225–249.
- Völker, S., Keller, H., Lohaus, A., Cappenberg, M., & Chasiotis, A. (1999). Maternal interactive behaviour in early infancy and later attachment. *International Journal of Behavioral Development*, 23(4), 921–936. <https://doi.org/10.1080/016502599383603>
- Weinberg, K. M., & Tronick, E. Z. (1998). Infant and caregiver engagement phases system. Boston, MA: Harvard Medical School.
- Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology*, 35(1), 175–188.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Mitsven, S. G., Prince, E. B., Messinger, D. S., Tenenbaum, E. J., Sheinkopf, S. J., Tronick, E. Z., Seifer, R., & Lester, B. M. (2021). Testing the mid-range model: Attachment in a high risk sample. *Developmental Science*, e13185. <https://doi.org/10.1111/desc.13185>