Parenting Behaviors and Vagal Tone at Six Months Predict Attachment Disorganization at Twelve Months

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Abstract:

The authors investigated the relationships among parenting behaviors, infant vagal tone, and subsequent attachment classification. Vagal tone was assessed among 6-month olds ($n = 95$) during the still-face paradigm (SFP) via respiratory sinus arrhythmia (RSA), while attachment security and disorganization were measured at 12 months during the strange situation procedure (SSP). Infants demonstrating higher levels of RSA during the normal interaction and reunion episodes of the SFP whose mothers were also rated as negative-intrusive exhibited higher levels of attachment disorganization at 12 months, while infants with lower RSA and mothers who were negative-intrusive did not exhibit higher levels of disorganization. These results suggest that high levels of RSA may not be adaptive within the context of negative-intrusive parenting.

Keywords: attachment | parenting | vagal tone | RSA | biological sensitivity to context

Article:

INTRODUCTION

High levels of vagal tone are thought to promote a state of calm engagement that is conducive to social communication and interaction (Porges, 2007), and thus high levels of vagal tone may be particularly adaptive for young children, who depend on interactive exchange with caregivers to scaffold their nascent self-regulatory abilities (Calkins & Marcovitch, 2010). However, results recently reported by Conradt, Measelle, and Ablow (2013) cast doubt on this "main effects" perspective, indicating instead that the association between high vagal tone and developmental outcomes may be contingent upon environmental context, and specifically, on the quality of the parent–child relationship in early childhood. Whereas Conradt and her colleagues demonstrated that the association of high vagal tone with later problem behaviors was contingent upon the

quality of parent–child attachment bonds in late infancy, in the current study we examined whether the relationship between high vagal tone and attachment was moderated by parent behavior in early infancy.

The 10th cranial or vagus nerve is one of five cranial nerves that regulate the motor pathways controlling the striated muscles of the face, and thus permit much of social interaction (Porges, 2001, 2003). The vagus nerve also innervates the heart, exerting an inhibitory influence that keeps heart rate low and the variability of the interval between heartbeats high. This variability is commonly referred to as vagal tone, and is often indexed by the amplitude of respiratory sinus arrhythmia, or RSA. High levels of vagal tone at rest have been linked to better socioemotional outcomes in adults (Kok & Fredrickson, 2010; Oveis et al., 2009), while both resting levels of vagal tone and reductions in vagal tone in response to challenge have been linked to better outcomes in children (El-Sheikh, Harger, & Whitson, 2001). However, there is also evidence to suggest that the sequalae of high vagal tone may not be "unmitigatedly positive" (Kogan et al., 2013, p. 600). Maintaining high levels of vagal tone during challenging conditions has been linked to problems with emotion regulation in young children (Beauchaine, Gatzke-Kopp, & Mead, 2007; Calkins, Graziano, & Keane, 2007), while high levels of vagal tone during situations of calm engagement have been associated with reduced social functioning in adolescent girls (Eisenberg et al., 1995) and difficulties with behavioral regulation in infants and young children (Dietrich et al., 2007).

While these inconsistencies could be ascribed to methodological issues (cf. Rottenberg, 2007), two recent papers have proposed alternative explanations. Kogan et al. (2013) argued that the relationship between vagal tone and socioemotional outcomes may be quadratic, while Conradt et al. (2013) hypothesized that that high levels of vagal tone may be indicative of biological sensitivity to context (BSC; Boyce & Ellis, 2005); high levels of vagal tone do not exert an *a priori* positive or negative influence on development, but rather render an individual especially sensitive to the influence of the developmental environment. Consistent with this hypothesis, Conradt et al. found that high levels of vagal tone during infancy, collected under conditions of calm engagement, combined with a secure attachment classification (assessed at 17 months), predicted lower levels of behavior problems (also at 17 months) relative to securely attached children with average levels of vagal tone. When high levels of vagal tone were combined with a disorganized attachment classification, higher levels of behavior problems were observed; at average levels of vagal tone, disorganization did not predict behavior problems.

