Parasympathetic Activity, Emotion Socialization and Internalizing and Externalizing Problems in
Children: Longitudinal Associations Between and Within Families

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Abstract

Biopsychosocial models of children's socioemotional development highlight the joint influences of physiological regulation and parenting practices. Both high and low levels of children's baseline respiratory sinus arrhythmia (RSA) have been associated with children's maladjustment, indicative of nonlinear associations. Negative or unsupportive parental responses to children's emotions are consistently linked with internalizing (IP) and externalizing problems (EP), although few studies have examined how associations vary within families. This study examined within- and between-person associations of children's quadratic baseline RSA, negative maternal emotion socialization, and children's problems over six years. RSA was measured in 133 3.5-year-old children (72 female) in predominantly middle- to upper-middle socioeconomic status, Caucasian families. Mothers reported on their emotion socialization practices and their children's adjustment concurrently and 1, 5, and 7 years later. Multilevel structural equation models revealed quadratic associations between baseline RSA and both IP and EP at the between-person level, suggesting that children with moderate RSA had fewer adjustment problems, on average, than children with lower or higher RSA. Across time and between families, children displayed more problems if their mothers reported more negative responses to their children's emotions. Within families, IP were elevated on years when mothers reported higher than usual negative responses, and children with either high or low baseline RSA had more problems on years when mothers reported greater than usual negative responses to their children's emotions. Altogether, these findings suggest that high and low baseline RSA may increase the risk for maladjustment, particularly in the time-varying context of aversive emotion socialization practices.

Keywords: quadratic RSA, externalizing, internalizing, socialization, longitudinal, moderation

Baseline respiratory sinus arrhythmia (RSA), a measure of tonic levels of parasympathetic nervous system (PNS) control over cardiac activity, is associated with individual differences in trait-like levels of arousal and emotional reactivity (Hastings, Kahle, & Han, 2014). Higher RSA at rest reflects greater capacity for flexible physiological and attentional self-regulation that underlies effective emotion regulation, supporting behavioral and psychological adjustment in children (Porges, 2007; Hastings et al., 2014). Correspondingly, there is considerable evidence for negative associations between baseline RSA and externalizing (EP) and internalizing (IP) problems (Beauchaine, 2015). However, the evidence is not entirely consistent, with a recent meta-analysis failing to find robust relations (Fanti et al., 2019). Researchers have tended to attribute inconsistent findings to sample biases and other methodological concerns (Shader et al., 2018; Zisner & Beauchaine, 2016). However, there may also be “too much of a good thing” with respect to baseline RSA (Kogan et al., 2013, p. 1), such that, in accord with polyvagal theory (Porges, 2003, 2007), baseline RSA may be non-linearly related to adjustment. That is, children with atypically low and high RSA could be more likely to develop problems related to poor self-regulation, compared to individuals with more moderate baseline RSA. Understanding the non-linearity of parasympathetic regulation is particularly salient during the preschool years, a critical window for the development and establishment of emotion, behavior, and physiological regulation that contribute to future trajectories of mental health (Eisenbeg, 2020).

Yet, children's development of behavioral and emotional adjustment also occurs in the context of close social relationships (Hastings & Kahle, 2019). Parents' emotion socialization practices, such as supportive responses to their children's emotions, are particularly fundamental for the development of effective emotion regulation. (Denham, Bassett, & Wyatt, 2015;

Eisenberg, Cumberland, & Spinrad, 1998; Saarni, 1999). Nonetheless, while there is continuity in parents' socialization efforts, parental expectations and behaviors may change as young children develop self-regulation skills, begin to establish emotional autonomy, and internalize (or not) parents' socialization practices (Klimes-Dougan & Zeman, 2007). Thus, relations between parents' emotion socialization and children's emotional functioning at any given time need to be understood as occurring within the ever-changing transactional interactions between children and their caregivers (Patterson & Reid, 1984; Sameroff & Mackenzie, 2003). Yet, empirical support for the dynamic association of parental emotion socialization and children's adjustment within families is largely based on between-person findings (Nelemans et al., 2019). That is, most of what we know about changes in parent-child dynamics has been inferred from comparisons across dyads in different families. Although important, such analyses provide limited insight into how individual families fluctuate and change over time (Curran & Bauer, 2011; Hoffman, 2019). Disentangling stable differences across dyads from potentially changing associations between children's adjustment and parents' emotion socialization within dyads requires the use of within-person approaches (Eisenberg, 2020).

