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Maternal Emotion Regulation and Parenting: A Physiological Perspective

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ABSTRACT

The psychological capacity for emotion regulation (ER) facilitates sensitive caregiving and fosters positive child outcomes. Parasympathetic regulation, indexed by respiratory sinus arrhythmia (RSA), is an important physiological component of ER. While growing evidence supports the link between parents' physiological ER and parenting behaviors, few studies distinguish parents' global ER capacity from ER in parenting-specific contexts, which can provide important insights for intervention. The current study examines the links between parenting behaviors, global ER (operationalized as resting RSA, measured during a baseline task), and parenting-specific ER (operationalized as phasic RSA change, measured during responses to the child-related questions for the Adult Attachment Interview [AAI]). Mothers ($N = 169$) and their toddlers participated in this study. Parenting behaviors were assessed through a standardized parent–child interaction task, yielding scores for overall parenting behaviors, overall parenting contingency, and specific parenting behaviors. Regression models suggested that resting RSA was positively associated with overall parenting behaviors and contingency, sensitivity to cues, and cognitive growth-fostering. Positive phasic RSA change (i.e., RSA augmentation) was significantly associated with overall parenting behaviors and social–emotional growth-fostering over and above resting RSA. Both global ER and parenting-specific ER may be promising targets for interventions to improve parenting behaviors.

1 | Introduction

Emotion regulation (ER) is a crucial capacity for adaptive functioning. In the realm of parenting, ER promotes well-being, enhances positive parenting behaviors, and contributes to positive child outcomes (Morris et al. 2007). When assessed specifically in parenting contexts, ER is also related to parenting behaviors (Shaffer and Obradović 2017), but we do not yet understand whether parenting behaviors are more closely related to trait-like aspects of parents' ER, which we refer to as global ER, or state-like aspects of ER specific to the parenting context, often referred to as parenting-specific ER (Zhang et al. 2023; Hajal and Paley 2020). The answer to this question has important implications for interventions seeking to enhance physiological regulation underpinning parenting behavior. The current study sought to advance our understanding of parents' ER by examining physiological measures of global and parenting-specific ER (i.e., resting and phasic assessments of parasympathetic regulation) within a sample of mothers to determine which is more strongly associated with parenting behaviors.

1.1 | ER: Definition, Significance, and Measurement

Emotions play an important role in individuals' survival and adaptation (Cosmides and Tooby 2000), as they facilitate goal-oriented physiological and cognitive changes in response to a changing environment (Barrett 2006). At the same time, emotional reactions can be maladaptive—for instance, if an individual's emotional reaction does not match the situational context in terms of valence, timing, or intensity, these disconnects can cause negative impacts on the self and those around them (Gross and Thompson 2007). When emotions are adaptive or well-regulated, they help individuals meet the demands of their environments. The process theory of emotion (Gross 2002) defines ER as the automatic or effortful *process* of modulating the occurrence, duration, and intensity of emotional states and emotion-related physiological processes.

1.2 | Parents' ER: Global and Parenting-Specific Elements

While ER is important across the lifespan, it serves distinct functions in the context of parenthood, necessitated by the neurocognitive changes, unique demands, and intense emotions parents face (Barros et al. 2015; Rutherford et al. 2015). In parenting-specific situations (e.g., a toddler broke a glass vase), parents need to flexibly juggle between regulating themselves (e.g., accepting that the vase is broken and preparing to clean up the mess) and regulating the child (e.g., comforting the child from the startling noise and keeping the child from getting hurt). Moreover, ER is uniquely important due to its profound influence on parents' behaviors and, subsequently, on child outcomes. According to Morris' tripartite model (Morris et al. 2007), parents influence children's ER via three pathways, all of which are influenced by parent characteristics such as parents' own regulation. In the first pathway, children observe and model parents' ER practices. In the second pathway, parents shape children's ER capacities through parenting practices. In the third pathway, children are impacted by the emotional climate of the family, which is reflected in relationship quality and the valence of emotions shown between family members. In particular, elements of parenting styles such as sensitivity (to child cues) and responsiveness (to child distress) are shown to positively influence children's ER (e.g., Moran et al. 2019).

Given the link between parental ER and parenting behaviors, one important question to consider is whether parenting behaviors are predicted by global ER or parenting-specific ER (Hajal and Paley 2020; Zhang et al. 2023). Most studies of parents' ER measure trait or state ER, and few attempt to make a distinction between these two or examine which is more predictive of parenting behaviors. Researchers have called for enhancing our understanding of this domain-specific form of ER (e.g., Bertie et al. 2021), including the potential distinction between global ER and parenting-specific ER, as well as how these two forms of ER may differentially associate with parenting behaviors (Jones et al. 2014).

Despite evidence linking global ER to parenting behaviors, it remains unclear whether it is one's global ER capacity that explains behaviors or whether global ER acts as a proxy for ER in parenting-specific contexts. Leerkes and Augustine (2019) proposed an integrated model, adapted from Lemerise and Arsenio's (2000) framework, to understand parents' emotions and parenting behaviors: parents' global or trait emotional characteristics (e.g., trait-positive emotionality) as well as parenting affective processes, which includes physiological regulation, may be jointly associated with parenting cognitions and behaviors.

Emerging evidence suggests that parenting-specific ER is a distinct construct and that there are differential associations between global ER versus parenting-specific ER and parenting behaviors. One study demonstrated the distinction between ER during parenting and global ER: Rodriguez and Shaffer (2021) developed and validated the Regulating Emotions in Parenting Scale (REPS) and found small to moderate correlations between REPS scores and global ER measured with the Emotion Regulation Questionnaire (ERQ; Gross and John 2003). Further, parenting-specific ER (REPS) was more strongly correlated with parenting behaviors than global ER (ERQ), explaining twice the variance in parenting behaviors, including positive parenting and disciplinary practices. While some evidence suggests the construct validity of parent-specific ER (e.g., Lorber 2012; Rodriguez and Shaffer 2021), these studies predominantly measure ER via parents' self-reports. More work is needed to look at other components of ER, such as physiology.

