CHILD DEVELOPMENT

Child Development, July/August 2013, Volume 84, Number 4, Pages 1373–1391

Associations Between First-Time Expectant Women's Representations of Attachment and Their Physiological Reactivity to Infant Cry

Jennifer C. Ablow, Amy K. Marks, S. Shirley Feldman, and Lynne C. Huffman
University of Oregon

Associations among 53 primiparous women's Adult Attachment Interview classifications (secure–autonomous vs. insecure–dismissing) and physiological and self-reported responses to infant crying were explored. Heart rate, skin conductance levels, and respiratory sinus arrhythmia (RSA) were recorded continuously. In response to the cry, secure–autonomous women demonstrated RSA declines, consistent with approach-oriented responses. Insecure–dismissing women displayed RSA and electrodermal increases, consistent with behavioral inhibition. Furthermore, insecure–dismissing women rated the cries as more aversive than secure–autonomous women. Nine months postpartum, secure–autonomous women, who prenatally manifested an approach-oriented response to the unfamiliar cry stimulus, were observed as more sensitive when responding to their own distressed infant, whereas women classified prenatally as insecure–dismissing were observed as less sensitive with their own infants.

Crying has been identified as one of the most salient attachment behaviors, and the human infant is similar to newborns of other species in its ability to emit vocal signals that serve as a stimulus for what becomes a complex interactional system through which infant and caregiver build their relationship (Broth, Goodman, Hall, & Raynor, 2004; Spangler & Grossmann, 1993). Contemporary biosocial models propose that the attachment relationship is a context in which caregivers play a critical role responding to infant distress and, in the process, regulating infants' behavioral and biological systems (Boyce & Ellis, 2005; Hofer, 2006). As do others (Groh & Roisman, 2009; Mills-Koonce et al., 2007; Moore & Calkins, 2004; Tronick & Cohn, 1989) , we speculate that to respond in an optimal manner that promotes infant organization, parents must first be able to manage their own physiological and emotional response to their infants' cues. The psychobiological reactions to their infants' cries that some parents experience may impact their ability to play a constructive role in their infants' regulation. In addition to questions about what individual difference factors explain how parents respond psychobiologically to child distress, the possibility exists that the bases for maladaptive parental responding may be detectable before the birth of a child. This study examined differences in expectant women's physiological responses to infant cry stimuli based on their own adult representations of attachment. Women were then observed when their infants were 9 months old to investigate whether attachment status and cry reactivity predicted maternal sensitivity in response to their own infant's distress.

Individual Differences in Adults' Response to Attachment Cues

Although being aroused by an infant's cries is typically a stimulus for sensitive maternal responding (mobilization for approach; Ham & Tronick, 2006), infant distress can also be dysregulating, especially when persistent and intense. For some caregivers, infant signals are subjectively aversive, emotionally upsetting (Zeskind & Marshall, 1988), and physiologically arousing (Weisenfeld, Malatesta, Whitman, Granrose, & Vili, 1985). Parents who self-report that they are prone to insensitive and, at times, abusive behavior, respond to infant cry stimuli with greater accelerations in heart rate (HR) and higher rates of respiration than comparison parents (Crowe & Zeskind, 1992; Frodi & Lamb, 1980; Lin, Bugental, Turek, Martorell, & Olster, 2002). When physiologically aroused, these parents appear to respond to their children's actions without reflective appraisal and, instead, draw involuntarily upon relationship schemas that have their origins in their own interpersonal histories (Bugental, Lewis, Lin,

Correspondence concerning this article should be addressed to Jennifer C. Ablow, Department of Psychology, 1227, University of Oregon, Eugene, OR 97403-1227. Electronic mail may be sent to jcablow@uoregon.edu.

 0009-3920/2013/8404-0019
DOI: 10.1111/cdev.12135

Lyon, & Kopeikin, 2000). Research has shown that when their working models of relationships as adults reflect ongoing insecurity, mothers appear to perceive a narrower range of infant emotions and are typically less accurate in their identification of specific infant emotions than secure–autonomous mothers (Blokland & Goldberg, 1988). Furthermore, research indicates that parents with insecure working models of attachment have greater difficulty interpreting their infants' ambiguous signals (Raval et al., 2001), have longer delays in responding to their infants' signals (Atkinson et al., 2000), and experience more negative affect while responding to their infants (Adam, Gunnar, & Tanaka, 2004) than do parents with secure working models of attachment. As such, a theoretical and empirical basis exists for predicting that differences in adults' attachment representations are associated with variation in how they perceive infants' distress cues.

Perhaps the most widely used and well-validated instrument to assess one's current working model of attachment is the Adult Attachment Interview (AAI; George, Kaplan, & Main, 1996). During the AAI, adults are asked a series of questions regarding their childhood experiences, providing memories relevant to loss, separation, rejection, and trauma. On the basis of the coherence of adults' verbal accounts, AAI interviews are classified as secure–autonomous, insecure–dismissing, or insecure–preoccupied and are thought to represent organized motivational tendencies toward attachment-related information (Main, 2000). In this study, we were specifically interested in women classified as secure–autonomous and insecure–dismissing. Not only are these two classifications the most representative of adult samples (Main & Goldwyn, 1998), but prior research has provided clear evidence that these two classifications, assessed both prenatally and postnatally, have implications for adults' capacity to develop sensitive and responsive relationships with their children (see meta-analysis by van IJzendoorn, 1995). Additionally, recent insights from an emerging literature on the psychophysiology of adult attachment has begun to identify physiological differences in adults' responses to attachment-related challenges, including responses to infant cry (e.g., Dozier & Kobak, 1992; Roisman, 2007; Roisman, Tsai, & Chiang, 2004), as a function of coherence within the AAI.

Psychobiological Responses to Attachment Cues

On the basis of theory originally advanced by Gray (1975), Fowles (1988) outlined evidence for the existence of two antagonistic components of the biological motivational system. The first, known as the behavioral inhibition system (BIS), is considered the anxiety system as it is involved in the effort to inhibit behavioral response when aversive consequences are anticipated. The second system, known as the behavioral activation system (BAS), is involved in approach-related activation. Fowles argued that behavioral inhibition is associated with electrodermal activity, specifically, increased skin conductance levels (SCL), and behavioral activation is associated with cardiovascular reactivity, typically in the form of increased HR.

Recent evidence from the attachment literature partially corroborates Fowles's (1988) hypothesis. For example, in separate studies, Dozier and Kobak (1992) and Roisman and colleagues (Dias, Soares, Klein, Cunha, & Roisman, 2011; Roisman et al., 2004) found that adults who used deactivating strategies while responding to questions during the AAI showed significant electrodermal increases from baseline. Social psychologists identify electrodermal response as a useful indicator of interpersonal processes (Dawson, Schell, & Fillion, 2000), often associated with states of anxiety and efforts to avoid difficult conversational material (Gottman & Levenson, 1992). For example, Roisman and colleagues found that both married (Roisman, 2007) and unmarried (Holland & Roisman, 2010) insecure adults who demonstrated a tendency to use deactivating strategies during the AAI manifested significantly elevated electrodermal responses while discussing areas of disagreement with their marital or romantic partner. Of particular relevance to this study, Groh and Roisman (2009) examined links between college students' secure base knowledge and changes in SCL following exposure to recorded infant cry. As predicted, individuals who generated narratives that were lower in secure base knowledge showed more electrodermal reactivity than did those high on secure base knowledge. In contrast, higher secure base knowledge was associated with little or no change in SCL in response to infant cry over baseline values (Groh & Roisman, 2009). Interestingly, no association was found between secure base knowledge and SCL response to recorded infant laughter, suggesting that BIS responses may be specific to attachment stimuli perceived as aversive or stressful. That Groh and Roisman (2009) identified attachment-linked differences in physiological reactions to infant cry in college students suggests that individual differences in cry reactivity may be in place before adults have infants of their own (Bugental et al., 2000).

Support for the BAS within the attachment literature, primarily examined using HR and HR variability, has been mixed. In their study of adopted adolescents, Beijersbergen, Bakermans-Kranenburg, van IJzendoorn, and Jeffer (2008) report that, relative to secure participants, dismissing adolescents demonstrated less cardiac reactivity as they discussed early attachment experiences during the AAI, yet elevated reactivity during a conflict-solving task with their mothers. In contrast, in the Roisman (2007) study, adults using a deactivating strategy during the AAI did not demonstrate elevated HR reactivity (compared to hyperactivating adults) during a conflict-solving task with their romantic partner. Other studies examining adult attachment strategies and HR variability found no significant differences in response to the AAI (Dias et al., 2011; Roisman et al., 2004) or an attachment-related challenge (Groh & Roisman, 2009). Conflicting and null findings may be because the heart is innervated by both the sympathetic (SNS) and parasympathetic (PNS) branches of the nervous system, which often have antagonistic effects during the response to stress (Cacioppo & Berntson, 1999). Activation of the SNS typically leads to elevations in HR and increased metabolic output typical of "flight-fight" responding. The PNS, by contrast, is responsible for the maintenance of homeostatic functioning and poststress metabolic recovery. However, withdrawal of PNS can enable more rapid and efficient change in HR (Berntson, Norman, Hawkley, & Cacioppo, 2008). Thus, a more accurate interpretation of the motivational response to particular stressors may be had when multiple physiological indicators are studied in response to the same stimulus (Beauchaine, 2001).

The measurement of cardiac vagal tone as indexed by respiration sinus arrhythmia (RSA) has become a common way to investigate PNS effects on self-regulation, information processing, and emotional functioning. RSA, the rhythmic oscillation in heart period accompanying breathing, is a noninvasive measure of cardiac vagal control (Rottenberg, Wilhelm, Gross, & Gotlib, 2002). Researchers have found that RSA is sensitive to environmental demands or challenge, and may serve as an index of underlying regulatory abilities in mammals (Porges, 1995). According to the Porges polyvagal theory (2007), individuals should show modest decreases in RSA (e.g., the removal of the "vagal brake") during challenging situations, removing inhibitory effects on HR and, as such, enabling increases in metabolic output needed for behavioral activity. However, when environmental demands have ceased, RSA increases (e.g., application of the "vagal brake") to promote decreases in HR and a return to a homeostatic or baseline state. Conversely, continued application or increases in vagal control when a behavioral response is indicated, or the failure to release vagal inhibition when a behavioral demand has passed, may reflect less adaptive emotional functioning (Beauchaine, 2001; Bornstein & Suess, 2000; Porges, 2007; Rottenberg et al., 2002).