Within-person approaches to developmental processes have rarely been used to examine how changes in socialization experiences affect associations between children's dispositional characteristics and emotional well-being over time. It is possible that young children's baseline parasympathetic regulation could predict subsequent maladjustment more or less strongly depending upon levels and fluctuations of socialization experiences. In the present study, we examined preschoolers' baseline parasympathetic regulation, and from preschool-age into middle childhood, their experiences of maternal negative responses to emotions and their IP and EP. This study aimed to (a) examine the nonlinear, quadratic associations of baseline RSA with

children's adjustment; (b) disaggregate stable between-person differences in associations between maternal negative responses to emotions and children's adjustment problems from concurrent within-person fluctuations in these associations; and (c) determine whether overall levels and fluctuations in maternal negative responses to emotions across time altered prospective nonlinear associations between preschoolers' baseline RSA and their IP and EP.

PNS and Adjustment: Evidence for Quadratic Associations of RSA

According to polyvagal theory, the myelinated vagus developed over the course of mammalian evolution to more effectively regulate the metabolically demanding sympathetic nervous system (SNS), facilitating capacities for affiliative behaviors and social engagement (Zisner & Beauchaine, 2016; Hastings et al., 2014; Porges, 2003). The vagus rapidly carries information between the central nervous system and PNS-innervated peripheral tissue through efferent and afferent nerve signals. PNS activity via the vagus nerve is frequently quantified using RSA, an index of heart rate variability that corresponds with the respiratory cycle due to the conjoint innervation of the cardiopulmonary system by the vagus nerve (Porges, 2003, 2007). Considerable research in developmental psychophysiology has focused on baseline RSA, an index of PNS activity in a wakeful relaxed state, as an important physiological component of emotion regulation capacities (Hastings et al., 2014; Zisner & Beauchaine, 2016).

Lower baseline RSA predicts a variety of emotional and behavioral difficulties (Shader et al., 2018). However, the evidence for linear associations between baseline RSA and children's adjustment is not entirely consistent, including in community samples of preschool-aged children with predominantly sub-clinical symptoms of psychopathology (Beauchaine et al., 2007; Shader et al., 2018). Some studies fail to find direct relations between baseline RSA and children's problems (Hastings & De, 2008; Hinnant & El-Sheikh, 2009); others show positive associations

between baseline RSA and IP and EP (Dietrich et al., 2007; Gao et al., 2017; Moore et al., 2018). Emerging research has found evidence for quadratic relations between baseline RSA and well-being (i.e., life satisfaction), prosocial behaviors, and executive functions (Acland et al., 2019; Kogan et al., 2013; Miller et al., 2017; Spangler et al., 2015). Thus far, whether there is a similar quadratic association between RSA and children's IP and EP has yet to be documented.

One reason for expecting higher baseline RSA to confer greater risk for adjustment difficulties is that, in addition to contributing to effective regulatory capacities, PNS activity via the vagus nerve may be indicative of thresholds for arousal in response to stimuli (Hastings & Kahle, 2019; Porges, 2003). Whereas children with lower baseline RSA have low thresholds for arousal, heightened vigilance and less effective physiological capacity for regulation (Beauchaine, 2015; Hastings et al., 2014), children with high baseline RSA have high thresholds for arousal that make them relatively unresponsive to social or emotional cues for behavioral responses (Hastings et al., 2006), akin to the fearlessness hypothesis of EP (Raine et al., 1997). Supporting this proposal, adults with higher baseline RSA were shown to have lower activation of the amygdala, insula and inferior frontal gyrus while viewing emotional faces (Miller et al., 2019), suggestive of decreased sensitivity to the emotional cues of others. If this extends to children's sensitivity to the normatively expected cues of their social contexts, it could suggest that children with higher baseline RSA would be less responsive to parents' socialization behaviors, including their emotion socialization.