1.3 | Global Versus Context-Specific Measures of RSA

ER can be measured through multiple means, including self-report, observation of behaviors, and physiological indicators. Physiological activity is a unique window into emotion regulatory capacity and effort because it minimizes social desirability biases, which can occur with self-report measures (Keefer 2014), while being minimally affected by intentional efforts to mask emotions, which can be a challenge of observational methods (Livingstone and Isaacowitz 2019). Physiological measures of ER offer advantages as unobtrusive methods to assess real-time ER, yet remain underutilized and understudied, particularly in the context of parenting.

One reliable physiological indicator of ER, respiratory sinus arrhythmia (RSA), reflects the variation in heart rate that occurs in synchrony with the breathing cycle due to modulation of the parasympathetic nervous system (PNS) (Butler et al. 2006). Two prominent theories, Porges' (2001) polyvagal theory and Thayer and Lane's (2000) neurovisceral integration theory, link the flexibility of the parasympathetic branch of the autonomic nervous system indexed by RSA with regulated emotional reactivity. While the two theories differ in some aspects, both posit that (1) the PNS plays an important role in mediating the inhibition of autonomic arousal in the expression and regulation of emotions and (2) measures such as RSA reflect parasympathetic regulation and thus can be indicative of individuals' ER capacity.

1.3.1 | Resting RSA

Individuals' resting levels of RSA and transient changes in RSA each provide valuable information on regulation. Resting RSA is a global measure of parasympathetic activity that reflects the flexibility of the vagal brake, which is activated during contexts of perceived safety to enhance engagement with the environment (Porges 2022). Resting or global RSA is often assessed during a period of relaxation or a paced breathing task (Butler et al. 2006). Higher resting RSA is associated with greater self-regulatory capacity (Fabes and Eisenberg 1997; Smith et al. 2011), adaptive coping strategies (O'Connor et al. 2002), and physiological flexibility, characterized by positive (Beauchaine 2001) or negative emotional reactivity (Butler et al. 2006) in response to the environment. In the context of parenting, high resting RSA moderates the association between parental shyness–anxiety and overprotection, such that shyness–anxiety is only associated with overprotection when parents have low RSA (Root et al. 2016).

1.3.2 | Phasic RSA

In contrast to resting measures of RSA, phasic RSA reflects the transient, intraindividual changes from a resting period to a specific situation. Phasic RSA changes in response to standardized laboratory tasks reflect changes in the vagal brake and are linked to self-regulatory effort (Butler et al. 2006). In the current study, we operationalized phasic RSA change by subtracting resting RSA from task RSA. In other words, a positive phasic RSA change indicated RSA augmentation, while a negative one indicated RSA suppression.

Notably, existing findings reveal mixed results for RSA augmentation versus suppression and positive or negative relationship outcomes. This may partly be due to the fact that, depending on the nature of the task or stimulus, better ER could be reflected in either RSA augmentation or suppression (e.g., Leerkes et al. 2017; Joosen et al. 2013). Given the limited body of work examining RSA in parenting, here we reviewed the literature on RSA and relationship outcomes more broadly. Several studies have examined mothers' phasic RSA during simulated negative parenting situations, such as during the still-face paradigm or infant cry tasks. These studies revealed that less RSA suppression was associated with poorer parenting behaviors, such as lower maternal sensitivity (Joosen et al. 2013), lower responsiveness to infant disengagement cues (Ham and Tronick 2006), (when combined with elevated cortisol) more intrusive parenting (Mills-Koonce et al. 2009), and more negative and self-focused processing (Leerkes et al. 2017). By comparison, a systematic review (Han et al. 2021) of 26 studies of adults in romantic relationships revealed that phasic RSA decrease (i.e., more RSA suppression) during stressful relationship situations was associated with poorer romantic relationship outcomes, such as higher aggression (Godfrey and Babcock 2020), and lower relationship satisfaction and poor relationship quality (Constant et al. 2020). While existing studies found different patterns with respect to the direction (positive vs. negative) of phasic RSA and optimal outcomes, they consistently link phasic RSA with behavior and health outcomes.

1.4 | Creating a Parenting-Specific Context for Assessing ER With the Adult Attachment Interview (AAI)

One way to measure parenting-specific ER is by recording parents' physiological responses during their parenting reflections on the AAI (George et al. 1996). Parents' attachment state of mind reflected in their response during the AAI predicts wide-ranging parenting outcomes, such as parental emotions, sensitivity, and cognitions (e.g., Adam et al. 2004), and thus provides a useful behavioral sample that taps into psychological constructs with great relevance for parenting. Moreover, several studies have examined physiology during the AAI in terms of its association with attachment (Dozier and Kobak 1992; Roisman 2004; Zingaretti et al. 2020), perceived distress during the interview (Tininenko et al. 2012), and subjective responses to questions about loss or abuse (Bakkum et al. 2022). For example, high PNS activation (indexed by increased heart rate variability) is linked to insecure–disorganized attachment (Zingaretti et al. 2020), while high sympathetic nervous system activation (indexed by increased skin conductance levels) is associated with insecure–dismissing attachment (Dozier and Kobak 1992). Although distinct from the research questions pursued in this study, this prior work suggests that the AAI can be a parenting-specific ER context that elicits meaningful physiological reactivity in parents.

1.5 | Current Study

The current project examined associations of mothers' global ER capacity, measured via resting RSA, as well as mothers' parenting-specific ER, measured via phasic RSA change during responses to questions about their relationship with their child in the AAI, with observed parenting behaviors in a diverse sample of mothers of toddlers. By examining these associations, this study aimed to elucidate the associations between different facets of parental ER and parenting behaviors from a physiological perspective.