These findings suggest that high levels of vagal tone during calm engagement, and the interactive behaviors these levels support, may only be adaptive within the context of certain parenting behaviors. The current study was designed to explicitly test this premise by examining whether the relationship of vagal tone and one of the most important developmental outcomes of infancy—the formation of attachment bonds—is contingent upon parenting behaviors. The formation of secure attachment bonds, in which the young child seeks to maintain physical proximity to the mother and consistently pursues the goal of re-establishing this proximity upon

maternal separation by signaling his or her distress (Ainsworth, Blehar, Waters, & Wall, 1978), are fostered by sensitive parenting behaviors (de Wolff & van Ijzendoorn, 1997; Goldsmith & Alansky, 1987)—warm, supportive and stimulating behaviors—which were operationally defined by Ainsworth, Bell, and Stayton (1974) as a composite of awareness of child cues (e.g., a child's crying to signal his or her distress) and appropriateness of response (e.g., picking up and soothing the child). Thus we hypothesized that high levels of RSA during parent–child interaction, in combination with high levels of sensitive parenting behaviors, would predict an increased likelihood of a secure attachment classification. In contrast, high levels of both negative regard and intrusiveness—a lack of respect for the child's autonomy (McElwain & Volling, 1999) have been found to predict disorganized or disordered patterns of attachment (Hesse & Main, 2006; Lyons-Ruth, Bronfman, & Parsons, 1999; Lyons-Ruth, Repacholi, McLeod, & Silva, 1991; Madigan et al., 2006; Main & Hesse, 1990), wherein young children exhibit unstable attachment goals and an absence of coherent strategies necessary to attain them (Main & Solomon, 1990). Therefore we also hypothesized that high levels of RSA during parent–child interaction, in combination with high levels of parental negativity and intrusiveness, would predict higher ratings of attachment disorganization.

METHODS

Participants were drawn from a larger sample of 206 children recruited at 3 months of age by the Durham Child Health and Development Study (DCHDS). The DCHDS sample was composed of approximately equal numbers of European American (EA) and African American (AA) families sampled from low- and high-income groups. Children who left the study prior to 6 months were necessarily excluded from the sample ($n = 11$), as were those without cardiac data at 6 months ($n = 65$) and those who were not assigned an attachment classification at 12 months ($n = 35$). There were no significant differences in gender, ethnicity, or income-to-needs ratio among children included in the final sample and those excluded from it. The final sample for analysis ($n = 95$) consisted of 45 males (47.4%) and 50 females (52.6%), 53.7% of whom were AA and 46.3% of whom were EA.

Infants were seen with their mothers within 1 week of their 6- and 12-month birthdays. At the 6-month visit, baseline cardiac data were collected for 2–4 min (see below), and then parenting behaviors were assessed during a 10-min, unstructured free-play task in which parents were asked to “Play with your child as you would if you had some free time during the day.” Infant–mother dyads then participated in the Still-Face Paradigm (SFP; Tronick, Als, Adamson, Wise, & Brazelton, 1978), which began with a normal interaction episode during which the mother was instructed to interact with her child for 2 min as she normally would at home. After turning away from her infant for 15 s, the mother initiated the still-face episode, looking at her child for 2 min without any facial movement or vocalization. After another 15 s break, the mother turned back toward her child for 2 min, responding in any way that she felt was appropriate. At the 12 month laboratory visit children participated in the Strange Situation Procedure (SSP). Each procedure was videotaped and subsequently coded by two observers trained by Sroufe and Carlson

following protocols developed by Ainsworth et al. (1978, for attachment security) and Main and Solomon (1990, for attachment disorganization). Thirty percent of the tapes were double-coded for reliability (Cohen's kappa = .85).

Mothers' behaviors during the free-play task were recorded and subsequently coded by a team of females of European and African descent under the direction of a senior parenting researcher using a system adapted by Cox and Crnic (2002) from the system developed by the National Institute of Child Health and Development's (NICHD) Early Child Care Research Network (1999). Behaviors were coded on seven indices—intrusiveness, sensitivity, detachment, cognitive stimulation, animation, positive regard, and negative regard—using a 5-point scale, where 1 indicated that a behavior was not at all characteristic of a parent, and 5 indicated that a behavior was highly characteristic of a parent. An exploratory factor analysis suggested two latent variables: negative-intrusiveness and sensitivity, in which the measured variables negative regard and intrusiveness loaded on the negative-intrusiveness latent variable, while sensitivity (the measured variable), detachment (reverse coded), cognitive stimulation, animation, and positive regard loaded on sensitivity (the latent variable). Composite scores of these broad aspects of parenting were constructed by averaging the scale scores of the measured variables that loaded on each latent variable. Cronbach's alpha values were .87 and .65 for negative-intrusiveness and sensitivity, respectively (see Mills-Koonce, Propper, & Barnett, 2012, for further information).