Emotion Socialization and Children's Adjustment

Emotion socialization refers to processes by which parents shape children's expression, understanding, and regulation of emotions (Denham et al., 2015; Eisenberg et al., 1998; Saarni, 1999). Most emotion socialization research has focused on parents' direct behaviors (Hastings,

2018). Parents' contingent, overt responses to children's expressions of emotions can be supportive, providing comfort, guidance and acceptance, and promoting children's effective expression and regulation of emotion (Denham et al., 2015; Eisenberg et al., 1998). Parents also display negative responses to children's emotions (NRE), such as punishing or criticizing children for their emotions, ignoring or neglecting children's emotions, and magnifying negative emotions by parents themselves becoming highly emotionally aroused (O'Neal & Magai, 2005). Young children have limited capacity to cope with their negative emotions (Eisenberg et al., 2010). NRE fail to teach or model effective emotion regulation strategies, convey rejection of children's emotions, and are likely to further exacerbate children's distress and negative arousal, thereby adversely affecting children's nascent regulatory abilities (Perry et al., 2012). In both concurrent and prospective analyses, NRE by parents are associated with children's negative affect and difficulties with emotion regulation (Eisenberg et al., 1998; Mirabile, 2014), and with their EP and IP (Hastings & De, 2008; Johnson et al., 2017; Silk et al., 2011).

Thus, NRE may shape children's trajectories of maladaptive emotional development, contributing to EP and IP. However, parents' emotion socialization practices can change over time (Hastings, 2019; Rubin & Mills, 1992). It is unclear whether changes in parental NRE correspond with changes in children's IP and EP *within* families, that is, whether a given child's IP or EP lessens or worsens as a parent's NRE decreases or increases throughout development (Eisenberg, 2020). There has been limited research on parental socialization that has used within-person approaches (for exceptions, Mastrotheodoros et al., 2019; Nelemans et al., 2019; Neppl, et al., 2020). Inferences about the dynamic associations between parents' emotion socialization and children's adjustment need to be tested with statistical models that disentangle between-family and within-family levels of analyses.

Joint Contributions of Physiology and Socialization

Multiple-levels-of-analysis and bioecological theories highlight how the dynamic interaction between individuals' physiological regulation and their socialization contexts partly explain probabilistic associations between risk factors and adjustment (Cicchetti, 2008). Although several biopsychosocial theories treat "bio" or dispositional characteristics as the moderator of the association between "social" (environment) and "psycho" (adjustment), environmental contexts and experiences can moderate how dispositional characteristics are expressed in emotions and behaviors (Hastings & Kahle, 2019). Children with particular neurobiological characteristics, such as high or low RSA at rest, may be prone to developing IP or EP within more aversive social contexts, but evincing normative psychosocial development within less aversive contexts (Cicchetti, 2008, Sapolsky, 2004). Social relationships, and in particular caregiver-child interactions, can either reinforce or buffer the links between neurobiological vulnerabilities and psychopathology (Cicchetti, 2008)

As proposed in Sameroff's transactional model, adjustment is a product of the "adaptiveness of the relationship between individual and context" (Sameroff & Mackenzie, 2003, p. 613). This adds a temporal approach to the multilevel perspective, where the expression of dispositional characteristics in development is influenced by ever-changing interactions within a dyad. It is unknown whether a quadratic, non-linear relation between baseline RSA and adjustment will be influenced by the overall strength of maternal NRE, or whether the nature of the association between physiology and IP and EP could change as maternal NRE fluctuates during middle childhood. In other words, are there individual differences in the non-linear association between children's parasympathetic physiology and emotional problems that are

contingent on fluctuations in parents' use of unsupportive emotional socialization responses over time, beyond the extent to which parents differ in NRE?