This study examines overall parenting behaviors and overall parenting contingency. Overall parenting behaviors were coded from observations in a standardized parent–child teaching task, indexed by a summated score of four specific aspects of parenting behaviors implicated in healthy child development: sensitivity to cues, response to distress, cognitive growth-fostering, and social–emotional growth-fostering. Parenting contingency refers to the timeliness of parents' behaviors in relation to children's behaviors. We also exploratorily analyzed the association between ER and each of the four aspects of parenting behaviors. Parental sensitivity to infant cues and response to infant distress are robustly shown to predict secure child attachment (Ainsworth 1979; Bowlby 1969). Children's cognitive growth, fostered by parental behaviors (e.g., using explanatory rather than imperative verbal style) in early childhood, is associated with higher literacy (Keels 2009), school readiness (Welsh et al. 2010), and mathematical competence (Clark et al. 2013). Parents' social–emotional growth-fostering behaviors (e.g., smiling or touching the infant within 5 s of the infant's smile or vocalization) promote children's social–emotional competency, which is linked to better educational, mental health, and social outcomes (Domitrovich et al. 2017).

Based on earlier findings suggesting positive associations between resting RSA and parenting behaviors, we hypothesized that higher resting RSA (global ER) would be related to higher overall positive parenting behaviors. Due to limited findings regarding specific forms of parenting behaviors, we did not advance hypotheses regarding specific aspects of parenting behaviors and planned to conduct exploratory analyses for each of the four parenting subscales.

To our knowledge, no existing studies have examined parents' resting RSA and phasic RSA change in the same model. Therefore, we did not advance a hypothesis regarding whether phasic RSA change (parenting-specific ER) would predict parenting behaviors over and above resting RSA (global ER). Finally, due to the mixed findings in the literature regarding phasic RSA of adults in parenting and relationship contexts, we did not pose a hypothesis about the directionality of the relation between phasic RSA change and parenting behavior.

2 | Method

2.1 | Participants

Mother–child dyads ($N_{\text{dyads}} = 169$) participated as part of a larger study on parenting. Participants were recruited using online advertisements (e.g., on Facebook) and flyers posted in the community (e.g., daycare centers). Children who were between 18 and 27 months old, residing with their mothers, and who had not been diagnosed with a developmental disability were eligible for this study. Participant demographics are shown in Table 1.

2.2 | Procedure

The current project utilized data from a larger study of mothers of toddlers (IRB, #4/29/2016JB-MP; see MASKED for more information). During a laboratory visit, mothers provided informed consent for themselves and their children. The dyad participated in a standardized teaching task. Mothers then completed questionnaires and a semistructured attachment interview assessing their early attachment experiences. Mothers' physiological activity was measured before and during the interview using an electrocardiogram (ECG). Before the interview, we assessed mothers' resting physiological activity during a 5-min period when mothers watched a nature video. Mothers were asked to sit calmly and refrain from gross motor movements during this time. During the attachment interview, mothers' physiological activity was continuously assessed and later segmented by each question of the interview.

2.3 | Measures

2.3.1 | Parenting Behaviors

Mother's parenting behaviors were assessed using the Nursing Child Assessment Satellite Training (NCAST): Parent-Child Interaction Teaching task (NCAST; Barnard and Eyres 1979). The NCAST is a standardized laboratory task designed for children aged 0–36 months and validated across different contexts and cultures (e.g., Huang et al. 2022; Kelly and Barnard 2000). During the teaching task, mothers introduce a novel, developmentally appropriate skill (e.g., stringing beads) to the child. Interaction tasks (M_{length} = 5 min 27 s, SD_{length} = 38.57 s) were video recorded and later coded for parent, child, and contingent dyad behaviors using the NCAST PCI-Teach assessment scale. Two certified NCAST coders reliably coded the parent–child interactions for each subscale, with interrater reliability ranging from moderate to substantial ($K_{\text{Sensitivity to cues}} = 0.68$, $K_{\text{Response to distress}} = 0.60$, $K_{\text{Social–emotional growth}} = 0.59$, $K_{\text{Cognitive growth}} = 0.66$). The NCAST assessment scale consists of 73 dichotomous questions that assessed overall parenting behaviors and overall parenting contingencies from four specific aspects of parenting behaviors: sensitivity to cues, response to distress, social–emotional growth-fostering, and cognitive growth-fostering. The overall parenting behaviors score is calculated by summing the scores from the four specific aspects of parenting behaviors. The overall parenting contingency score is calculated by summing specific items from each of the four aspects of parenting behaviors that relates to the timeliness of parental response to child (e.g., smiling or touching the infant *within 5 s* of infant smile or vocalization). Contingency scores indicate reciprocity or the extent to which actions by one individual in the dyad are temporally linked to actions by the other. In other words, high contingency scores reflect the caregiver's contingent response to the child's cues.

The NCAST provides separate scores for each of the four specific aspects of parenting behaviors that contribute to the overall parenting behavior score. Sensitivity to cues captures the caregiver's sensitivity to the child's cognitive, emotional, and physical needs (e.g., "Caregiver changes position of child and/or materials after unsuccessful at completing the task"). Response to distress reflects the caregiver's timely recognition and appropriate response in the face of the child's distress (e.g., "Caregiver makes a positive, sympathetic, or soothing verbalization"). Social–emotional growth-fostering behaviors capture caregivers' social–emotional engagement through smiling at the child or praising the child's efforts (e.g., "Caregiver smiles or touches child within 5 s after the child smiles or vocalizes"). Cognitive growth-fostering behaviors recognize caregivers' actions that stimulate cognitive growth (e.g., "Caregiver uses explanatory verbal style more than imperative style in teaching the child").

2.4 | Physiological Data Collection and Processing

2.4.1 | Collection

Mothers' physiological activity was assessed before and during the AAI (George et al. 1996), generating resting RSA (indicating global ER) and phasic RSA change (indicating parenting-specific ER). BioLab software 2.5 was used for signal acquisition. Disposable Mindware 1.5-inch foam ECG electrodes with 7% chloride wet gel were fixed to the mother's torso in standard locations, and touch-proof snap leads were connected to a BioNex 8-slot chassis equipped with an impedance cardiograph (Mindware Technologies, Gahanna, OH). Electrocardiograph was sampled at 1000 Hz. Data were collected by placing six ECG sensors on the participants' torsos in a Lead-II configuration. Respiration rate was derived from cardiac impedance signals and included as a

TABLE 1 | Participant demographic characteristics.