Few studies have considered adults' parasympathetic response to attachment-related cues. Dias et al. (2011) found evidence that insecure women diagnosed with an eating disorder show poorer vagal tone than secure participants during the AAI. And although Roisman and colleagues (Holland & Roisman, 2010; Roisman, 2007) did collect RSA when studying couples engaged in discussions of interpersonal difficulties, they did not find that RSA differentiated between secure versus insecure or deactivating versus hyperactivating adults, suggesting that more challenging attachment-related experiences are needed to discriminate between secure and insecure adults (Roisman, 2007).

Present Study

The central goal of this study was to investigate associations between expectant women's attachment status and their physiological response to infant cry. We then used these prenatal associations to predict maternal sensitivity to their own infant's distress 9 months postpartum. In the present investigation, participants were presented with two different cry stimuli, which we labeled as the "simple" and "complex" cry conditions. In our simple cry condition, women saw a static video image of a crib while they heard but could not see an infant cry for 2 min. Audio-only presentations of infant cry have been the predominant paradigm in the infant cry literature, but have also raised questions about their ecological validity (Zeskind & Lester, 2001). Accordingly, our complex cry stimulus provided a more typical parenting context where woman could reasonably interpret the infant's cry as distressed. Specifically, in our complex cry condition, women watched 3 min of videotape of a mother and infant playing contentedly (1 min), followed by the infant becoming distressed once the mother departed (1 min.). The complex cry condition ended with a pseudo reunion, during which a female actor, dressed to look like the mother, tried unsuccessfully to soothe the baby (1 min.).

Based on theory reviewed above, and evidence that secure and insecure–dismissing adults show

different physiologic responses to attachment cues, we expected that women with secure–autonomous models of attachment would show autonomic reactions consistent with approach-related behavior, in particular, increased HR and decreased RSA. In contrast, we predicted that expectant women with insecure–dismissing attachment models would show an autonomic response consistent with behavioral inhibition, specifically, increased SCL and increased RSA. Our hypotheses reflect our prediction that exposure to an infant's cry would be differentially arousing for women with secure versus insecure models of attachment.

Following each cry stimulus, women were asked to rate the characteristics of the cry as well as to rate how they would have felt emotionally had they been the distressed infant's mother. Infant cry that is described as distressed typically elicits self-reports of concern that are consistent with the initiation of ameliorative care. In contrast, infant cry that is described as aversive can elicit both nonresponsive and insensitive parenting responses (Crowe & Zeskind, 1992). Accordingly, we predicted that women would rate the complex cry more negatively than the simple cry, in terms of both the cry's characteristics (e.g., distressing, urgent, aversive) and how the stimuli would have made them feel had they been the infant's mother (e.g., anxious–overwhelmed, angry–rejected). In addition, we expected self-reported reactions to the cry stimuli would differ according to women's AAI classification. We predicted that insecure–dismissing women would rate both cry conditions as more aversive than secure–autonomous women; secure–autonomous women would rate infant crying as more distressing. We also predicted that secure women, imagining they were the crying infant's mother, would indicate greater feelings of distress, whereas insecure–dismissing women would report greater feelings of anger–rejection. In general, we expected stronger effects for the complex cry condition.

Next, we examined whether prenatal differences in attachment classification and autonomic reactivity to cry predicted women's sensitivity when responding to their own 9-month-old babies' distress following a disruption in social interaction (i.e., a brief separation). We expected that secure–autonomous women would be more sensitive with their infants than insecure–dismissing women. Consistent with Porges (2007), we also hypothesized that women who manifested autonomic patterns in response to infant cry that were consistent with behavioral inhibition would be our least sensitive mothers when responding to their infants' distress; by contrast, women showing patterns of physiological engagement in response to infant cry would show greatest sensitivity with their infants.

In a final set of multivariate regression models, we examined how attachment and physiology might work together to predict maternal sensitivity to infant distress. Although bivariate associations have been identified previously in the literature, the links among adult attachment classifications, physiological response to infant distress, and maternal sensitivity have not yet been well explored (Fox & Hane, 2008; Thompson, 1997). In line with our notion that physiological response to infant distress might shape how parents with different attachment histories respond, we expected that women's prenatal autonomic response to infant cry would mediate the link between attachment and maternal sensitivity. However, such a model presumes that attachment representations temporally precede how women react physiologically to infant cry. Because establishing temporal precedence is needed to validate causal chains (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001), the conclusions drawn from this study will need to be statistical in nature until experimental or true prospective longitudinal designs can clarify this question. As such, we tested for mediation and moderation by employing the analytic criteria outlined by Baron and Kenny (1986) and refined by Kraemer et al. (2001).

Method

Participants

Sixty-nine primiparous women in their third trimester of pregnancy were successfully recruited through local childbirth education classes, obstetric practices, and hospitals in the mid San Francisco Bay area. Recruitment material informed that the project was investigating the process by which women who were expecting their first baby prepared for motherhood, both psychologically and biologically. The participants ranged in age from 19 to 41 years (M = 32.65 years, SD = 4.38 years). Postnatally, mother and infant dyads were visited in their homes approximately 9 months after the baby's birth; infants were on average 283 days of age (SD = 13 days) during this visit. The majority of the sample was self-identified as European American (77%), with 9% Asian, 5% African American, and 3% of Hispanic origin. The socioeconomic status of the sample was mostly middle to upper-middle class with the average annual household income of \$120,000 (SD = \$16,500), ranging from less than

$10,000 to more than $200,000. All participants, except one, were married at entry into the project, with average length of marriage of 3.43 years (*SD* = 2.2 years), ranging from 6 months to 10 years. Fifty-four percent of the women had college degrees, 33% had postgraduate degrees, and less than 2% did not have a high school degree. Although no women in the project had given birth previously, 29% of the sample had at least one prior pregnancy.

Procedure

Women visited our research laboratory at approximately Week 32 of gestation. One week prior to the visit, participants received a packet of informed consent documents and research questionnaires by mail. This packet assessed an array of issues, from health history and practices, mental health history, family functioning, current psychosocial functioning, and current symptomatology. Upon arrival at the laboratory, informed consent was documented. Women were asked to sit in the data collection chair facing a TV monitor while a female laboratory assistant placed surface sensors and a respiratory bellow to measure continuously cardiovascular activity, SCL, and respiration. Baseline values were established before women participated in the infant cry stimuli tasks followed by the AAI.

Approximately 9 months postpartum, women were visited in their homes where they completed additional questionnaires and participated in a mother–infant interaction that comprised a free play and an unexpected social disruption. Our 9-month interaction task was designed to bridge the social challenge of the still-face paradigm (Tronick & Cohn, 1989) and the strange situation (Ainsworth, Blehar, Water, & Wall, 1978) by stressing the infant with a brief period of parental unavailability and separation. The purpose of the interaction was to observe maternal behavior in response to infant distress. Although free play has been the dominant mode of assessing maternal sensitivity early in development, research has revealed that observations during distress rather than nonstress contexts (Atkinson et al., 2005) may be more indicative of individual differences in maternal sensitivity that are predictive of attachment-related outcomes. Biringen (1990) has documented that although brief maternal separation in the home is a regular and frequent occurrence, it can cause transient infant distress. Within this study, significant increases in infant distress in response to the brief maternal separation point to the internal validity of this procedure (as reported elsewhere in the Results). During our 9-month interaction, infants and mothers were first placed on a blanket on the floor in a comfortable room in their house (typically, living room). Mothers were instructed to interact with their infants for 2 min without toys and then for 2 more min with soft toys provided by the experimenters. At 4 min, mothers were signaled to leave their infant in the room and go to another room. Mothers returned after 90 s or, if the infant became distressed, sooner. For the 2-min reunion, mothers were instructed to respond to their infants' distress so that they could resume "play as usual." The interactions were videotaped and subsequently coded for both infant distress and maternal behavior. In this study, only maternal behavior on reunion with her baby was used in our central analyses given our focus on maternal response to infant distress (vs. maternal behavior while playing).

Infant Cry Stimuli

Women's continuous physiological reactions to infant cry were measured during two separate cry stimulus conditions, specifically, a simple cry stimulus and a complex cry stimulus. Order of condition presentation (baseline–simple cry/baseline–complex cry or baseline–complex cry/baseline–simple cry) was counterbalanced and assigned to women at random. After prerecorded instructions were administered via videotape, women were familiarized with an electronic rating dial that they would use to provide self-reported reactions following each cry stimulus. Before presentation of the first cry condition, participants watched a 1-min video clip of a tranquil seascape scene during which baseline physiology was measured and after which women reported on their mood state using the rating dial. Next, women watched either the complex cry condition or the simple cry condition.

The complex cry condition consisted of three separate 1-min segments. During the play segment, women watched a gender-ambiguous 9-month-old infant playing contently on the floor with its mother; all that could be seen of the mother was her legs in blue jeans and part of her white t-shirt. At the end of the play segment, participants watched the mother (lower torso) get up and leave the room, at which point the baby began to cry; we refer to this as the mother-departs segment. The mother-departs segment started when the on-screen mother leaves the room and the baby is seen crying on the floor for 60 s. As such, this segment consists of the video image and accompanying audio of the baby

crying. We refer to the next 60-s segment as the mother-actor segment, during which an adult woman who was a stranger to the baby, yet dressed exactly like the baby's mother, enters the room. Women watched as the mother actor tried unsuccessfully to soothe the baby. The instruction for the complex and simple cry conditions was, "Please watch the following film." For both conditions, women sat in a comfortable chair that was positioned 1.5 m away from a 36-in. television monitor; women listed to the audio through the monitor's internal speakers. The average fundamental frequency (F_0) of the cry was 653 Hz (range = 454–785 Hz). The average sound pressure level of the cry was 69.61 dBA (range = 65–73 dBA), as measured with a Brüel & Kjær (Brüel & Kjær, Sacramento, CA) precision sound level meter type 2235, which was placed where a subject's head would be.