The Current Study

In this study, we utilized measures of baseline physiology acquired during preschool and measures of maternal negative responses to child emotions (NRE) and child maladjustment (IP and EP) assessed four times over seven years to disentangle within- (WP) and between-person (BP) influences. First, we tested whether (1) there were quadratic associations between baseline RSA and problems, predicting that, on average, children who had relatively lower and higher RSA would have more IP and EP across time. At the BP level, we examined (2) whether NRE was related to development of IP and EP from early to middle childhood and hypothesized that higher NRE would be associated with more EP and IP. At the WP level, we examined (3) how fluctuations in NRE related to changes in IP and EP across assessments, expecting positive associations after controlling for BP effects. Finally, (4) we tested whether NRE moderated associations of RSA with EP and IP, at the BP and WP levels. At the BP level, we expected the quadratic association between RSA and problems to be stronger for children whose mothers engaged in more NRE. At the WP level, we expected that this quadratic association would be more evident on years when mothers reported more NRE. These hypothesized relations were expected to hold true while controlling for the linear association between RSA and adjustment.

Method

Participants

At Time 1 (T1), 133 children (72 girls) between 2 and 5 years old ($M_{\text{age}} = 3.5$ years; $SD = 0.75$) and their mothers ($M_{\text{age}} = 35.32$ years, $SD = 5.10$) were recruited over three consecutive summers (2002-2004) through advertisements and letters distributed in daycares and preschools.

Inclusion criteria were children being 2 to 5 years old, living with their mother, and enrolled in daycare or preschool. Exclusion criteria were serious physical or cognitive challenges that would limit abilities to complete procedures. Targeted recruitment and screening produced a sample of children with elevated IP as reported by mothers using the Child Behavior Checklist IP items at screening (CBCL; Achenbach & Rescorla, 2000). The sample had 42 children in the borderline clinical to clinical range of IP ($T \geq 60$), 48 above average but below borderline levels ($51 \leq T \leq 59$), and 43 at or below the mean for IP ($T \leq 50$). Families lived in a large city in Canada and most included two parents (85%) and identified as Caucasian (73.7%). Family socioeconomic status ranged considerably with the majority of families reporting middle- to upper-middle income ($M = \$80,229.17$ CND, $mode = \$50,000$, $SD = \$47,777.21$) and college or university degree completion (62% of mothers, 52% of fathers).

At *Time 2* (T2; 12 months post T1) 76 parents completed surveys reporting on their children's adjustment problems and parenting practices. Children (43 girls) were 4.7 years old, on average ($SD = 0.92$). At *Time 3* (T3; 5 years post T1) 95 families reported on their parenting practices and children's adjustment. Children (55 girls) were 9.08 years, on average ($SD = 0.80$). At *Time 4* (T4; 7 years post T1) 77 families reported on their parenting practices and children's adjustment. Children (44 girls) were 11.13 years, on average ($SD = 0.78$).

Procedure

This study used data from a study of biopsychosocial processes contributing to the development of young children at risk for IP, which was conducted from 2001 to 2010. The project titled "*The socialization of early social and emotional competence: Parent's and children's contributions to adjustment in daycare and preschool*" was reviewed and approved by the Institutional Review Board of Concordia University, protocol No. UH2000-067-3. At T1,

data were collected over two visits, one at each family's home, and one at the laboratory. During the home visit, child's baseline RSA was acquired, mothers completed an emotion socialization questionnaire and reported on their child's age and gender, and their family's household income, education, and ethnicity. At the lab, mothers reported on their children's EP and IP on the full CBCL (the screening IP scores obtained at recruitment were not used in these analyses.) At T2, the CBCL and emotion socialization questionnaire were mailed to participants. Finally, at T3 and T4, both measures were collected from mothers in a home visit.