Characteristic	
N	169
Mother's age, years	30.57 (5.30)
Child's age, months	20.91 (2.49)
Ethnicity: Hispanic or Latina (%)	67 (41.1)
Race (%)	
American Indian or Alaska native	3 (1.9)
Asian	10 (6.2)
Native Hawaiian or pacific islander	0 (0.0)
Black or African American	4 (2.5)
White or Caucasian	105 (64.8)
More than one race	18 (11.1)
Other	22 (13.6)
Education (%)	
High school or less	18 (10.7)
Some college	40 (23.7)
Community college/trade school	35 (20.7)
Bachelor's degree	45 (26.6)
Graduate degree	31 (18.3)
None of the above	0 (0.0)
Income (%)	
Less than $40,000	53 (32.5)
$40,000–$60,000	26 (16.0)
$61,000–$80,000	27 (16.6)
$81,000–$100,000	21 (12.9)
$101,000–$120,000	17 (10.4)
Greater than $120,000	19 (11.7)

covariate in the analyses to increase the validity of RSA as an index of PNS regulation.

Resting physiological activity was assessed over a 5-minu period when mothers were asked to watch a nature video (i.e., a video of a forest) and remain calm and seated. For the resting baseline collection, each participant had five 60-s RSA data segments, which were averaged to create a mean resting RSA score.

Phasic physiological activity was assessed via changes in mothers' physiological activity during child-related questions in the AAI (George et al. 1985). The AAI is an extensively tested and validated semistructured interview that aims to assess individuals' mental representations of attachment figures through questions that query their early attachment experiences and their experiences as parents. It comprises 20 questions, of which 17 pertained to mother's own childhood experiences with her parents and three queried mother's experiences with her child. Based on our interest in mothers' parenting-specific ER, we focused on the child-related Questions 17 (current relationship with your child; feelings during separation; worry about your child), 18 (three wishes for your child's future), and 20 (hopes for your child to learn from being parented by you). The Cronbach's alpha for RSA between the three items in this thematic cluster was 0.89.

Phasic RSA data were also collected in segments of 60 s. BioLab was configured to allow for capturing up to 30 segments of 60 s for each question. As participants answered each AAI question, their answers populated time segments. Unpopulated segments for each question were coded with NA. Segments that were shorter than 30-s were considered unpopulated and dropped from analyses. In other words, if a participant spent 3 min 11 s answering Question 17, the physiological data for Question 17 would include three populated segments and 27 unpopulated segments. Two (1.18%) participants had zero segments and were not considered for the analysis. While answering child-related questions (Questions 17, 18, and 20), participants in the study used 4.09 segments across the three questions on average, with a minimum of 1 segment and a maximum of 11 segments. Due to the large variation in the length of participants' answers to child-related questions (i.e., from 1 to 11 min), we set a cutoff to ensure a comparable amount of phasic RSA data across participants. A total of 75% of participants answered all three questions in 5 min or less, so we limited our analyses to a maximum of five 60-s segments per participant, excluding RSA data beyond the first 5 min of responding to child-related questions.

To generate a phasic RSA score for the child-related question clusters in the AAI, we first computed a mean RSA score for each participant and each question by averaging all segments within one question (each participant's question-specific average RSA). We then averaged the question-specific mean RSA scores across the three child-related questions (i.e., Questions 17, 18, and 20) to obtain a mean RSA score for the cluster (each participant's cluster average RSA). For example, for each participant, the question-specific average for Question 17 was obtained by averaging RSA segments within Question 17, and the cluster average for child-related questions was obtained by averaging the question-specific averages for Questions 17, 18, and 20. The phasic RSA during these three child-related AAI questions demonstrated similar valence and magnitude of change, albeit nonsignificant increases, compared to resting RSA ($\Delta_{17.\text{resting}} = 0.06$, $\Delta_{18.\text{resting}} = 0.16$, $\Delta_{20.\text{resting}} = 0.20$). Lastly, consistent with the approach commonly used and statistically defended in the psychophysiological literature (e.g., Hastings et al. 2019; Dozier and Kobak 1992), phasic RSA change scores for each participant were obtained by subtracting the participant's resting RSA from the participant's cluster average RSA. Therefore, a positive phasic RSA change score reflects RSA augmentation, while a negative RSA change score reflects RSA suppression.

2.4.2 | Processing

All ECG data were cleaned and processed prior to analyses. Data cleaning was completed by one trained research assistant and double-checked by another. The cleaning process involved confirming that heartbeats were accurately identified by the program and adding midbeats if needed. The cleaned data were then edited for peak errors and noise due to movement using BioLab HRV 2.0 application (Mindware Technologies, Gahanna, OH). Respiration rate was computed from an impedance signal. RSA was extracted, capturing changes in the high-frequency heart rate variability that were in phase with respiration. The respiration rate was adjusted by setting the HF/RSA band to the standard adult range of 0.12–0.4, enabling the HR/RSA band to be used in respiration rate settings. This also allowed researchers to identify if any segments fell outside of the standard adult range. In the current study, we included all segments regardless of the participant's respiration rate and controlled for respiration rate in analyses (see the statistical analysis section for more information).

2.5 | Statistical Analysis

Prior to hypothesis testing, we examined the normality of dependent variables, namely, parenting behaviors, by reviewing z-scores of distribution skewness and kurtosis. The z-scores were obtained by dividing values (skew value, excess kurtosis) by their respective standard errors. According to the recommendation of normality check for clinical research (Kim 2013), in medium-size samples (with between 50 and 300 participants), the critical value for rejecting the null hypothesis of normal distribution should correspond to a z-score of 3.29. Following this recommendation, we identified that cognitive growth-fostering significantly deviated from normal distributions. Thus, we transformed data from this variable. We tested three data transformation methods, taking the square, square root, and natural log to see which method was best at reducing the skew value and excess kurtosis. We proceeded with squaring the variable, as this method transformed the data closest to a normal distribution.

Subsequent statistical analyses were conducted using R version 4.0.2 (R Core Team 2018). We began by reviewing descriptive statistics and bivariate correlations for all variables. Mother age, child age, child gender, and the number of segments for phasic RSA during the AAI were significantly correlated with several parenting behaviors and were therefore included in all models as covariates. To account for missing data, full information maximum likelihood (FIML) estimation was used via the Lavaan package (Rosseel 2012).