The simple cry condition used the same audio track as the complex cry condition, but superimposed the track on a still image of a crib; the crib had a baby blanket draped over the sides, obscuring views of any baby that might have been (but was not) in the crib. Thus, in contrast to the complex cry condition, which consisted of video and audiotape of a crying infant, the simple cry consisted of only the audio cry. Following the baseline, women listened to the audio track of the crying infant for 120 s, which we divided into two 60-s segments for analytic purposes—Minutes 1 and 2 of the simple cry—because these 2 min corresponded to the baby's cry during the mother-departs segment and mother-actor segment of the complex cry condition. Following the cry episodes, a female interviewer administered the AAI to all participants. Interviewers underwent extensive training (supervised by the first author, who was trained by Mary Main) and followed a standardized, semistructured interview script.

Measures

Psychological measures. In addition to a demographics questionnaire, which included questions regarding age, ethnicity, marital status, occupational status, household income, number of prior pregnancies, prior child-care experience, and history of mental health care utilization, participants completed the depression and anxiety subscales of the Brief Symptom Inventory (BSI; Derogatis, 1975). The BSI is a 53-item self-report inventory designed to assess the symptom patterns of respondents. Items are rated on a 5-point scale, ranging from 0 (*not at all distressed*) to 4 (*extremely distressed*). The BSI's reliability (test–retest rs > .61), internal consistency (Cronbach's $\alpha > .86$), and convergent validity are strong (see review by Boulet & Boss, 1991).

Adult Attachment Interview. The AAI (George et al., 1996) is a semistructured, clinical interview designed to provide an assessment of an individual's current state of mind with respect to past caregiver–child attachment-related experiences (Hesse, 2008). Interpretations of the adult attachment categories do not rest on the assumption that they represent veridical accounts of early childhood experience. Rather, transcripts of the interviews are coded by trained raters according to how coherently people recount their past. The individual's strategy during the AAI (e.g., derogating or minimizing of attachment vs. valuing and rendering a balanced, coherent narrative despite positivity or negativity of actual experience) reflects the quality or security of one's current state of mind with respect to attachment (Hesse, 2008).

The AAIs were transcribed verbatim, and identifying information was removed prior to coding. To assess individual differences in attachment, transcripts were coded by a certified AAI coder, trained by Mary Main and Erik Hesse, who had achieved greater than 80% agreement with Main on the official reliability test for both three-group (Ds, F, E) and four-group (Ds, F, E, U) coding. For reliability, a second certified AAI coder scored 20 transcripts. Both coders were blind to all other project data and to each other's AAI scores. Interrater agreement between these two coders was 82% (k = .70) for the three-group coding and 75% (k = .64) for the four-group coding. Coding resulted in the following classification breakdown: 39 (56.5%) secure–autonomous; 17 (24.6%) insecure–dismissing of attachment; 3 (4.3%) insecure–preoccupied; 7 (10.1%) unresolved with respect to trauma; and 3 (4.6%) could not be classified. We focused only on the women classified as secure–autonomous and insecure–dismissing.

Physiological data acquisition and reduction. Measures of physiology were sampled continuously. Two silver–silver chloride electrodes were placed axially on the left and the right rib cage, approximately 10–15 cm below the armpits. A ground electrode was placed on the collarbone. Respiration was collected with pneumatic bellows, placed around the participant's chest and fixed with a metal bead chain. Data were collected with equipment from James Long Company (James Long Co., Caroga Lake, NY).

Heart rate. For electrocardiography (ECG), the bioamplifier was set for band-pass filtering with half-power cutoff frequencies of 0.1 and 1000 Hz, and the

signal was amplified with a gain of 500. The pneumatic bellows was attached to a pressure transducer with a band pass of direct current to 4000 Hz so that no segment or time shifts were introduced in the measurement of respiration. Data were digitized at a sampling rate of 1000 Hz with a 12-bit analog-to-digital board in laboratory computer.

R waves were identified in the ECG using an automated algorithm. Although rarely necessary, an interactive graphical program enabled manual correction of missed or misidentified *R* waves. The *R*-wave times were converted into interbeat intervals (IBIs) and resampled into equal time intervals of 125 ms. The prorated IBI values were saved for analyses of the mean and variance of heart period as well as further processing of heart period variability due to RSA.

Respiratory sinus arrhythmia. Respiratory sinus arrhythmia (RSA) represents the rhythmic fluctuation in heart period during cycles of respiration (Grossman & Kollai, 1993; Porges, 2007). In this study, RSA was measured in seconds and computed with the peak–valley method, which has been shown to correlate highly with spectrally derived measures of RSA (Galles, Miller, Cohn, & Fox, 2002). The respiration signal was used to identify the onset of inspiration and expiration times and relative tidal volume. RSA was computed as the difference in IBI between the onset of inspiration and the onset of expiration for consecutive respiratory cycles. As such, RSA was automatically computed twice per breath, once from inspiration to expiration and again from expiration to inspiration. The breath-by-breath differences across respiratory cycles were then averaged so that any underlying trends in heart period had minimal impact on the computed mean RSA.

Skin conductance levels. Participant's SCL (expressed in microSiemens) was examined using two Ag–AgCl skin conductance electrodes filled with Bio-Gel, an isotonic NaCl electrolyte gel. Velcro bands secured electrodes to the volar surfaces of distal phalanges of participant's first and second fingers on their nondominant hand. Double-sided adhesive collars with a 1-cm hole in the center were used to control gel contact. A constant sinusoidal (AC) voltage was used to avoid biasing the electrodes. The voltage was 0.5 V RMS. SCL responses were assessed at a rate of 1,000 readings per second, and SCL was calculated using the James Long Company software. A 14-Channel A/D converter was used to digitize and amplify signals. Averages for SCL responses were obtained for each baseline and segment of the cry conditions.

Graphs were made of each participant's HR, SCL, and RSA across all segments. Data outliers for each participant were examined graphically and statistically. Points above or below 3 *SD* of the mean were removed and an entire case was removed if more than 15% of their data files needed editing. Segment averages for all three physiological measures were computed for the discrete segments in each cry stimuli. For the simple cry episode, averages were computed for the baseline segment, Minute 1 segment, and Minute 2 segment. For the complex cry episode, averages were computed for the baseline segment, infant–mother play segment (1 min), mother-departs cry segment (1 min), and mother-actor cry segment (1 min).

Missing physiological data. None of the women from the overall sample of 69 was excluded because their data files required more than 15% editing. However, 4 of 69 women (5.7%)—2 secure–autonomous, 1 insecure–dismissing, and 1 women classified as unresolved with respect to trauma—had to be treated as missing because our equipment failed to detect accurate physiological levels. Consequently, in this study, our sample ($N = 53$) comprised 37 women classified as secure–autonomous and 16 women classified as insecure–dismissing.

Self-Report Ratings at Baseline, of Cry and Feelings as Mother

Using procedures and scales developed by Gross and Levenson (1995), women used a rating dial to describe their mood state before the cry tasks began. Using the dial with a scale of 1 (*not at all*) to 7 (*very much*), in response to a video-recorded prompt, women indicated how they felt on three dimensions: anxious, happy, and relaxed. Following each cry stimulus, five rating scales developed by Zeskind and Lester (1978) were used to quantify women's reports of how unpleasant or aversive they perceived the cries. Using a 7-point scale, women rated the quality of the infant's cry on five cry dimensions: urgent, soothing, piercing, grating, and distressed. The polarity of the scales was consistent in the scoring (e.g., the highest level of grating was represented by 7 and the lowest by 1). High intercorrelations (rs > .68) and a principal components analysis (all eigenvalues > 1.92) of these scales yielded the following reduced set of cry scales: urgent (urgent and soothing, reversed), aversive (grating and piercing), and distressed. Using the same rating dial, participants were asked to indicate how they would have felt had they been the crying infant's mother on eight scales that were developed

for this study, but patterned after the Description of the Child's Behavior Questionnaire (Zeanah et al., 1993), which asks participants to infer the emotional state of a distressed infant. Asked to infer how they would have felt if they had been the distressed baby's mother, participants rated the following eight dimensions: angry, rejected, anxious, overwhelmed, loved, needed, happy, and patient. The polarity of the 7-point scales was consistent in the scoring (e.g., the highest level of rejected was represented by 7 and the lowest by 1). High intercorrelations (rs > .71) and a principal components analysis (all eigenvalues > 1.48) of these scales yielded the following reduced set of cry scales: angry–rejected (angry and rejected), alarmed (overwhelmed and anxious), and loved (loved, needed, happy, and patient).

Maternal Behavior With Infant at 9 Months Postpartum

Maternal sensitivity was assessed following a brief separation from her infant using an adaptation of the global ratings of mother–infant interaction (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). Coders coded five dimensions of maternal behavior on a scale from 1 to 5. Higher scores represented higher levels on five dimensions: warmth, acceptance, responsiveness, demandingness (reversed), and sensitivity. *Warmth* was defined as the degree to which the mother expressed love and affection toward her baby, *acceptance* included the willingness and ability of the mother to follow the infant's lead, *responsiveness* was operationalized as the mother's awareness of her infant's signals and response to them, *demandingness* was defined as the degree to which the mother required the infant to behave in a certain way, and *sensitivity* included mothers to identify her infant's signals and vary behavior appropriately.

A subset of tapes (20; 43%) was coded by two coders to evaluate interrater reliability. Intraclass correlations between coders for each of the five dimensions coded were .82 (warmth), .82 (accepting), .95 (responsive), .87 (demanding, reversed), and .90 (sensitivity). Because the scales were highly intercorrelated (mean r = .67, range = .43–.88) and accounted for by a single factor in a principal components analysis, we averaged each woman's score on all five dimensions, creating a single measure of maternal sensitivity to her infant's distress.

Infant Distress

Infant distress was coded during the initial minute of play and during the entire 90-s separation phase of our infant–mother interaction to determine which infants became distressed in response to their mother's unexpected departure. Following a procedure similar to Haley and Stansbury (2003), distress was coded in 1-s intervals; for each second of interaction, infants received a distress score (1 point) if they protested, cried, or fussed, or 0 point for nondistressed behavior. Percentage scores of infant distress were calculated by summing the total number of seconds in each episode that distress occurred. This sum was then divided by the total interaction time per episode. Coders reliably observed infant distress (percent agreement = .84).