Measures

Mother-reported EP and IP. At T1, T2, T3, and T4, mothers completed the Child Behavior Checklist (CBCL) matched to child's age, with the preschool form (ages 1.5-5) used for all children at T1 and most children at T2, and the school age form (ages 6-18) used for some children at T2 and all children at T3 and T4 (Achenbach & Rescorla, 2000). The CBCL is extensively used to assess children's maladjustment and has good reliability and validity (Achenbach & Rescorla, 2000). In the current sample, reliability coefficients ranged from $\alpha = 0.85$ to $\alpha = 0.87$. The IP scale includes measures of somatic complaints, anxiety, and withdrawn behaviors, whereas the EP scale includes attention problems, rule-breaking, and aggressive behaviors. The CBCL broadband T-scores for EP and IP were used in all analyses.

Mother-reported negative responses to emotions. At T1, T2, T3, and T4, mothers completed the Responses to Child Emotions questionnaire (Hastings & De 2008), which reflects whether, and to what extent, mothers magnify, punish, or neglect their children's sad, anxious, and frustrated/angry emotional expressions. Participants used a 5-point Likert scale ranging from one (*not at all typical*) to five (*very typical*) to indicate their responses, with 3 items each characterizing punitive (e.g., "when my child has been angry or frustrated, I said she/he should

be ashamed”), neglectful (e.g., “when my child has been scared or anxious, I usually didn’t notice”) and magnifying (e.g., “when my child has been sad or down, I got tearful or cried myself”) responses to each of the three negative emotions. The negative response to emotion (NRE) score reflects the average of 27 questions (Cronbach’s α T1 = 0.82; α T2 = 0.81; α T3 = 0.79; α T4 = 0.83). Higher scores reflect more punitive, neglectful or magnifying strategies.

Respiratory sinus arrhythmia. Baseline RSA at T1 was recorded at home using an ambulatory cardiac monitor (Mini-Logger 2000, Mini-Mitter, Inc) connected to the child’s chest via two adhesive electrodes or an elasticized belt. The sampling rate was set at 250 Hz, with continuous cardiac interbeat intervals (IBIs) computed from R-waves rounded to the nearest millisecond. Baseline RSA was acquired near the start of the home visit. Parents were asked to identify the part of the home where they were less likely to be disturbed by participant’s siblings. In two-parent families, one parent helped ensure baseline acquisition was not interrupted. In single-parent families, a second examiner fulfilled this role. After parents provided consent, children were encouraged to inspect the monitor and pretend to put it on a stuffed animal until they felt comfortable enough to wear it themselves. Five minutes after attaching the monitor, parents were asked to sit next to their children and watch a low-action animated video or read a children’s picture book to keep them sitting still and calm. Five children refused to wear the monitor and did not provide any baseline cardiac data.

Data were manually edited to correct recording artifacts using Mxedit (Delta Biometrics, Inc., Bethesda, MD) by research assistants trained by the last author to standardized editing on 20 files (differences in RSA $\leq .05$ for each case; correlation between assistant and author $r \geq .90$). Mxedit uses a rolling 21-point polynomial algorithm to compute RSA in $\ln(\text{ms})^2$ at the amplitude and oscillation period of spontaneous respiration. The frequency band was set to 0.24-

1.04 Hz, commonly used for preschool samples (Dollar et al., 2020), with RSA computed for the entire duration of the baseline. Baseline data were discarded for four children due to multiple consecutive recording errors, and for another five children for whom there was slightly less than 60s of uninterrupted usable data. For the remaining 119 children, on average, cardiac activity was recorded for more than four uninterrupted minutes ($M_{duration} = 4 \text{ min } 43.89 \text{ s}$, $SD = 1 \text{ min } 42 \text{ s}$) while the child was in a calm, stationary state, with 89% of children having 3 min or more of continuous data, and 100% of children having at least 1 min of continuous data. RSA did not differ by task (video or book), $t(117) = 0.25$, and was not correlated with duration of recording, $r = .16$, ns.