Cardiac data were collected using two pediatric electrodes affixed to the child's chest. The amplified output of these electrodes was transmitted to a heart inter-beat interval (IBI) monitor (Mini Logger; Mini-Mitter/Respironics, Bend OR) for R-wave detection. IBI data were continuously collected during each episode of the SFP and the baseline period in which the child was seated facing away from their mother on her lap. Data files containing IBI data for the period of collection were edited for artifacts due to bodily movements using MXEdit software (Delta Biometrics, Bethesda, MD). Data files that required editing of more than 10% of the data were not included in the analyses. After editing and processing the IBI files, measures of respiratory sinus arrhythmia (RSA) were extracted using Porges' (1985) moving 21-point polynomial method (with band-pass filter set to 0.24–1.04 Hz, the frequency of spontaneous respiration in infants). RSA was calculated every 15 s during each 2-min episode and for baseline (epochs of this length are valid for studies of short duration tasks; cf. Huffman et al., 1998). Vagal tone was indexed by the mean RSA of the 15-s epochs within each SFP episode.

Child behaviors observed during the SSP were used to classify children as secure, insecure-avoidant, or insecure-resistant in their attachment, and to assess level of disorganization on a continuous 9-point scale in which higher levels of disorganization are indicated by increasing, half-point increments. To preserve statistical power when predicting attachment security, children were recoded as securely ($n = 57$, 60.0%) or insecurely attached ($n = 38$, 40.0%). While this classification summarizes individual differences in the attachment goals and the behavioral strategies employed to achieve them, disorganization captures the degree to which stable goals

and coherent behavioral strategies are absent (Main & Solomon, 1990); hence security and disorganization may be considered distinct but related dimensions of attachment.

Six children in the final sample for analysis were missing parenting data. Missingness was unrelated to either dimension of attachment, RSA during each episode and at baseline, gender and ethnicity. Twenty-two children (23.2%) were missing RSA at baseline; RSA was missing for 12 (12.6%), 15 (15.8%), and 17 (18.1%) children for the normal interaction, still-face, and reunion episodes, respectively. Missingness of RSA data for each episode and baseline was unrelated to attachment security, disorganization, gender, and ethnicity. Missing RSA data were imputed 20 times using fully conditional specification, with all other variables for which data were present (including interaction terms; see below) included as predictors in the imputation model (Graham, Olchowski, & Gilreach, 2007).

Analyses were conducted in three steps. First, preliminary analyses were conducted to identify relevant covariates, defined as variables that were significantly related to the dependent variables of interest or the focal predictors (Aiken & West, 1991). Then two sets of multivariate regressions were run: one set in which attachment security was regressed on sensitivity, RSA during each episode of the SFP, and their interaction, while controlling for relevant covariates; a second set of models were run in which disorganization was regressed on negative-intrusiveness, RSA during each episode, and their interaction while controlling for covariates. All models were run using SPSS Statistics v. 21. For models in which the interaction between parenting behaviors and infant RSA was significant, the degree of variance in the dependent variable attributable to the focal predictors was calculated and interactions were probed using the online utilities developed by Preacher, Curran, and Bauer (2006) and guidelines established by Aiken and West (1991).