Results

Preliminary Analyses

Preliminary analyses were conducted to determine whether key health, mental health, and psychosocial variables were associated with our primary variables of interest. As shown in Table 1, AAI classification was unrelated to all demographics except for average level of educational attainment, $F(1, 52) = 7.23$, $p < .01$, with women classified as secure typically having completed college and women classified as insecure–dismissing typically having completed some though not all college. None of these demographic variables was associated significantly with women's physiology or with maternal sensitivity postpartum. Because inclusion of education level in our central analyses did not alter our findings when tested as main or interactive effects, these variables were dropped and are not discussed further.

Table 1 presents women's self-reported mood ratings and their physiological levels of arousal during the baseline segment prior to exposure to an initial cry condition. A multivariate analysis of variance (MANOVA) conducted on women's baseline mood ratings indicated that women classified as secure–autonomous and insecure–dismissing were statistically equivalent during our pretask baseline, $F(3, 49) = 1.31$, $p = .28$. MANOVAs conducted on women's physiological baselines also revealed no significant differences in levels of autonomic arousal between secure–autonomous and insecure–dismissing women, $F(3, 49) = 1.93$–2.17, $p > .12$. This general pattern of self-report and physiological equivalence at baseline increased confidence that subsequent divergences between secure–autonomous and insecure–dismissing women might reasonably be attributed to differences in women's response to our cry stimuli (Wainer, 1991).

Table 1
Demographic and Baseline Differences Between Women Classified as Autonomous or Dismissing on the Adult Attachment Interview (AAI)

	Total sample (N = 53) M (SD) or % (n)		AAI autonomous (n = 37) M (SD) or % (n)		AAI dismissing (n = 16) M (SD) or % (n)	
Demographics						
Age	31.91	(4.17)	32.16	(3.56)	31.55	(5.33)
Household income	$119,000	($9K)	$121,000	($10K)	$116,000	($9K)
Length of marriage in years	3.11	(1.85)	3.22	(1.71)	3.10	(2.24)
Education[a]	4.11	(.79)	**4.35**	**(.54)**	3.81	(.91)
Race/ethnicity						
African American	1.9%	(1)	0%	(0)	6.3%	(1)
European American	78.8%	(41)	83.8%	(31)	68.8%	(11)
Latina	3.8%	(2)	2.7%	(1)	6.3%	(1)
Asian	9.6%	(5)	10.8%	(4)	6.3%	(1)
Other	5.8%	(3)	2.7%	(1)	12.5%	(2)
Previous pregnancies ("yes")	26.9%	(11)	29.7%	(11)	18.8%	(3)
Prior child-care responsibilities ("no" = 1, "yes" = 2)	1.23	(.19)	1.25	(.23)	1.21	(.19)
History of intrapartum medical problems ("no")	92.4%	(49)	91.9%	(34)	93.8%	(15)
History of psychological counseling ("yes")	38.3%	(21)	43.2%	(16)	31.3%	(5)
BSI depressive symptom subscale	0.24	(.29)	0.25	(.37)	0.22	(.26)
BSI anxiety symptom subscale	0.34	(.30)	0.36	(.41)	0.33	(.24)
Baseline measures						
Anxiousness	1.54	(1.09)	1.42	(.76)	1.67	(1.37)
Happiness	4.80	(1.18)	4.88	(.99)	4.71	(1.36)
Relaxed	5.44	(1.45)	5.35	(1.41)	5.54	(1.50)
Heart rate	87.92	(10.24)	89.22	(10.84)	85.95	(9.10)
Skin conductance level	9.77	(4.45)	9.62	(4.10)	10.12	(5.21)
RSA	.045	(.02)	0.040	(.02)	0.055	(.02)

Note. Baseline physiology and self-reported rating data were derived from the resting period before the first cry stimulus task. Bold mean (standard deviation) indicated that one AAI classification's value was significantly different from the other AAI classification.
[a]Education coding: 3 = some college, 4 = 4-year college graduate.

The order in which the cry stimuli were presented was evaluated to see if it affected women's physiological responses. Although presentation order was significant in only 7 of 42 (16.7%) effects tested, we covaried potential order effects in our analyses but do not comment on it further.

Women's Self-Reported Reactions to the Cry Stimulus

As a way to understand how women perceived our cry stimuli, we first analyzed their self-reported reactions to our cry stimuli using the rating dial data. A repeated measures MANOVA was used to evaluate women's ratings of the characteristics of the infant cry (cry scales) and in a second model, how they would have felt had they been the baby's mother (maternal scales). Significant multivariate effects were found for the different cry scales, $F(3, 45) = 38.91$, $p < .000$, $\eta_p^2 = .36$; cry condition, $F(1, 50) = 3.94$, $p = .045$, $\eta_p^2 = .21$; and a significant AAI × Cry Scale interaction, $F(1, 50) = 3.83$, $p = .053$, $\eta_p^2 = .19$. Averaged across both cry conditions, women rated the cry stimuli as significantly more urgent ($M = 5.39$, $SD = 0.98$) than they did distressed ($M = 4.30$, $SD = 1.38$), and significantly more distressed than they did aversive ($M = 3.57$, $SD = 0.98$). These results indicate that both cry conditions created a reasonably salient stimulus. Collapsing across scales, women rated the qualities of the complex cry condition ($M = 4.65$, $SD = 1.73$) more negatively than the qualities of the simple cry condition ($M = 4.02$, $SD = 1.48$). A probe of the significant interaction revealed that insecure–dismissing women rated both the simple and complex cry conditions as more aversive than secure–autonomous women, $t(51) = 3.09$ and 3.29, $p < .05$, respectively. Contrary to prediction, there were no significant differences between secure–autonomous and insecure–dismissing women's rating of the cries' urgency or level of distress.

Analysis of the maternal scales yielded a significant multivariate effect, $F(2, 49) = 18.97$, $p < .000$, $\eta_p^2 = .25$, and a significant three-way interaction between Maternal Scale × Cry Condition × AAI

Status, $F(2, 49) = 5.71$, $p = .021$, $\eta_p^2 = .19$. Our probe of the interaction revealed that secure–autonomous and insecure–dismissing women rated the three maternal scales similarly following the simple cry condition. However, compared to secure–autonomous women ($M = 1.37$, $SD = 0.87$), insecure–dismissing women ($M = 1.47$, $SD = 1.57$) reported significantly higher levels of anger–rejection, $t(51) = 2.73$, $p = .018$, and significantly lower levels on the alarmed scale, $t(51) = 2.31$, $p = .023$ (Ms = 4.15 and 3.23, SDs = 1.16 and 1.41, respectively), in response to the complex cry condition. There were no significant differences between secure and insecure women's ratings on the loved–needed scale.

Physiological Responses to Cry Stimulus

Tests of the study's central physiological questions were conducted using separate repeated measures MANOVAs with planned contrasts to test-specific differences between and within the cry conditions (means are shown graphically in Figure 1 and results are presented in Table 2). MANOVA is particularly useful for analyzing repeated measures as the variance–covariance matrix of the error terms taking into account all dependencies between repeated measures (Bagiella, Sloan, & Heitjan, 2000). In all models, women's classification as secure–autonomous or insecure–dismissing on the AAI served as the two-level between-subjects factor. The within-subject factor comprised the different segments of each cry condition. The first planned contrast compared (a) women's physiological responses during the cry segment of each condition, specifically, the average of both simple cry minutes against the average of the mother-departs and mother-actor segments of the complex cry condition. The next two contrasts focused on the simple cry condition, specifically, (b) how the baseline and first minute of the simple cry condition differed, and (c) how the first and second minutes of the simple cry condition differed. The next three contrasts focused on the complex cry condition, specifically, differences between (d) the baseline and the mother–infant play segments, (e) the mother–infant play and the mother-departs segments, and (f) the mother-departs and the mother-actor cry segments. Because we held specific hypotheses about these contrasts, alpha was set at .05.

Heart rate. The analyses of HR revealed (Table 2) a nonsignificant effect of AAI classification and a nonsignificant effect of cry segment. Contrary to prediction, the multivariate test of the interaction between women's AAI classification and the cry segments of both conditions was not significant, suggesting that our cry stimuli affected the HR of

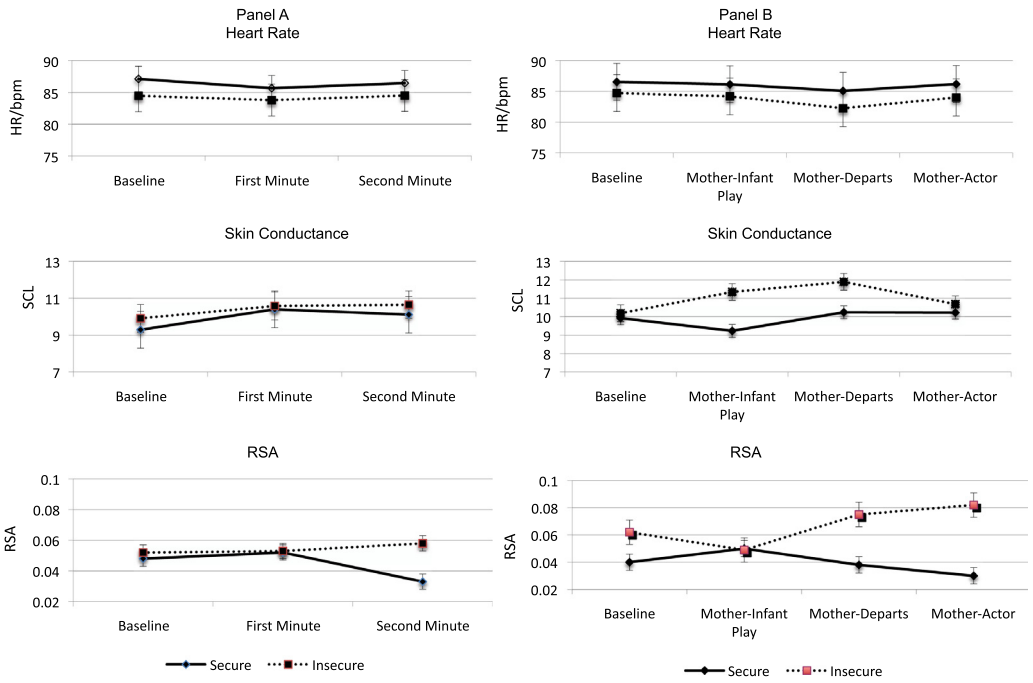

Figure 1. Heart rate (HR), skin conductance level (SCL), and respiratory sinus arrhythmia (RSA) during the simple cry stimulus (Panel A) and complex cry stimulus (Panel B).