To test our hypotheses, hierarchical linear regressions were conducted examining the degree to which mothers' resting RSA and phasic RSA change were associated with parenting behaviors. In the first step, we included mothers' resting RSA as the predictor variable along with covariates. In the second step, we added maternal phasic RSA change as a second predictor variable. This allowed us to adjust for resting levels of RSA when examining RSA changes, which has been suggested by researchers (Graziano and Derefinko 2013).

We tested our main hypothesis by examining predictors of overall parenting behaviors and overall parenting contingency. Then, we conducted exploratory analyses with each of the four parenting subscales: sensitivity to cues, response to distress, social–emotional growth-fostering, and cognitive growth-fostering.

In all statistical models, we included each participant's resting respiration rate and the average phasic respiration rate during the child-related cluster in the AAI. Statistically controlling for respiration enhances the validity of RSA as an index of cardiac vagal tone, since respiration rate influences RSA (Beauchaine 2001). To be thorough, we re-ran all the models without respiration rate statistically controlled to examine the robustness of the findings. Results not controlling for respiration rates are included in the Supporting Information and briefly described in the results section.

3 | Results

3.1 | Descriptive Statistics and Correlations

The means, standard deviations, and bivariate correlation coefficients of all continuous variables for participants included in the analyses are shown in Table 2.

3.1.1 | RSA Reactivity Between Resting State and Each Question Cluster

The average resting RSA was 6.51, and the average phasic RSA during the child questions was 6.62. A dependent sample *t*-test showed that mothers' phasic RSA was not significantly different during the child question cluster compared to resting state, $t(105) = -0.67$, 95% CI [−0.21, 0.10]. Phasic RSA change values ranged from −2.14 to 1.64. Resting RSA values ranged from 4.23 to 8.32. Among participants, 58% showed higher phasic RSA compared to the resting state (i.e., showing RSA augmentation) and 42% showed lower phasic RSA compared to the resting state (i.e., showing RSA suppression).

3.2 | Hypothesis Testing

Table 3 shows all standardized and unstandardized regression coefficients for tested models. The following results are from Step 2 of the regression models, with resting RSA, phasic RSA change, and covariates all included in the model as predictors.

3.2.1 | Associations Between RSA and Overall Parenting Behaviors and Contingency

Both mothers' resting RSA and phasic RSA change were significantly positively associated with the overall quality of parenting. Mothers' resting RSA was significantly positively associated with overall parenting contingency, whereas phasic RSA change was not (see Table 3 for more information).

3.2.2 | Associations Between RSA and Parenting Subscales

The exploratory analyses of associations between resting and phasic RSA and the four parenting subscales are presented in Table 4. Maternal resting RSA was significantly and positively associated with mothers' sensitivity to cues and cognitive growth-fostering but not with mothers' response to distress or social–emotional growth-fostering. Maternal phasic RSA change was significantly and positively associated with mothers' social–emotional growth-fostering.

3.3 | Results Without Respiration Rate Included as Statistical Covariate

To understand the robustness of our results without respiration rate statistically controlled, we re-ran all models without controlling for resting respiration rate and the average phasic respiration rate during the child-related cluster in the AAI. As shown in the Supporting Information, not including resting and phasic respiration rates, all six previously identified associations in Step 2 of the analyses remained significant.

4 | Discussion

This study explored the relations between mothers' parasympathetic regulation of arousal and their parenting behaviors while engaging in a teaching task with their child. Associations were evident for both maternal resting RSA and maternal RSA during a section of the AAI. Mothers with higher resting RSA, indicative of greater capacity for PNS influence over arousal, were observed to engage in higher quality and more contingent parenting overall, particularly for sensitivity to their child's cues and fostering of their child's cognitive growth. In addition, mothers for whom RSA increased more while answering questions about their child, indicative of further PNS downregulation of arousal, engaged in higher quality parenting overall and better social–emotional growth-fostering. Thus, the associations between RSA and parent-child interactions were consistently positive, indicating that greater parasympathetic influence, both at rest and while mothers discussed their attachment experiences with their children, was associated with more optimal parent–child teaching interactions.

TABLE 2 | Means, standard deviations, and correlations with confidence intervals.

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Resting RSA	6.51	0.91							
2. Phasic RSA change	0.12	0.68	−0.59**						
			[−0.70, −0.45]						
3. Overall parenting behaviors	36.30	3.91	0.18	0.03					
			[−0.01, 0.35]	[−0.17, 0.23]					
4. Overall parenting contingency	12.90	2.45	0.16	−0.01	0.83**				
			[−0.03, 0.33]	[−0.21, 0.18]	[0.78, 0.88]				
5. Sensitivity to cues	8.90	1.18	0.20*	−0.01	0.50**	0.33**			
			[0.01, 0.37]	[−0.21, 0.18]	[0.38, 0.61]	[0.18, 0.46]			
6. Response to distress	8.51	1.41	0.06	−0.01	0.45**	0.55**	−0.06		
			[−0.13, 0.24]	[−0.20, 0.19]	[0.32, 0.57]	[0.43, 0.65]	[−0.21, 0.10]		
7. Social–emotional growth-fostering	7.67	1.25	−0.03	0.19	0.55**	0.39**	0.29**	0.22**	
			[−0.21, 0.16]	[−0.01, 0.37]	[0.43, 0.65]	[0.25, 0.51]	[0.14, 0.43]	[0.07, 0.36]	
8. Cognitive growth-fostering	11.22	2.59	0.16	−0.04	0.77**	0.63**	0.19*	0.06	0.10
			[−0.02, 0.34]	[−0.23, 0.16]	[0.70, 0.83]	[0.52, 0.71]	[0.04, 0.34]	[−0.10, 0.21]	[−0.06, 0.25]

Note: M and *SD* are used to represent mean and standard deviation. Values in square brackets indicate the 95% confidence interval for each correlation.
$^{*}p < 0.05$; $^{**}p < 0.01$.