RESULTS

While attachment security was not related to gender or ethnicity, levels of attachment disorganization were significantly higher among boys ($n = 44$, $M = 2.57$, $SD = 2.01$) than girls ($n = 50$, $M = 1.72$, $SD = 1.62$; $t(92) = 2.27$, $p = .026$) and were also higher among children classified as insecurely attached ($n = 33$, $M = 2.70$, $SD = 2.04$) than among children classified as securely attached ($n = 60$, $M = 1.72$, $SD = 1.54$; $t(91) = -2.61$, $p = .011$). Although ethnicity was unrelated to security and disorganization, mothers of EA children exhibited significantly higher levels of sensitivity ($n = 41$, $M = 3.49$, $SD = .718$) than mothers of AA children ($n = 48$, $M = 3.09$, $SD = .833$; $t(87) = 2.41$, $p = .018$). Mothers of EA children were also rated as displaying significantly lower levels of negative-intrusiveness ($n = 41$, $M = 2.27$, $SD = .593$) than mothers of AA children ($n = 48$, $M = 2.77$, $SD = .939$; $t(87) = -2.96$, $p < .01$). AA children exhibited higher levels of RSA during the normal ($t(81) = -2.20$, $p = .031$), still-face ($t(78) = -2.58$, $p = .012$), and reunion ($t(76) = -2.39$, $p = .020$) episodes of the SFP. RSA values were significantly inter-correlated (see Table 1). It should be noted that ethnicity was not

confounded with socioeconomic status, as indexed by income-to-needs ratio, in this sample ($p = .214$).

Table 1. Descriptives and Bivariate Correlations

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	***M***	***SD***
1. Sensitivity	—	−.291**	−.015	−.107	−.059	−.195	−.037	3.27	.803
2. Negative-intrusiveness		—	−.027	.030	.081	.075	.295**	2.54	.833
3. RSA, baseline			—	.787**	.774**	.725**	.243*	3.72	.909
4. RSA, normal				—	.816**	.806**	.305**	3.57	1.00
5. RSA, still-face					—	.803**	.224*	3.46	1.09
6. RSA, reunion						—	.260*	3.51	1.08
7. Disorganization							—	2.12	1.85

*p < .05; **p < .01.

Six multivariate regression models were run, three in which attachment security was the dependent variable, and three in which disorganization was the dependent variable (to protect against Type I error, a Bonferroni-adjusted value of $\alpha = .05/6$ tests $= .008$ was used) to assess the overall model. Attachment security was regressed on sensitivity, RSA during each episode of the SFP, and their interaction (focal predictors), with ethnicity (due to its relation with sensitivity), disorganization (due to its relation with security), and RSA at baseline included as covariates.[1] None of these three models were significant. Post-hoc analyses revealed that higher levels of sensitivity predicted an increased likelihood of a secure attachment classification within the EA subsample ($Wald(1) = 4.81$, $p = .028$), but not within the AA subsample ($p = .790$).

Disorganization was regressed on negative-intrusiveness, RSA during each episode of the SFP, and their interaction, with security, gender (due to its relation with disorganization), ethnicity (due to its relations with negative-intrusiveness and RSA), and basal RSA as covariates. The models including RSA during the normal interaction and reunion episodes were significant, as were the interactions between negative-intrusiveness and RSA (see Tab. 2). For the model including RSA during normal interaction, 14.5% of the variance in disorganization scores was uniquely attributable to negative-intrusiveness, RSA, and their interaction ($sR^2 = .145$; $F(7,79) = 6.16$, $p < .001$); for the model including RSA during the reunion episode, this figure was 13.7% ($sR^2 = .137$; $F(7,79) = 5.76$, $p < .001$).

Table 2. Regressing Attachment Disorganization on Negative-Intrusiveness and Respiratory Sinus Arrhythmia (RSA)

Model Results			**Variables Included in the Model**				
R^2	***F***	***p***	**Variable**	***B***	***SE***	***t***	***p***
RSA During Normal Interaction Episode							
.310	5.08	<.001	Gender (0 = male)	−.693	.350	−1.98	.048
			Ethnicity (0 = EA)	−.642	.371	−1.73	.084
			Attachment security (0 = secure)	.877	.366	2.39	.017

			RSA (basal)	.250	.319	.783	.434
			Negative-intrusiveness	−1.06	.910	−1.16	.246
			RSA (normal interaction)	−.842	.635	−1.33	.185
			Negative-intrusiveness X RSA	.482	.240	2.01	.045
RSA During Reunion Episode							
.302	4.88	<.001	Gender (0 = male)	−.853	.352	−2.42	.015
			Ethnicity (0 = EA)	−.575	.376	−1.53	.126
			Attachment security (0 = secure)	.840	.369	2.28	.023
			RSA (basal)	.411	.270	1.53	.127
			Negative-intrusiveness	−.885	.828	−1.07	.285
			RSA (reunion)	−.928	.529	−1.75	.080
			Negative-intrusiveness X RSA	.431	.214	2.02	.044