Table 2
Multivariate Analysis of Variance (MANOVA) and Planned Contrasts Output for Women's Heart Rate (HR), Skin Conductance Level (SCL), and Respiratory Sinus Arrhythmia (RSA)

MANOVA of main and interaction effects	HR			SCL			RSA		
	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
AAI classification (df_{num} = 1, df_{den} = 51)	2.47	.075	.054	.097	.917	.001	16.05	.000	.239
Cry segments (df_{num} = 6, df_{den} = 46)	1.40	.160	.103	7.15	.008	.382	.89	.517	.103
AAI × Cry Segments (df_{num} = 6, df_{den} = 46)	0.28	.942	.032	3.67	.047	.212	3.15	.011	.291

Analysis of planned contrasts	Effect	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
Comparison of cry stress segments	Segment	2.30	.135	.04	4.23	.041	.12	1.09	.301	.00
	AAI × Segment	.31	.579	.01	.16	.694	.00	3.35	.073	.10
Baseline versus first minute of simple cry	Segment	1.28	.264	.01	1.04	.300	.02	.15	.837	.00
	AAI × Segment	.09	.953	.00	1.54	.220	.03	.19	.855	.00
First versus second minutes of simple cry	Segment	2.09	.154	.01	.41	.154	.09	.91	.345	.01
	AAI × Segment	.54	.464	.01	2.23	.142	.04	5.67	.018	.19
Baseline versus mother–infant play during complex cry	Segment	4.23	.046	.09	3.31	.078	.09	.01	.943	.00
	AAI × Segment	.23	.631	.01	6.75	.012	.20	1.05	.310	.01
Mother–infant play versus mother departs during complex cry	Segment	0.77	.144	.03	4.08	.036	.17	1.09	.302	.01
	AAI × Segment	.50	.483	.01	.18	.752	.00	7.08	.010	.23
Mother-departs cry versus mother actor during complex cry	Segment	3.21	.079	.05	1.37	.271	.15	.75	.391	.02
	AAI × Segment	.42	.520	.01	4.53	.065	.18	4.17	.046	.11

Note. Each contrast comprised two effects: a main effect for the difference between the contrasted segments and an effect for the interaction between women's AAI status and the contrasted cry segments; each contrast has a corresponding F-test value. AAI = Adult Attachment Interview.

secure–autonomous and insecure–dismissing women similarly.

Skin conductance level. The analysis of SCL produced (Table 2) a nonsignificant effect of AAI classification yet a significant effect for cry condition; collapsed across AAI classifications, women's SCL during the complex cry condition was significantly higher than during the simple cry condition, suggesting that the complex cry condition elicited a larger electrodermal response than the simple cry condition. This effect was subsumed, however, by the significant interaction between cry segments and women's AAI classification. Results from the planned contrasts provide a more complete picture of the nature of this interaction.

As shown in Table 2, none of the simple cry condition contrasts for SCL reached significance. Secure–autonomous women and insecure–dismissing women did, however, respond to the complex cry condition differently. Contrast 4 was significant and when probed revealed that secure–autonomous women showed a marginally significant decline in their mean SCL between baseline and the mother–infant play segment, $t(36) = 2.00$ $p = .065$, whereas insecure–dismissing women showed a significant increase in mean SCL from baseline to play, $t(15) = -2.29$ $p = .042$. Contrast 5 revealed that both AAI groups responded to the mother-departs segment with a significant increase in SCL. It was unexpected that both groups responded to the mother-departs segment with increased electrodermal activity. However, an additional t test revealed that whereas the insecure–dismissing women showed a clear rise in SCL between baseline and the mother-departs segment, $t(15) = -5.61$ $p = .009$, there was no difference between the baseline SCL and mother-departs SCL for the secure–autonomous women, $t(36) = .92$ $p = .392$; this may suggest that secure–autonomous women were returning to baseline SCL, a possibility that seemed further supported by the interaction in Contrast 6. Specifically, between the mother-departs segment and the final mother-actor segment, secure–autonomous women's SCL remained statistically unchanged, $t(36) = 1.06$, $p = .229$, whereas the SCL of insecure–dismissing women declined marginally, $t(15) = 2.27$, $p = .062$.

Respiratory sinus arrhythmia. The analysis of RSA revealed (Table 2) a significant effect of AAI

classification, a nonsignificant effect of cry segments, and, as predicted, a significant interaction between cry segments and AAI classification. Across all cry segments, secure–autonomous women had lower mean RSA levels (M = .04, SD = 0.02) than insecure–dismissing women (M = .07, SD = 0.04).

As shown by Contrast 2, there was no change in RSA for either AAI group from baseline to the first minute of the simple cry condition. However, there was a significant difference between the first and second minutes of the simple cry (Contrast 3), with secure–autonomous women showing a significant decline in RSA, $t(36) = 3.35$, $p = .002$, and insecure–dismissing women showing no significant change in RSA, $t(15) = -1.12$, $p = .281$.

Women's RSA levels did not change significantly from the complex cry baseline to the mother–infant play segment (Contrast 4). The two AAI groups did, nonetheless, respond differently to the subsequent aspects of the complex cry condition. Contrast 5 was significant and when probed revealed that secure–autonomous women showed a significant decline in their mean RSA from the mother–infant play and mother-departs segments, $t(36) = 2.56$, $p = .014$, whereas insecure–dismissing women showed a significant increase, $t(15) = -3.51$ $p = .025$. Contrast 6 also was significant, and showed that the RSA of secure–autonomous women continued to decrease albeit not significantly between the mother-departs and the mother-actor segment, $t(36) = 1.85$, $p = .072$, whereas insecure–dismissing women showed a significant increase during the mother-actor segment, $t(15) = -2.30$ $p = .040$.

Predictions of Maternal Sensitivity at 9 Months Postpartum

In a final set of hierarchical multiple regression analyses, we explored longitudinal associations between women's attachment representations, prenatal physiological reactions to our cry stimuli, and postnatal observations of women's sensitivity with their 9-month-old infant following a brief separation designed to cause the infant distress. The 1-year gap between women's prenatal and postnatal visit to our laboratory resulted in the attrition of 6 (11%) subjects (5 secure-autonomous and 1 insecure-dismissing); as such, our sample size for these analyses was $n = 47$ (32 secure and 15 insecure) women. To limit the number of models used to predict maternal sensitivity, we only utilized women's physiological responses during the acute cry segment of each cry condition (i.e., Minute 2 of the simple cry and the mother-departs segment of the complex cry). Infant distress in response to the separation was examined first.

A 2 (infant distress while playing with mother and during the separation) × 2 (AAI classification) repeated measures ANOVA revealed that the infants' frequency of distress increased significantly between the play segment (Ms = 5.77, SD = 9.22) and the separation segment of the mother–infant interaction (Ms = 25.91, SD = 20.18), $F(1, 45) = 4.68$, $p = .036$, $\eta_p^2 = .10$. However, a nonsignificant AAI, $F(1, 45) = 1.94$, $p = .35$, $\eta_p^2 = .01$, and AAI × Task Segment interaction, $F(1, 45) = 0.79$, $p = .72$, $\eta_p^2 = .00$, meant that the infants in both AAI groups were similarly distressed.

Higher infant distress was not significantly associated with maternal AAI classification ($r = .17$, *ns*), but it was associated with greater maternal sensitivity ($r = .29$, $p = .03$). In terms of women's physiology, infant distress was not associated with mothers' prenatal HR response to cry (rs = .18 and .14, $p > 1.0$, simple and complex cry, respectively) or with SCL (rs = −.18 and −20, $p > .10$, simple and complex cry, respectively), but was significantly associated with RSA (rs = −.29 and −.35, $p < .05$, simple and complex cry, respectively); greater distress was associated with lower levels of RSA during Minute 2 of the simple cry and during the mother-departs segment of the complex cry. Because infant distress in response to our mother–infant separation task showed associations with both predictor and outcome variables, we controlled for infant distress in our multivariate regression models.

Based on eligibility criteria outlined by Kraemer et al. (2001), the results associated with Table 2 constrained the models we could actually test. Specifically, our inability to detect significant bivariate associations between AAI and women's HR and SCL response to the cry stimuli precluded tests of mediation but not moderation. Alternatively, a significant bivariate association between AAI and RSA enabled us to test for mediation, but not moderation. With women's sensitivity as criterion, infant distress was entered first to control for individual differences in infants' response to our separation task. As shown in Table 3, we ran separate models for each physiological system as well as separately for each cry stimulus. In all models tested, AAI classification was a significant independent predictor of maternal sensitivity (ps < .05), above and beyond the contributions of infant distress and prenatal physiology. As predicted, women's state of mind with regard to attachment predicted individual differences in their sensitivity to their own infant's

Table 3
Prenatal Predictors of Postnatal Maternal Sensitivity—Tests of Mediation and Moderation