Analytic Strategy

Data preparation. The data had a nested structure: EP, IP, and NRE were nested within individuals, with unequal time intervals between assessments. There was one year between T2 and T1, five years between T3 and T1, and seven years between T4 and T1. To account for the nested structure of our data and model multivariate relations of change, we used multilevel structural equation models (M-SEM; Hoffman, 2019), which allows for unequal time intervals between measurements and does not assume stability of variables.

Modeling the effects of time on EP and IP. Intraclass correlations were calculated from a no growth model to get between- and WP variance in EP and IP throughout the four assessments. We modeled the effects of assessment time by testing fixed and random effects of linear and quadratic time on both variables, modeling EP and IP simultaneously and including covariances at both levels. The degree of model fit was assessed using likelihood function, Akaike information criterion (AIC) and Bayesian information criterion (BIC; Kuha, 2004).

Modeling quadratic RSA and its association with EP and IP. First, we examined the sample distribution of RSA for skewed distribution. RSA followed a normal distribution ($M = 5.39$, $SD = 1.36$, $Median = 5.29$, $Skewness = 0.19$). RSA was mean centered and squared, so that higher positive values represented either higher or lower RSA scores in relation to the sample mean. We fitted an M-SEM of RSA on EP and IP controlling for the effects of time, age, and the relation between both outcomes. To probe quadratic RSA associations with IP and EP, we examined the RSA values at which the simple slopes crossed the threshold for significance using Johnson-Neyman techniques for regions of significance (RoS) of linear models with curvilinear effects (Miller et al., 2013).

Modeling between and within-person effects of NRE. To disentangle BP and WP effects we used person-mean centering. Each individual's mean NRE score across the four assessments represented BP NRE, centered at the grand mean of the sample, such that zero represents the sample average NRE. WP NRE was centered at the person-mean, such that for every mother, the NRE score at each assessment was subtracted from that mother's mean NRE score across the four assessments. Therefore, a positive WP NRE value represents a higher than average NRE score for that mother, in that assessment, and a negative WP NRE score represents a lower than average score for that mother, in that assessment.

Examining between- and within-person differences in IP and EP based on quadratic RSA and NRE. To test the relation between baseline RSA, maternal NRE, and adjustment in the transition from early to middle childhood, we added the following to our M-SEM; Level 1 (WP) describes assessment-to-assessment fluctuations in children's behavioral outcomes and how they differed by assessment-to-assessment fluctuations in NRE, over and above the effects of time. Level 2 (BP) describes how individuals' average levels across seven years differed by linear and

quadratic RSA, overall NRE, and covariates. We tested predictors of interest for EP and IP simultaneously guided by model fit indicators, adding interactions with NRE at the end. The proposed M-SEM were fitted using Mplus version 7.31 (Muthen & Muthen, 1998-2015).

Missing data. Attrition after T1 reflects parents who did not respond to letters and phone calls and participants who agreed to participate but never returned materials. 109 of the original 133 families provided data at two or more occasions (# assessments 1 = 24, 2 = 25, 3 = 33, 4 = 51). Little's (1988) MCAR test indicated that data were not missing completely at random, $\chi^2 (df = 341) = 403.72, p < .05$, yet attrition analysis revealed no differences between continuing and non-continuing families on any focal variables except for EP at T2; *t*-tests and one-way ANOVA using Bonferroni post-hoc analysis showed that children who had data for all four waves had significantly fewer EP at T2 in comparison to those who had data at fewer waves. Missingness was not associated with demographic characteristics, such as socioeconomic status, indicating that the data conformed to missing at random (MAR; Enders, 2010). We included participants with only one measurement as they are still useful for estimating BP associations in our models (total $N = 133$, Schafer & Graham, 2002). Finally, to account for missingness in multilevel model analysis, we used full information maximum likelihood (FIML) as the estimation method for covariance parameters. As long as data is MAR, FIML is highly flexible to deal with partially random missing data (Graham et al., 2007).