Post-hoc probing of the interactions between negative-intrusiveness and RSA during normal interaction and reunion episodes revealed parallel patterns of results. As is suggested by Figure 1, during normal interaction and at low levels of RSA (−1 *SD* = 2.58), the slope defining the relationship between negative-intrusiveness and disorganization is not significantly different from zero ($p = .598$). However, when RSA is high (+1 *SD* = 4.58), a positive relationship between negative-intrusiveness and disorganization is observed ($B = 1.15$, $SE = .321$; $t = 3.58$, $p < .001$). Similarly, during the reunion episode no relationship is observed between negative-intrusiveness and disorganization at low levels of RSA ($p = .632$) but at high levels of RSA a positive relationship is observed ($B = 1.09$, $SE = .535$, $t = 2.04$, $p = .045$).

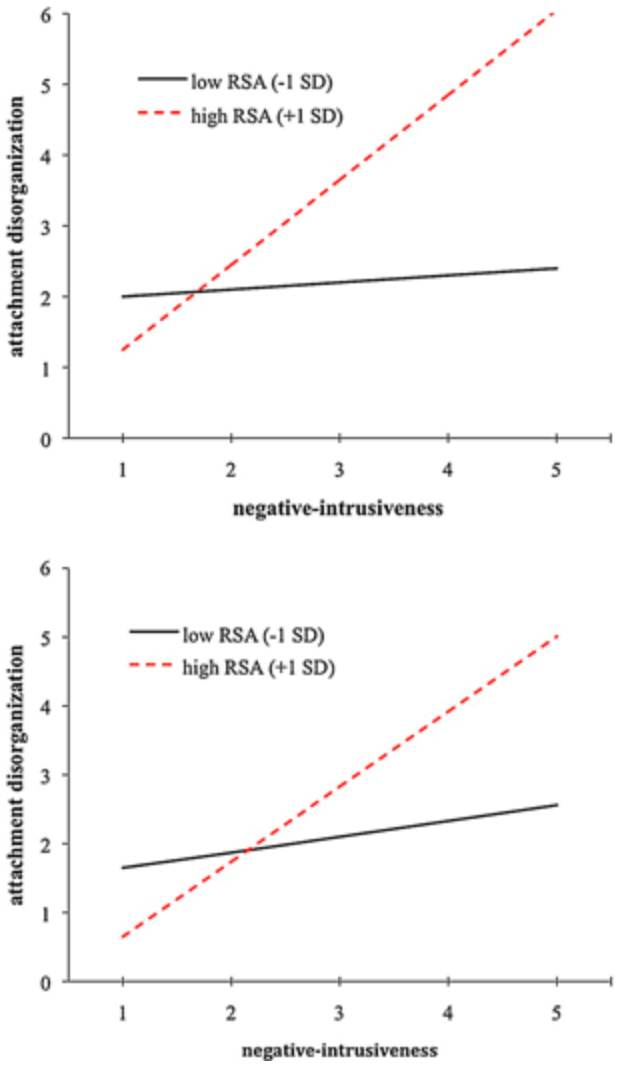

Figure 1. Relationship between negative-intrusiveness and attachment disorganization is moderated by respiratory sinus arrhythmia (RSA) during the normal interaction (top panel) and reunion (lower panel) episodes.

DISCUSSION

Attachment disorganization at 12 months was predicted by the interaction of negative-intrusiveness and RSA during the normal interaction and reunion episodes of the SFP. Specifically, high levels of RSA during these episodes, in conjunction with high levels of negative-intrusiveness, were associated with higher degrees of attachment disorganization. No relationship between negative-intrusiveness and disorganization was observed for children with lower levels of RSA. Thus the effects of negative-intrusiveness on attachment disorganization were contingent upon children exhibiting high levels of RSA during parent–child interaction.

There are at least two possible explanations for these findings. First, it is possible that we are observing reciprocal or bidirectional influences between child RSA and parenting behaviors (cf.