TABLE 3 | Hierarchical regressions examining maternal resting RSA and phasic RSA change as predictors of overall parenting behaviors and overall parenting continency while statistically controlling for resting and/or phasic respiration.

	Dependent variables									
	Overall parenting behaviors					Overall parenting contingency				
	$\Delta R^2/\beta$	*b*	*SE*	95% CI		$\Delta R^2/\beta$	*b*	*SE*	95% CI	
Step 1 ΔR^2	0.20					0.15				
Resting RSA	0.26*	1.03*	0.41	0.06	0.46	0.19	0.50	0.28	−0.02	0.39
Resting respiration	−0.02	−0.04	0.18	−0.23	0.18	−0.11	−0.13	0.13	−0.32	0.10
Step 2 ΔR^2										
Resting RSA	0.34**	1.46**	0.46	0.13	0.55	0.25*	0.67*	0.30	0.03	0.46
Resting respiration	−0.16	−0.29	0.19	−0.36	0.04	−0.19	−0.21	0.12	−0.39	0.02
Phasic RSA change	0.31*	1.77*	0.71	0.06	0.55	0.22	0.78	0.46	−0.04	0.47
Phasic respiration	0.06	0.16	0.25	−0.13	0.25	0.06	0.10	0.16	−0.13	0.25

4.1 | Resting RSA Consistently Linked to Parenting Behaviors

Resting RSA emerged as a more consistent predictor of parenting behaviors than phasic RSA change in this study. Higher resting RSA was linked to better overall parenting behaviors and contingency, higher sensitivity to cues, and enhanced cognitive growth-fostering. Our findings align with accumulating evidence suggesting that higher resting RSA is associated with more adaptive parenting behaviors. Previous studies have found that higher resting RSA buffers against the negative outcomes of child maltreatment (Zhang et al. 2021), maladaptive parenting practices (Kennedy et al. 2004), and parent marital conflict (Katz and Gottman 1995). This may be because higher resting RSA can reflect individuals' PNS flexibility, the degree to which it can flexibly respond to stressors without being excessively activated (Beauchaine 2015). Being in a more physiologically regulated state at one's resting state may translate to better control over parenting behaviors as well as perceptions of children's behaviors as less threatening. PNS, as part of the autonomic nervous system, regulates the human body's homeostatic functioning during restful states, such as digestion and heart rate reduction (Porges 2010). In contrast with the "fight or flight" response initiated by the sympathetic nervous system, the PNS initiates the "rest and digest" response, facilitating recovery and restoration following stress (Porges 2010). High parasympathetic flexibility allows parents to flexibly respond to the demands of parenting by adaptively addressing the needs of regulating the self and regulating the child. This finding underscores the importance of physiological support for maintaining ER while engaging in child-rearing.

The positive link between resting RSA and mothers' overall parenting behaviors as well as cognitive growth-fostering may be explained by parental executive functioning abilities. In the neurovisceral integration theory (Thayer and Lane 2000), resting RSA reflects prefrontal cortex function, which represents executive functioning ability. Higher parental executive functioning was conceptually and empirically associated with more positive parenting practices such as more sensitive and involved parenting (e.g., Bridgett et al. 2017; Cuevas et al. 2014). Thus, parents with higher resting RSA may have higher abilities to control, anticipate, and manage incoming information, which may be why they were better able to engage in cognitive growth-fostering behaviors as well as more positive overall parenting practices and, in a timely way, contingent on their perception of their children's needs.

The association between resting RSA and overall parenting contingency is also noteworthy. This may be because PNS activity, indicated by resting RSA, is linked to synchrony in caregiving interactions (Stallworthy et al. 2024), allowing parents to have more contingent interactions with their children. Contingency is an important component of quality parent–child interaction: parents' prompt responses help children connect parent responses to their own behaviors, which in turn fosters adaptive interaction patterns (Sumner and Spietz 1994).

TABLE 4 | Exploratory analyses examining maternal resting RSA and phasic RSA change as predictors of specific parenting behaviors while statistically controlling for resting and/or phasic respiration.

	Dependent variables									
	Sensitivity to cues					Response to distress				
	$\Delta R^2/\beta$	*b*	*SE*	95% CI		$\Delta R^2/\beta$	*b*	*SE*	95% CI	
Step 1 ΔR^2	0.17					0.03				
Resting RSA	0.26*	0.33*	0.13	0.06	0.46	0.16	0.24	0.17	−0.06	0.38
Resting respiration	−0.02	−0.01	0.06	−0.23	0.19	0.03	0.02	0.08	−0.19	0.25
Step 2 ΔR^2										
Resting RSA	0.28*	0.36*	0.15	0.06	0.50	0.14	0.21	0.19	−0.10	0.37
Resting respiration	−0.05	−0.03	0.06	−0.27	0.17	−0.07	−0.05	0.08	−0.30	0.16
Phasic RSA change	0.13	0.23	0.24	−0.14	0.40	0.15	0.30	0.29	−0.13	0.42
Phasic respiration	−0.03	0.02	0.08	−0.24	0.17	0.13	0.12	0.10	−0.08	0.34
	Social–emotional growth-fostering					Cognitive growth-fostering				
	$\Delta R^2/\beta$	*b*	*SE*	95% CI		$\Delta R^2/\beta$	*b*	*SE*	95% CI	
Step 1 ΔR^2	0.05					0.19				
Resting RSA	−0.06	−0.08	0.14	−0.28	0.16	0.21*	11.91*	5.83	0.01	0.42
Resting respiration	−0.03	−0.02	0.06	−0.25	0.19	−0.05	−1.23	2.62	−0.26	0.16
Step 2 ΔR^2										
Resting RSA	0.16	0.22	0.17	−0.08	0.40	0.25*	15.00*	6.46	0.04	0.46
Resting respiration	−0.05	−0.03	0.07	−0.28	0.18	−0.17	−4.34	2.63	−0.37	0.03
Phasic RSA change	0.33*	0.60*	0.26	0.06	0.61	0.18	14.17	10.20	−0.07	0.43
Phasic respiration	0.02	0.02	0.09	−0.19	0.24	−0.01	−0.21	3.49	−0.19	0.18

4.2 | Phasic RSA Change Linked to Overall Parenting Behaviors and Social–Emotional Growth-Fostering

Mothers' positive phasic RSA change (i.e., RSA augmentation) was significantly associated with mothers' overall parenting behaviors and social–emotional growth-fostering. These positive links between mothers' phasic RSA change and more positive parenting align with Joosen and colleagues' (2013) previous finding regarding average RSA during a parenting task: mothers who demonstrated more sensitive parenting showed higher average phasic RSA combined with lower average heart rate during an infant cry paradigm. Similarly, Miller and colleagues (2015) found that mothers expressed less negative control when they had higher RSA while working on a difficult puzzle with their preschool-aged children.