Results

Descriptive statistics

Table 1 displays means, standard deviations, and zero-order correlations for all measures. Linear RSA was not related to NRE, IP, and EP. Quadratic RSA was correlated with greater NRE, EP and IP at T1 and T3, and higher EP and IP at T4. That is, parents of children with

lower and higher RSA reported greater NRE and more problems in children across three out of four assessments, compared to children with moderate RSA. Child age was negatively associated with baseline RSA at T1. Gender was not significantly associated with target variables, and in models fit with gender and age as covariates, gender was not significantly associated with EP, IP, NRE or RSA. Therefore, the most parsimonious longitudinal models included only age as a covariate. Mean NRE scores differed across the assessments, $F(3, 171) = 5.27, p < 0.01$, and orthogonal polynomials contrasts revealed a quadratic effect, $F(1, 57) = 12.94, p < .001$. NRE decreased after T1, then increased again by T4. There was not a significant difference in NRE between T1 and T4, $t(72) = 1.35, p = 0.182$.

Intraclass correlations as calculated from a no growth model were .57 and .63 for BP variance in IP and EP, respectively, such that children's problems varied from assessment to assessment while also maintaining individual differences in typical levels, with slightly greater stability of individual differences in typical levels of EP. After testing unconditional growth model specifications, a linear growth curve model for change in IP and EP, with random effects for intercept and EP linear time only, had the best fit to the data ($-2 \text{ Log likelihood} = -2573.279$, $\text{AIC} = 5170.56$, $\text{BIC} = 5217.49$). EP significantly increased across assessments, $b = 0.55, p = .001$; IP did not change across assessments ($p = .45$). EP and IP significantly co-varied at both BP and WP levels, suggesting EP and IP were correlated on average across assessments and at each assessment. To facilitate interpretability, time was centered at the midpoint of the span assessed in this study (between T2 and T3, equivalent to 3.5 years), with intercepts for EP and IP representing average problem T-scores throughout the seven years of the study.

Quadratic RSA and negative responses to emotions predicting problems across six years

To test hypothesis one, we specified a model of quadratic RSA predicting overall IP and EP with time of assessment, age and linear RSA as covariates (see Table 2). The slopes of the linear RSA term were not significant. The slopes of the quadratic RSA term were significant and positive. Thus, the association between baseline RSA and mother-reported IP and EP followed a U-shaped curve (see Figure 1 and 2). Children who had either higher or lower resting RSA at preschool had higher IP and EP scores, on average across seven years, compared to children with moderate RSA. RoS analysis revealed a significant negative relation between baseline RSA and IP when RSA was -0.70 *SD* and lower, and a significant positive association between baseline RSA and IP when RSA was $+0.24$ *SD* and higher. Likewise, there was a significant negative relation between RSA and EP when RSA was -0.90 *SD* and lower, and a significant positive association when RSA was 0.10 *SD* and higher.

To test hypotheses two and three, we specified an M-SEM that included main effects of linear and quadratic RSA and BP and WP associations of NRE predicting average levels and fluctuations in IP and EP across seven years (see Table 3). The effect of quadratic RSA on EP and IP was maintained. There was a significant BP effect of NRE on problems. Mothers who reported overall greater punishing, magnifying or neglecting of children's emotions, also reported that children had more IP and EP, on average, across seven years. There was a significant WP effect for NRE for IP. In years when mothers reported higher NRE with respect to their own average, they reported more IP in their children with respect to their child's average IP. There was not a significant WP effect for EP; EP did not vary from individual averages across assessment in years when mothers reported relatively more or fewer NRE than average.

To test hypothesis four we added interactions between RSA and WP and BP NRE predicting EP and IP (see Table 4). The two interactions terms of quadratic RSA X BP NRE

were not significant, but both quadratic RSA X WP NRE interactions were significant. When mothers reported more NRE in a given year relative to their own average NRE, children with either high or low baseline RSA had more IP and EP relative to their own average problem scores (see Figure 3 and 4). Conversely, children with moderate baseline RSA at preschool-age did not manifest more or fewer problems as maternal NRE varied across assessments.