Haley & Stansbury, 2003; Porter, 2003), such that infants who exhibit higher levels of RSA during parent–child interaction elicit harsher parenting behaviors. However, this explanation runs counter to both previous research findings linking *lower* levels of RSA to harsher parenting behaviors (Kennedy et al., 2004) and polyvagal theory (Porges, 2007), which suggests that high levels of RSA and the interactive behaviors they may support would elicit more positive parenting behaviors. Alternatively, it is possible that infants whose parents engage in negative and intrusive behaviors perceive the parent–child interaction as challenging, but nevertheless maintain high levels of RSA because their previous exposure to negative-intrusive parenting has constrained their ability to reduce these levels. Indeed there is evidence linking exposure to negative-intrusive parenting to the maintenance of higher levels of RSA among older children even the face of challenge (Calkins et al., 1998; Hastings et al., 2008). Whatever its precise ontogeny, for most infants, whose parents display low levels of negative-intrusiveness, maintaining high levels of RSA is adaptive (Friedman, 2007), but for infants whose parents display more negative-intrusiveness, maintaining high levels of RSA may in fact be maladaptive (Lovallo, 2005) in that it renders these infants especially receptive to this negative social input. An integration of attachment and polyvagal theories suggests that combining a physiological predisposition for the acceptance of social input with repeated exposure to input of a negative-intrusive nature will favor the formation of a disorganized attachment bond, and indeed this is what was observed.

Contrary to our hypothesis, the interaction of high levels of both RSA and sensitivity did not predict an increased likelihood of a secure attachment classification. Indeed, post-hoc analyses revealed that for the sample as a whole sensitivity did not predict attachment security, though this relationship was observed within the EA subsample. Thus the ethnic heterogeneity of our sample may explain why our findings diverged from those of Conradt et al. (i.e., our sample was 43.6% EA, compared to 81.0% for Conradt et al., 2013), and more broadly may support the premise advanced by Cassidy et al. (2005) that the applicability of the construct of maternal sensitivity has limits within an ethnically diverse sample. However, it is also plausible that while the construct of maternal sensitivity is applicable across cultures, as a field our ability to measure that construct in diverse samples must be refined. This limitation may apply to the present study, in that some portion of the variance in ratings of maternal sensitivity may be due to discrepancies in demographics between the members of the coding team and the families being studied. While it would therefore be premature to interpret the results presented above as supporting a stress-diathesis account of the relationship between vagal tone, parenting behaviors, and attachment, rather than the biological sensitivity to context account offered by Conradt et al. (2013), it may also be premature to accept that biological sensitivity to context can be generalized to the interpretation of results obtained from ethnically heterogeneous samples.

One clear direction for future research would be to investigate the ontogeny of high levels of RSA. In the present study, we have treated RSA as a "dispositional" trait, when in fact RSA is influenced by a host of environmental factors (see Propper & Holochwost, 2013, for a review).

Moreover, while we have discussed RSA as though it captured the total of all vagal output, in fact RSA measures only the output of the ventral nuclei of the vagus, the nucleus ambiguous (NA). Total vagal output equals the output of the vental vagus (NA) plus that of the dorsal vagus (DMX; Porges, 2007). It may be that for children exposed to negative-intrusive parenting, higher levels of RSA are disproportionately a product of DMX output. Certainly the behaviors supported by the activation of the DMX, such as immobilization and freezing, are strikingly similar to those observed among disorganized infants during the Strange Situation Procedure (cf. Main & Hesse,1990).

The findings presented herein underscore the importance of considering context in the study of physiological processes, in terms of both the macro-context of the infant's accumulated interactive experience with the parent, and the micro-context of the moment-to-moment interaction nested there within, represented in this study by the episodes of the SFP. By doing so we might avoid classifying certain patterns of physiological activity as uniformly adaptive or maladaptive. Our results demonstrate that certain patterns of physiological activity typically considered adaptive may in fact be maladaptive within the context of negative-intrusive parenting.

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Note

1. Given that the interaction terms were of primary interest and centering does not change the value or interpretation of these terms, results for models without centered predictors are used throughout. However, models were also run using centered predictors, and, as expected, results were consistent across models.