However, our finding contradicts other findings regarding RSA change during parenting tasks. As mentioned previously, several studies on parents' physiological reactivity during stressful parenting tasks, such as the still-face paradigm or an infant cry paradigm, revealed that higher phasic RSA (i.e., RSA augmentation) was associated with more negative outcomes (e.g., low responsiveness to infant disengagement cues; Ham and Tronick 2006). By contrast, our findings suggested a positive relation, such that higher phasic RSA change was associated with more positive parenting behaviors. One potential explanation is that rather than assessing RSA during a challenging task with their child, the present study recorded mothers' RSA while the mother was talking about her child with another adult within the context of the AAI. Mothers who showed lower RSA while talking about their children may have experienced talking about their child as more stressful, whereas mothers with higher RSA may have experienced the conversation as nonthreatening. Consistent with the concept of neuroception (Porges 2009), mild to moderate increases in parasympathetic influence (i.e., RSA augmentation) during ambiguous situations may reflect mothers perceiving the environment as secure and nonthreatening, with PNS downregulation of arousal serving to enhance their social engagement (Porges 2011). The AAI is not a laboratory stressor; rather, it is an interview that prompts individuals to think about their close relationships, activating their cognitive schema about attachments (George et al. 1985). Therefore, engaging in the AAI would not be expected to elicit a stress response from mothers, unless the cognitive schema of mothers serves to associate close relationships with stress or distress (i.e., insecure adult attachment). Mothers who evinced RSA augmentation while answering questions about their child could be expected to approach close relationships, including parent–child interactions, with greater self-efficacy and less trepidation, which would support higher-quality parenting behavior. Conversely, mothers who experience a conversation about their child as stressful may approach parent–child interactions as more difficult or unpleasant, which would be reflected in less contingent and less effective parenting behavior.

4.3 | Comparing Resting RSA and Phasic RSA as Predictors of Parenting Behaviors

Compared to phasic RSA change, resting RSA emerged as a more consistent predictor of parenting behaviors. This is in line with existing empirical evidence showing that resting RSA is a consistent and robust correlate of regulation, both in terms of ER (e.g., Appelhans and Luecken 2006) and self-regulation more broadly (e.g., Zahn et al. 2016). Parenting is full of unexpected ER challenges—parents whose resting state is more regulated may be better able to respond to whatever comes their way. In the context of the interaction task used in this study, the NCAST, parents have the goal of teaching their child how to do a novel task, but the child may also present the parent with an array of other behaviors, such as emotional displays, noncompliance, or interest in engaging in other activities. The parent may also have their own emotional reaction to manage—for instance, if the parent tries to engage the child and the child rejects the parent, this could evoke painful emotions in the parent. Further, the parent may have stressors unrelated to the child that could intrude in their minds during the interaction—they could be reminded of a work-related stressor, for instance. Parents who have a better trait-like ability to regulate emotion may be better equipped to manage the wide array of ER challenges that come their way. One possible explanation for this pattern of effects is that trait-like characteristics may better explain parenting than transient state-like characteristics. This finding is consistent with previous findings demonstrating parents' trait-like sensitivity was more predictive of children's adaptive development compared to sensitivity in a parenting task (Ding et al. 2020). Global ER capacity might reflect more trait-like characteristics, potentially explaining why resting RSA was significantly linked to four parenting behaviors controlling for phasic RSA change, while phasic RSA change was only significantly linked to two parenting behaviors controlling for resting RSA.

4.4 | AAI as a Parenting-Specific Context

Of note, the selection of the AAI as a parenting-specific context may influence the physiological reactivity observed. Leerkes and colleagues (2012) asserted that parenting behaviors may be domain specific: for example, maternal sensitivity to infant nondistress cues is a distinct construct compared to maternal sensitivity to infant distress cues. The central idea is that these two constructs may have more unshared variance than shared variance, predict different outcomes, and have different origins (Leerkes et al. 2012).

It is possible that distinct parenting-specific contexts bring about different manifestations of parental ER, as indicated by different levels of physiological reactivity. In this study, the parenting-specific context we created was one where mothers discuss their children, talking about their relationships with their children, their parenting, and hopes for the children's future. This represents one of the three types of parenting-specific emotion contexts summarized by Leerkes and Augustine (2019): when parents are exposed to stimuli related to parenting (e.g., seeing pictures of their child). This likely represents an indirect, nondistressing context where parents are not interacting with their children (e.g., compared with engaging in a parent–child conflict task), nor prompted to discuss a previous experience with their children (e.g., a time when they were angry at their children), which are the two other types of parenting-specific emotion contexts (Leerkes and Augustine 2019). These latter two contexts may present greater ER challenges for certain parents, though the context in which we assessed ER may still be activating for certain parents.

Compared to resting RSA, mothers showed higher average, albeit nonsignificant, phasic RSA during the child question cluster. A previous study that examined physiological reactivity during the AAI suggested that the AAI evoked physiological responses (eliciting a decrease in skin conductance), but importantly, this former study focused on a different cluster of questions within the AAI (Dozier and Kobak 1992). However, our study showed that mothers' RSA during the child-related question cluster, on average, did not significantly change compared to the resting state. This indicates that on average, mothers did not exhibit significant parasympathetic activation. More activation may be needed to parse out mothers' individual differences and variability in state-like, parenting-specific ER—on closer inspection of our data, it appears that there was considerable variability in participants' RSA to the AAI (some increased and some decreased compared to their RSA at the resting state). The observational context is important for understanding the implications of study findings: global ER in a nonstressful parenting context (i.e., talking about one's child) was associated with parenting behaviors in a not-necessarily stressful parenting context (i.e., teaching the child a novel task). Future research is needed to examine other parenting-specific contexts as Leerkes and colleagues suggested (2012), such as tasks that necessitate parenting in the moment (e.g., when the mother helps the child overcome an obstacle).