	Maternal sensitivity							
	Simple cry condition[a]				Complex cry condition[b]			
Predictors	β	*B*	95% CI	% var. exp.	β	*B*	95% CI	% var. exp.
HR models—moderation								
Infant distress	.19†	.38	−.30 to .47	.06	.18†	.35	−.32 to .49	.05
AAI	−.34*	−.62	−1.04 to −.19	.11	−.33*	−.60	−1.10 to −.21	.12
HR	.67	.05	−.02 to .14	.02	.72	.09	−.03 to .11	.03
AAI × HR	.50	.02	−.02 to .08	.01	.53	.06	− 01 to .07	.02
	R^2 = .20, $F(4, 43)$ = 2.91, p = .042				R^2 = .22, $F(4, 43)$ = 3.67, p = .021			
SCL models—moderation								
Infant distress	.15	.36	−.32 to 1.05	.04	.17†	.36	−.31 to 1.00	.05
AAI	−.32*	−.59	−1.03 to −.17	.12	−.34*	−.61	−1.05 to −.16	.13
SCL	−.34	−.06	−.51 to .10	.01	−.33	−.05	−.15 to .08	.01
AAI × SCL	−.48†	−.11	−.15 to .06	.06	−.52*	−.20	−.29 to −.03	.08
	R^2 = .23, $F(4, 43)$ = 4.18, p = .013				R^2 = .27, $F(4, 43)$ = 4.70, p = .009			
RSA models—mediation								
Infant distress	.19†	.37	−.30 to .44	.06	.19†	.37	−.30 to .44	.06
AAI	−.35*	−.63	−1.01 to −.15	.12	−.35*	−.63	−1.01 to −.15	.12
	R^2 = .18, $F(2, 45)$ = 4.67, p = .016				R^2 = .18, $F(2, 45)$ = 4.67, p = .016			
Infant distress	.20†	.39	−.28 to .43	.06	.18†	.37	−.30 to .51	.05
RSA	−.27**	−2.24	−10.42 to −.05	.10	−.32**	−4.07	−12.61 to −.22	.13
	R^2 = .16, $F(2, 45)$ = 3.99, p = .025				R^2 = .18, $F(2, 44)$ = 4.85, p = .010			
Infant distress	.18†	.37	−.32 to .50	.05	.18†	.39	−.30 to .49	.05
AAI	−.31*	−.52	−.97 to −.18	.11	−.30*	−.49	−1.01 to −.20	.12
RSA	−.37**	−5.12	−14.07 to −1.90	.10	−.40**	−5.79	−15.24 to −1.99	.13
	R^2 = .26, $F(3, 44)$ = 5.25, p = .007				R^2 = .30, $F(3, 44)$ = 6.21, p = .001			

Note. AAI = Adult Attachment Interview; HR = heart rate; SCL = skin conductance level; RSA = respiratory sinus arrhythmia; % var. exp. = percent of maternal sensitivity explained by predictor.
[a]Physiological data collected during Minute 2 of the simple cry condition used in the simple cry models.
[b]Physiological data collected during the mother-departs phase of the complex cry condition used in models.
†p < .10. *p < .05. **p < .01.

distress 1 year later, with secure–autonomous women showing significantly more sensitivity to their infants than insecure–dismissing women.

As shown in Table 3, women's prenatal HR responses during the simple and complex cry conditions did not predict sensitivity, either alone or in interaction with AAI. In both SCL models, SCL did not directly predict sensitivity, nor did it interact with AAI in the simple cry model. However, the AAI × SCL interaction was significant in the complex cry model. To probe this interaction we computed simple intercepts and simple slopes to represent the association between attachment status and maternal sensitivity (following Cohen, Cohen, West, & Aiken, 2003) at lower (−1 *SD*) and higher (+1 *SD*) levels of women's SCL. As shown in Figure 2, analyses revealed that the association between attachment status and behavioral sensitivity was significant among women who responded to our complex cry with higher SCL, $B = -.58$, $SE = .20$, $p < .01$, but not among women with low SCL, $B = -0.21$, $SE = .18$, *ns*; insecure–dismissing women who responded with high SCL during the complex cry were significantly less sensitive in response to their distressed infant than secure and insecure–dismissing women with low SCL.

As shown in Table 3, neither model involving RSA yielded statistically significant support for the prediction that prenatal RSA mediated the link between AAI and women's sensitivity in response to their infants' distress. As well, we tested for and found that the AAI × RSA interaction terms were nonsignificant, although this test was technically precluded by criteria used to guide tests of moderation (Kraemer et al., 2001). Importantly, however, in both the simple cry and the complex cry models, both AAI and RSA independently predicted maternal sensitivity in response to infant distress. Specifically, women who were secure–autonomous on the AAI and women who responded with

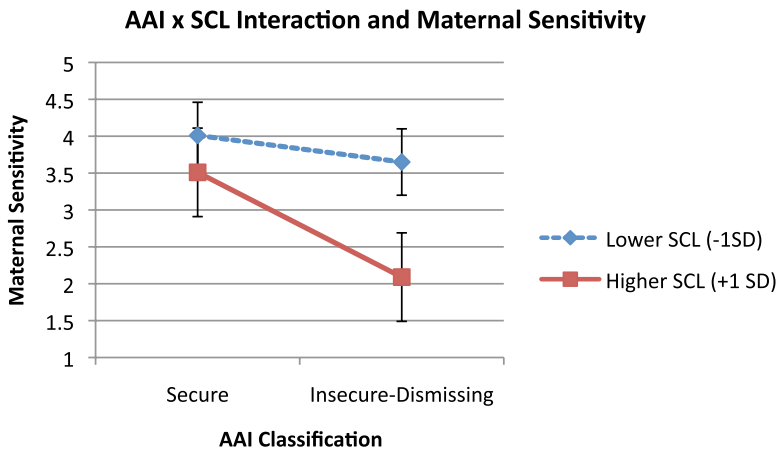

Figure 2. Adult Attachment Interview (AAI) × Skin Conductance Level (SCL) Interaction and maternal sensitivity at 9 months postpartum.

lower levels of RSA to our prenatal cry tasks showed higher levels of maternal sensitivity with their own infant.

Discussion

The results support the hypothesis that women's psychological and physiological responses varied as a function of their attachment classification on the AAI, and prenatal patterns of cry reactivity predicted individual differences in women's maternal sensitivity to their own infants' distress. As in previous studies of cry reactivity (Del Vecchio, Walter, & O'Leary, 2009; Groh & Roisman, 2009; Zeskind & Lester, 2001), the women in this study were presented with levels of infant cry that are typically reached by infants when distressed and that are typically perceived as distressed by parents (Del Vecchio et al., 2009; Frodi & Lamb, 1980). When an infant's cry is perceived as distressed, or engenders a sense of alarm in a mother, women indicate that they would respond more quickly than if they did not perceive the cry as distressed (Wood & Gustafson, 2001). Although secure–autonomous and insecure–dismissing women in this study rated both the simple (audio-only) and complex cry (audio and video) stimuli as comparably distressing, secure women reported feeling more alarmed by the cry, whereas insecure–dismissing women experienced the cry as more aversive. When infant cry is perceived as aversive, some mothers are found to be at risk of withdrawing from their infants (Zeskind & Lester, 2001) or responding too quickly and, potentially, insensitively (Del Vecchio et al., 2009). Furthermore, in response to the complex cry, insecure–dismissing women reported feeling greater anger and rejection than secure women. These self-report data are consistent with evidence that distressed infant cries can elicit orthogonal reactions (Zeskind & Marshall, 1988), although the basis for these differences has not been well identified. These data suggest that secure–autonomous women were concerned by the infant crying, whereas the insecure–dismissing women seemed to experience our cry stimuli as somewhat aversive and angering.

Analyses of our physiological data also revealed that secure–autonomous and insecure–dismissing women manifested reasonably distinct autonomic responses to our cry stimulus. Contrary to prediction, the average HR of both secure–autonomous and insecure–dismissing women remained comparable across both cry conditions. The lack of HR findings in this study is not unparalleled in the attachment literature (Holland & Roisman, 2010; Roisman, 2007). Animal and human studies comparing the effects of reward incentives versus punishment consistently find that physiological reactivity increases in response to appetitive or hedonic motivation (i.e., anticipated reward), but less so in response to increases in aversive motivation (i.e., anticipated punishment; Cacioppo & Berntson, 1999). Although the motivation to soothe a distressed infant may be an important objective for parents, the actual act of listening to a distressed infant may not be experienced physiologically as a reward, per se.

In response to our simple cry condition, secure–autonomous and insecure–dismissing women showed neither significant nor different SCL. This finding is in contrast to Groh and Roisman's (2009) study, in which lower levels of secure base knowledge were associated with heightened SCL from baseline in response

to an audio recording of infant crying. It is possible that Groh and Roisman's use of headphones and higher sound pressure levels for their cry stimulus (M_{dBA} = 89.51) affected electrodermal responses more acutely than in our study where women listened to cry via a TV monitor and at lower volumes (M_{dBA} = 69.61). Our participants did manifest significant electrodermal responses during the complex cry condition, which we had designed to be more stressful, as participants could see and hear the distressed infant. On the whole, expectant women classified as insecure–dismissing showed a significant increase in their SCL between our baseline segment and the period during which they heard and saw the infant cry following its mother's departure. This increase may reflect activation of the BIS, or physiological efforts to inhibit behavioral responses when aversive consequences are anticipated (Dozier & Kobak, 1992; Fowles, 1988; Roisman, 2007). Importantly, these data also are consonant with Groh and Roisman's (2009) study that found electrodermal increases to infant crying among college students with limited secure base script knowledge. Bowlby (1980) argued that insecure–dismissing adults passively or actively employ a strategy of deactivating the attachment system to defend against, discount, or ignore attachment cues that would ordinarily increase appetitively motivated behavior. In this study, women classified as dismissing of attachment responded to seeing and hearing a distressed infant's cry in a psychophysiological manner that was potentially consistent with the motivation to avoid the attachment bids of a crying infant.

Insecure–dismissing women also responded with a significant increase in SCL while viewing the infant playing contently with its mother. This is in contrast to the nonsignificant but measurable decrease in the SCL of secure–autonomous women in response to the mother–infant play segment. To the extent that women generally rate positive infant affect as pleasurable (Zeanah et al., 1993), we expected women in our study to show little or no autonomic response to the infant–mother play segment. It is possible that the insecure–dismissing women in our study were not reacting to the infant–mother play condition per se but were instead anticipating an impending stressor. Adults prone to anxious symptoms tend to show elevated sympathetic reactivity and heightened attention to environmental stimuli when negative experiences are expected (Berntson, 2008). However, this electrodermal increase remained meaningful for insecure–dismissing women even when controlling for anxious and depressed symptomatology. Given the tendency to distance themselves from attachment-related material, it is plausible then that these expectant women experienced the mother–infant play epoch as mildly aversive.

In response to the simple cry and paralleling SCL results, insecure–dismissing women showed little RSA response. However, they did show steadily increasing RSA across the complex cry condition. Consistent with our initial predictions, polyvagal theory (Porges, 2007), and paralleling work by Tronick and colleagues (Ham & Tronick, 2006), the increase in RSA exhibited by the insecure–dismissing women may reflect parasympathetic attempts at self-regulation following sympathetic activation, and is generally not indicative of efforts to mobilize infant soothing behaviors. From the standpoint of attachment theory, these insecure–dismissing women may have been engaged in a strategy of regulation designed to exclude or to divert their attention away from an attachment-related stressor. Regulating one's arousal before attending to one's infant may enable some parents to respond more sensitively. However, there is evidence that parents classified as insecure–dismissing tend to respond to their children's attachment bids with delay, inconsistency, or irritation (Main, 2000). In this study, insecure–dismissing women reported that they would have felt more anger and rejection as the crying infant's mother. Although these self-reported reactions to our cry stimuli do not speak conclusively to women's mind-set during our cry conditions, along with the physiological findings they do suggest that insecure–dismissing women may be engaged in inhibiting a behavioral response that is partially related to an emotionally negative response to infant attachment cues.