Another consideration of using the AAI as a parenting-specific context is individuals' attachment classification and quality of disclosure. Namely, mothers with insecure attachment (e.g., dismissing attachment—emotionally distancing self), or low coherence of mind (talking about prior experiences less coherently), may experience talking about their children as stressful and display a unique pattern of physiological activity compared to mothers with secure attachment or high coherence of mind. Individuals with insecure attachment were found to experience emotional inhibition during the AAI, indicated by heightened electrodermal activity (Roisman et al. 2004; Dozier and Kobak 1992). In our sample, we found that coherence of mind is not significantly associated with patterns of RSA change during child-related questions ($\beta = 0.04$, $p = 0.50$). However, future studies should consider the potential influence of coherence of mind or attachment security when using the AAI as a parenting-specific context for ER.

4.5 | Implications for Intervention

Many evidence-based psychotherapies target individuals' global ER capacity. For example, dialectical behavior therapy (DBT) and acceptance and commitment therapy (ACT) include components that aim to improve ER (e.g., modulating emotional arousal in ACT; Juarascio et al. 2013) and show efficacy in improving ER (Gratz et al. 2016). Evidence-based interventions designed for nonclinical populations that specifically target ER, such as Learning to BREATHE (L2B; Broderick and Frank 2014), may also be effective in improving parents' global ER capacity and, in turn, improving parenting behaviors. Parenting interventions also target parents' ER in child-rearing, focusing on their ability to engage in emotion socialization, model the use of appropriate emotion vocabulary, and appropriately respond to children's emotional distress (Porzig-Drummond et al. 2014). Examples of effective interventions for parenting-specific ER include Tuning in to Kids (TIK; Havighurst and Kehoe 2017), which seeks to develop parents' own ER capacity to appropriately respond to children's distress; Minding the Baby (MTB; Slade et al. 2019), which helps parents separate their own emotion dysregulation that stemmed from past trauma from their children's current distress; and the Reflective Parenting Program (RPP; Grienenberger et al. 2015), which enhances parents' ability to understand their own and children's internal worlds. Moreover, a 12-week skill-based emotion coaching parenting program demonstrated effectiveness for mothers who experienced intimate partner violence, as shown by increased resting RSA, positive parenting behaviors during interactions with children, and senses of parenting competence (Katz et al. 2020).

4.6 | Limitations

This study has some limitations that should be noted. First, as this paper is the first to use phasic RSA change during the AAI as a measure of parenting-specific ER, the validity of this approach warrants further examination. To validate this approach, future studies could examine its correlation with self-reported parenting-specific ER (e.g., REPS; Rodriguez and Shaffer 2021). Second, we examined these questions using a cross-sectional design, precluding the assessment of longitudinal research questions and causal inference. Although we have an interest in being able to speak to physiological reactivity as a predictor of parenting, our findings could be reflective of the influence of parenting on physiology, of bidirectional associations between the two, or of the influence of a third (unmeasured factor) that explains the association between the two. Similarly, the assessment of parenting behaviors via a standard laboratory observation can also be limited by social desirability bias and external validity. Future studies can adopt a multiple-informant, multiple-measurement approach in naturalistic (e.g., home) settings. Third, on average, mothers' phasic RSA during the child-related cluster did not significantly differ from their resting states, indicating that overall, they did not display significant parasympathetic activation when answering the child-related AAI questions. This is likely due to the nature of the AAI as an attachment interview but not a physiological stressor task per se. This does not mean that the AAI did not elicit an emotional response from participants or increases in PNS response among some participants, but that it did not elicit a sample-wide response that was evident in participants' RSA. If researchers desire to impact stress physiology, they could employ more provocative parenting-specific contexts to generate more variance in physiological responses. Fourth, this study only tested one parenting-specific context, but as Leerkes and colleagues (2012) suggested, parenting behaviors may be domain specific. Studies that examine different parenting contexts, especially those that involve direct parent–child interactions, may provide more ecological validity and can be an important direction for future research. Further, the study only examined one index within the physiological system—RSA as an indicator of PNS activation—as well as one mode of measuring ER (physiological and not subjective/behavioral). Several studies pinpointed the importance of looking at co-occurring changes in multiple physiological indexes as predictors of parenting behaviors (e.g., Miller et al. 2015). Miller and colleagues (2015) found that the physiological states marked by the interactions of PNS and SNS have different implications, such that SNS dominance (high SNS activation with low PNS activation), PNS dominance (high PNS activation with low SNS activation), and the coactivation or coinhibition of these two systems reveal different physiological states and relate to different parenting behaviors. Mills-Koonce and colleagues found that mothers who exhibited both lower RSA suppression and higher cortisol showed more negative intrusiveness (2009).

Future studies may benefit from examining multiple indices of the physiological system response. While it provides a real-time, objective indication of individuals' emotion regulatory effort, transient changes in RSA can occur in response to other mechanisms including cognitive control (Overbeek et al. 2014) and memory (Thayer and Lane 2000). Future studies could also assess individuals' ER via multiple methods concurrently, such as including behavioral observations, to enhance validity. Finally, to reduce statistical noise, the study focused on mothers, but fathers play an important caregiving role with significant impacts on children's development (Cabrera et al. 2018; Sarkadi et al. 2008), and the links between physiological reactivity and parenting behaviors are worthy of investigation.

5 | Conclusion

Overall, the findings suggest that both global ER capacity and parenting-specific ER are related to parenting behaviors, with global ER capacity emerging as more consistently related. The findings support future inquiry regarding the independent and intersecting roles of different measures of parental ER. These results may provide potential implications for intervention development, suggesting that interventions that target parents' global ER or parenting-specific ER may both be effective in enhancing positive parenting behaviors.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.