Secure–autonomous women, by comparison, showed a significant decrease in RSA in response to both cry conditions, a pattern suggestive of the parasympathetic withdrawal needed to initiate a behavioral response (Beauchaine, 2001). The parasympathetic nervous system enables restorative functions, for example, slowing HR. However, the efferent fibers to the heart that originate in the nucleus ambiguous also enable increased metabolic output when a behavioral response is seen as adaptive or when needing to respond to an emotional stressor (Beauchaine, Gatzke-Kopp, & Mead, 2007). Studies linking attachment representations to parenting behavior demonstrate that adults classified as secure–autonomous typically tend to respond to their infant's bids in an attuned, sensitive, and contingent manner (Crowell & Feldman, 1988; Ward & Carlson, 1995). The RSA reduction shown by the secure–autonomous women in response to the

infant's distress is consistent with behavioral. Moreover, such an interpretation is consonant with Porges (2007) and parallels evidence that emotionally sensitive mothers show RSA decreases when finally able to respond to their infant after the neutral segment of the still-face paradigm (Ham & Tronick, 2006; Moore et al., 2009) or during the reunion phase of the strange situation procedure (Hill-Soderlund et al., 2008).

Our final goal was to link prenatal attachment status and ANS cry response to women's response to their own, distressed infant. Our finding that women's prenatally assessed AAI status predicted maternal sensitivity almost a year later adds to the corpus of evidence linking adult attachment representations to their own behavior as mothers (van IJzendoorn, 1995). Particularly noteworthy is that this association was between prenatal AAI status and maternal sensitivity to infant distress, rather than sensitivity to nondistress, as the effects of parental attachment histories may be most evident when parents are challenged by attachment stressors requiring a parenting response (Thompson, 1997). Not only has parental sensitivity to distress been shown to predict infant attachment security more reliably than sensitivity to nondistress (McElwain & Booth-LaForce, 2006), it also has shown stronger associations with infants' own physiological self-regulation during distress (Conradt & Ablow, 2010).

The results linking women's physiology to maternal sensitivity were mixed and suggest that there may be differences in how aspects of women's autonomic nervous system (ANS) predict maternal sensitivity, as well as variation in the ways in which attachment and physiology operate together to predict behavior. Following established (Barron & Kenny, 1986) and more recent criteria (Kraemer et al., 2001), we also tested for mediated and moderated processes between our prenatal predictors.

Cardiac arousal in the form of increased HR was not associated with greater sensitivity, nor did prenatal HR interact with attachment status to predict behavior. Although prior research has documented HR elevations in response to infant cry (Frodi & Lamb, 1980), the level of cardiac arousal evoked by our cry paradigm was either too small or incommensurate with the level of cardiac response needed to support maternal sensitivity (Bornstein & Suess, 2000). Likewise, women's electrodermal reaction to infant cry did not predict later maternal response to their distressed infant. Instead, women's SCL response to cry appeared to moderate the association between attachment status and sensitivity such that women classified as insecure–dismissing who responded to the complex cry stimulus with increased SCL were significantly less sensitive with their distressed infant than the insecure–dismissing women who showed low SCL, or secure women at either level of SCL. As such, high SCL in response to infant cry may operate as added vulnerability, whereas low SCL may operate as a protective factor against less sensitive parenting in the context of insecure–dismissing attachment.

In contrast to the HR and SCL cry results, we found that women's prenatal RSA levels predicted individual differences in maternal sensitivity and lower RSA in response to both cry stimuli anticipated higher maternal sensitivity, whereas higher RSA predicted less sensitivity. These findings converge with Porges (2007) in suggesting that maternal vagal self-regulation during stressful parent–child interactions plays a significant role in organizing effective parenting behaviors (Hill-Soderlund et al., 2008; Mills-Koonce et al., 2007; Moore et al., 2009). We attempted to extend this line of work by testing the extent to which vagal regulation might account for the links between attachment and maternal sensitivity. Although our initial analyses showed that lowered RSA in response to infant cry was characteristic of secure–autonomous women, and that elevated RSA was characteristic of insecure–dismissing women, we did not find support for the hypothesis that women's prenatal RSA response mediated (or moderated) the links between attachment status and postnatal maternal sensitivity. As such, we cannot conclude that mother's vagal regulation in response to infant cries explains why mothers with secure attachment representations are more sensitive than insecure–dismissing women when responding to their distressed babies. The lack of mediation over the course of the first year does not rule out the possibility that women's concurrent vagal response to their own infant's distress is not mediating the effects of their attachment representations on how they respond to their own distressed infant. Nevertheless, these data suggest that both prenatal attachment status and RSA in response to an unfamiliar infant's cry signals contribute uniquely to mothers' sensitivity and responsiveness to their own infants' distress 1 year later.

These findings and their interpretations must be considered in the context of several limitations. First, given this sample comprised primarily White, middle- to upper-middle-class women, the generalizability of these findings is limited. Greater cultural and socioeconomic diversity should be sought

before biobehavioral findings of the type reported here can be applied more broadly. The size of our sample, both overall and in terms of the number of women with secure and insecure representations of attachment, was another limitation. Not only did this yield modest cell sizes for our analyses, but we had too few cases to explore the biobehavioral implications of the AAI's two other primary classifications (insecure–preoccupied and unresolved with respect to trauma). Still, despite our modest sample size, the effect sizes reported herein were noteworthy. In particular, interactions involving attachment status and the different segments of our two cry stimuli consistently yielded meaningful effect sizes (Cohen, 1992). Provided these results can be replicated, these are not trivial levels of association and support the contention that women's physiological reactions to infant cry signals may differ partially as a function of their attachment history.

Conclusions

Variation in caregivers' responsiveness to infants' signals can lay the groundwork for subsequent emotion regulation abilities. Much of this early programming transpires within the context of the primary attachment relationship(s), where infants' bids for regulation may or may not be met with effective parenting. Consequently, caregivers' psychophysiological reactions to attachment cues are an important focus of research that could help to elucidate individual differences in sensitive parenting and, in turn, emotion development in children. Our goal was to contribute to an understanding of these potential processes both before women actually gave birth to their first child. We found that expectant women manifested reasonably distinct patterns of autonomic response to infant cry stimuli based on their AAI classification and that these attachment-linked differences in women's sympathetic response, in particular, predicted differences in maternal sensitivity once their child was born. These data suggest that primiparous women who were classified as secure–autonomous on the AAI showed an autonomic response that was consistent with approach-related behavior. In contrast, primiparous women classified as insecure–dismissing on the AAI showed an autonomic response that was more consistent with behavioral inhibition. Once mothers, insecure–dismissing women who responded highest on autonomic markers of behavioral inhibition were observed as the least sensitive with their own 9-month-old children. Although replication will be essential, these data appear to imply that exposure to an infant's cry is differentially arousing for women with secure versus insecure models of attachment. As these findings were derived with first-time expectant women during their final trimester of pregnancy, these data point to a potentially fruitful period of intervention. Universal psychoeducational programs that were embedded within standard prenatal health care practices might sensitize expectant parents to the importance of optimal response patterns as well as to their own characteristics that might interfere with optimal parenting.

References

Adam, E. K., Gunnar, M. R., & Tanaka, A. (2004). Adult attachment, parent emotion, and observed parenting behavior: Mediator and moderator models. *Child Development*, *75*, 110–122.

Ainsworth, M. D. S., Blehar, M. C., Water, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the strange situation*. Hillsdale, NJ: Erlbaum.

Atkinson, L., Goldberg, S., Ravel, V., Pederson, D., Benoit, D., Moran, G., et al. (2005). On the relation between maternal state of mind and sensitivity in the prediction of infant attachment security. *Developmental Psychology*, *41*, 42–53.

Atkinson, L., Niccols, A., Paglia, A., Coolbear, J., Parker, K. C. H., Poulton, L., et al. (2000). A meta-analysis of time between maternal sensitivity and attachment assessments: Implications for internal working models in infancy/toddlerhood. *Journal of Social and Personal Relationships*, *17*, 791–810.

Bagiella, E., Sloan, R. P., & Heitjan, D. F. (2000). Mixed-effects models in psychophysiology. *Psychophysiology*, *37*, 13–20.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, *13*, 183–214.

Beauchaine, T. P., Gatzke-Kopp, L., & Mead, H. K. (2007). Polyvagal theory and developmental psychopathology: Emotion dysregulation and conduct problems from preschool to adolescence. *Biological Psychology*, *74*, 174–184.

Beijersbergen, M. D., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., & Jeffer, F. (2008). Stress regulation in adolescents: Physiological reactivity during the Adult Attachment Interview and conflict interaction. *Child Development*, *79*, 1707–1720.

Berntson, G. G., Norman, G. J., Hawkley, L. C., & Cacioppo, J. T. (2008). Cardiac autonomic balance versus cardiac regulatory capacity. *Physiology*, *45*, 643–652.

Biringen, Z. (1990). Direct observation of maternal sensitivity and dyadic interactions in the home: Relations to

maternal thinking. *Developmental Psychology*, *26*, 278–284.

Blokland, K., & Goldberg, S. (1988). *Attachment and expectant mothers' responses to infant emotion*. Paper presented at the biennial International Conference on Infant Studies, Washington, DC.

Bornstein, M. H., & Suess, P. E. (2000). Physiological self-regulation and information processing in infancy: Cardiac vagal tone and habituation. *Child Development*, *71*, 273–287.

Boulet, J., & Boss, M. (1991). Reliability and validity of the brief symptom inventory. *Journal of Consulting and Clinical Psychology*, *3*, 433–437.

Bowlby, J. (1980). *Attachment and loss: Vol. 3. Loss, sadness, and depression*. New York: Basic Books.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*, 271–301.

Broth, M. R., Goodman, S. H., Hall, C., & Raynor, L. C. (2004). Depressed and well mothers' emotion interpretation accuracy and the quality of mother-infant interaction. *Infancy*, *6*, 37–55.

Bugental, D. B., Lewis, J. C., Lin, E., Lyon, J., & Kopeikin, H. (2000). In charge but not in control: The management of authority-based relationships by those with low perceived power. *Developmental Psychology*, *35*, 1367–1378.

Cacioppo, J. T., & Berntson, G. G. (1999). The affect system: Architecture and operating characteristics. *Current Directions in Psychological Science*, *8*, 133–137.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 155–159.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Erlbaum.

Conradt, E., & Ablow, J. C. (2010). Infant physiological response to the still-face paradigm: Contributions of maternal sensitivity and infants' early regulatory behavior. *Infant Behavior and Development*, *33*, 251–265.

Crowe, H. P., & Zeskind, P. S. (1992). Psychophysiological and perceptual responses to infant cries varying in pitch: Comparison of adults with low and high scores on the Child Abuse Potential Inventory. *Child Abuse and Neglect*, *16*, 19–29.

Crowell, J. A., & Feldman, S. S. (1988). Mothers' internal models of relationships and children's behavioral and developmental status: A study of mother–child interaction. *Child Development*, *59*, 1273–1285.

Dawson, M. E., Schell, A. M., & Fillion, D. L. (2000). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 200–223). New York: Cambridge University Press.

Del Vecchio, T., Walter, A., & O'Leary, S. G. (2009). Affective and physiological factors predicting maternal response to infant crying. *Infant Behavior and Development*, *32*, 117–122.

Derogatis, L. R. (1975). *Brief Symptom Inventory*. Baltimore: Clinical Psychometric Research.

Dias, P., Soares, I., Klein, J., Cunha, J. P. S., & Roisman, G. I. (2011). Autonomic correlates of attachment insecurity in a sample of women with eating disorders. *Attachment & Human Development*, *13*, 155–167.

Dozier, M., & Kobak, R. R. (1992). Psychophysiology in attachment interviews: Converging evidence for deactivating strategies. *Child Development*, *63*, 1473–1480.

Fowles, D. C. (1988). Physiology and psychopathology: A motivational approach. *Psychophysiology*, *25*, 373–391.

Fox, N. A., & Hane, A. A. (2008). Studying the biology of human attachment. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed., pp. 217–240). New York: Guilford Press.

Frodi, A. M., & Lamb, M. E. (1980). Infants at risk for child abuse. *Infant Mental Health Journal*, *1*, 240–247.

Galles, S. J., Miller, A., Cohn, J. F., & Fox, N. A. (2002). Estimating parasympathetic control of heart rate variability; two approaches to quantifying vagal tone. *Psychophysiology*, *39*, S37.

George, C., Kaplan, N., & Main, M. (1996). *Adult Attachment Interview*. Unpublished manuscript, University of California at Berkeley.

Gottman, J. M., & Levenson, R. W. (1992). Marital processes predictive of later dissolution: Behavior, physiology and health. *Journal of Personality and Social Psychology*, *63*, 221–233.

Gray, J. A. (1975). *Elements of the two-process theory of learning*. New York: Academic Press.

Groh, A. M., & Roisman, G. I. (2009). Adults' autonomic and subjective emotional responses to infant vocalizations: The role of secure base script knowledge. *Developmental Psychology*, *45*, 889–893.

Gross, J. J., & Levenson, R. W. (1995). Emotion elicitation using films. *Cognition and Emotion*, *9*, 87–108.

Grossman, P., & Kollai, M. (1993). Respiratory sinus arrhythmia, cardiac vagal tone, and respiration: Within- and between-individuals relations. *Psychophysiology*, *30*, 486–495.

Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and reunion. *Child Development*, *74*, 1534–1546.

Ham, J., & Tronick, E. Z. (2006). Infant resilience to the stress of the still-face. *Annals of the New York Academy of Sciences*, *1094*, 83–104.

Hesse, E. (2008). The adult attachment interview: Protocol, method of analysis, and empirical studies. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed., pp. 552–598). New York: Guilford Press.

Hill-Soderlund, A. L., Mills-Koonce, W. R., Propper, C., Calkins, S. D., Granger, D. A., Moore, G. A., et al. (2008). Parasympathetic and sympathetic responses to the strange situation in infants and mothers from avoidant and securely attached dyads. *Developmental Psychobiology*, *50*, 361–376.

Hofer, M. A. (2006). Psychobiological roots of early attachment. *Current Directions in Psychological Science*, *15*, 84–88.

Holland, A. S., & Roisman, G. I. (2010). Adult attachment security and young adults' dating relationships over time: Self-reported, observational, and physiological evidence. *Developmental Psychology*, *46*, 552–557.

Kraemer, H. C., Stice, E., Kazdin, A., Offord, D., & Kupfer, D. (2001). How do risk factors work together? Mediators, moderators, and independent, overlapping, and proxy risk factors. *American Journal of Psychiatry*, *158*, 848–856.

Lin, E. K., Bugental, D. B., Turek, V., Martorell, G. A., & Olster, D. H. (2002). Children's vocal properties as mobilizers of stress-related physiological responses in adults. *Personality and Social Psychology Bulletin*, *28*, 346–357.

Main, M. (2000). The organized categories of infant, child, and adult attachment: Flexible vs. inflexible attention under attachment-related stress. *Journal of the American Psychoanalytic Association*, *48*, 1055–1096.

Main, M., & Goldwyn, R.. (1998). *Adult Attachment Interview scoring and classification manual* (6th version). Unpublished manuscript, University of California, Berkeley.

Marcos, H.. (1987). Communicative functions of pitch range and pitch direction in infants. *Journal of Child Language*, *14*, 255–268.

McElwain, N. L., & Booth-LaForce, C. (2006). Maternal sensitivity to infant distress and nondistress as predictors of infant-mother attachment security. *Journal of Family Psychology*, *20*, 247–255.

Mills-Koonce, W. R., Gariepy, J. L., Propper, C., Sutton, K., Calkins, S., Moore, G., et al. (2007). Infant and parent factors associated with early maternal sensitivity: A caregiver-attachment systems approach. *Infant Behavior and Development*, *30*, 114–126.

Moore, G. A., & Calkins, S. D. (2004). Infants' vagal regulation in the still-face paradigm is related to dyadic coordination of mother-infant interaction. *Developmental Psychology*, *40*, 1068–1080.

Moore, G. A., Hill-Soderlund, A. L., Propper, C. B., Calkins, S. D., Mills-Koonce, W. R., & Cox, M. J. (2009). Mother-infant vagal regulation in the face-to-face still-face paradigm is moderated by maternal sensitivity. *Child Development*, *80*, 209–223.

Murray, L., Fiori-Cowley, A., Hooper, R., & Cooper, P. (1996). The impact of postnatal depression and associated diversity on early mother-infant interactions and later infant outcomes. *Child Development*, *67*, 2512–2526.

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage: A polyvagal theory. *Psychophysiology*, *32*, 301–318.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*, 116–143.

Raval, V., Goldberg, S., Atkinson, L., Benoit, D., Myhal, N., Poulton, L., et al. (2001). Maternal attachment, maternal responsiveness and infant attachment. *Infant Behavior & Development*, *24*, 281–304.

Roisman, G. I. (2007). The psychophysiology of adult attachment relationships: Autonomic reactivity in marital and premarital interactions. *Developmental Psychology*, *43*, 39–53.

Roisman, G. I., Tsai, J. L., & Chiang, K.-H. S. (2004). The emotional integration of childhood experience: Physiological, facial expressive, and self-reported emotional response during the Adult Attachment Interview. *Developmental Psychology*, *40*, 776–789.

Rottenberg, J., Wilhelm, F. H., Gross, J. J., & Gotlib, I. H. (2002). Respiratory sinus arrhythmia as a predictor of outcome in major depressive disorder. *Journal of Affective Disorders*, *71*, 265–272.

Spangler, G., & Grossmann, K. E. (1993). Biobehavioral organization in securely and insecurely attached infants. *Child Development*, *64*, 1439–1450.

Thompson, R. A. (1997). Sensitivity and security: New questions to ponder. *Child Development*, *68*, 595–597.

Tronick, E. Z., & Cohn, J. F. (1989). Infant–mother face-to-face interaction: Age and gender differences in coordination and the occurrence of miscoordination. *Child Development*, *60*, 85–92.

van IJzendoorn, M. H. (1995). Adult attachment representations, parental responsiveness and infant attachment: A meta-analysis on the predictive validity of the Adult Attachment Interview. *Psychological Bulletin*, *117*, 387–403.

Wainer, H. (1991). Adjusting for differential base rates: Lord's paradox again. *Psychological Bulletin*, *109*, 147–151.

Ward, M. J., & Carlson, E. A. (1995). Associations among adult attachment representations, maternal sensitivity, and infant-mother attachment in a sample of adolescent mothers. *Child Development*, *66*, 69–79.

Weisenfeld, A. R., Malatesta, C. A., Whitman, P. B., Granrose, C., & Vili, R. (1985). Psychophysiological response of breast- and bottle-feeding mothers to their infants' signals. *Psychophysiology*, *22*, 79–86.

Wood, R. M., & Gustafson, G. W. (2001). Infant crying and adults' anticipated caregiving responses: Acoustic and contextual influences. *Child Development*, *72*, 1287–1300.

Zeanah, C. H., Benoit, D., Barton, M., Regan, C., Hirshberg, L. M., & Lipsitt, L. (1993). Representations of attachment in mothers and their one-year-old infants. *Journal of the American Academy of Child and Adolescent Psychiatry*, *32*, 278–286.

Zeskind, P. S., & Lester, B. M. (1978). Acoustic features and auditory perceptions of the cries of newborns with prenatal and perinatal complications. *Child Development*, *49*, 580–589.

Zeskind, P. S., & Lester, B. M. (2001). Analysis of infant crying. In L. T. Singer & P. S. Zeskind (Eds.), *Biobehavioral assessment of the infant* (pp. 149–166). New York: Guilford Press.

Zeskind, P. S., & Marshall, T. R. (1988). The relations between variations in pitch and maternal perceptions of infant crying. *Child Development*, *59*, 193–196.