Discussion

This seven-year longitudinal study examined between- (BP) and within-person (WP) associations among mothers' punitive, neglectful and magnifying responses to emotions (NRE), children's IP and EP, and their respective non-linear associations with baseline RSA. Consistent with a growing body of evidence for quadratic links between RSA at rest and children's psychosocial functioning (Acland et al., 2019; Miller et al., 2017; Spangler et al., 2015), children's IP and EP across childhood were elevated when RSA at preschool had been either high or low, compared to moderate RSA. Conversely, there was no evidence for linear effects of baseline RSA on IP and EP. Based on RoS analyses, children with moderately high RSA (just above average) had more IP and EP, whereas children with markedly lower RSA (approaching 1 SD below average) had greater IP and EP. NRE were associated with BP differences in IP and EP, with higher NRE predicting increased IP and EP throughout middle childhood. As predicted, on assessments when mothers reported more NRE than their own averages, they also perceived children as displaying more IP. Most strikingly, there were WP differences in NRE moderating the developmental course of IP and EP followed by children with relatively low and high RSA; these children had more EP and IP than their own averages on assessments when mothers reported more NRE than their own averages. On assessments when mothers reported fewer NRE, the EP and IP of children with low and high RSA were comparable to children with moderate

RSA. Accordingly, our findings suggest that the developing links between physiology, parenting, and adjustment in children are even more complex than typically depicted in the literature.

Quadratic baseline RSA and children's problems

The relation between RSA and adjustment is often characterized as linear without consideration for whether quadratic effects may be present, such that it is unknown whether the regulatory benefits of RSA extend to the upper level of the distribution (Spangler et al., 2015). We found a quadratic pattern for relations between baseline RSA at preschool-age and children's subsequent IP and EP. Preschoolers with moderate RSA had fewer problems from early to late childhood than preschoolers with relatively lower and relatively higher RSA, akin to evidence that moderate RSA is an index of well-being and prosociality (Kogan et al., 2013; Miller et al., 2017). It is unlikely that our findings could be explained by unusually greater numbers of children with lower and higher RSA in this sample compared to prior studies, as baseline RSA was normally distributed. Further, there were no significant zero-order correlations between baseline RSA and IP or EP, and we found no significant effects of linear RSA in our models.

Lower baseline RSA is often interpreted as reflecting compromised autonomic capacity to support emotion regulation, due to an overly vigilant state that augments distress and undermines a child's ability to cope with mildly challenging situations, increasing the chances of developing IP (Hinnant & El-Sheik, 2009; Beauchaine et al., 2007). Lower RSA also contributes to greater emotional lability and arousal, and lower volitional control of attention, contributing to impulsivity, aggression and EP (Beauchaine, 2015). In contrast, although higher baseline RSA is often viewed as an index of greater capacity for emotion regulation and effortful control (Beauchaine, 2015) there have been suggestions that strong tonic parasympathetic influence may confer convergent risks for distinct reasons.

Capacities to inhibit negative affect and arousal may lead to over-regulation of emotions. Psychological research often only considers maladaptive emotion regulation to involve under-regulation of negative affect, such that over-regulation or suppression of emotions remains relatively unaddressed (Costas Martins et al., 2009), although it has been linked to anxiety and depression in children (Zahn-Waxler et al., 2000). High baseline RSA is associated with more spontaneous use of emotion suppression (Pu et al., 2010), and adults with high baseline RSA and a tendency to suppress emotions have worse executive function ability (Spangler et al., 2015). Children with a tendency for strong parasympathetic influence might suppress their emotions without effectively learning how to cope and regulate their negative affect, conveying increased risk for manifesting problems.

High RSA also may be indicative of higher threshold for arousal (Hastings & Kahle, 2019), making children less responsive to subtle but important social cues from others (Hastings et al., 2006; Porges, 2003), and therefore less likely to terminate their own actions that others find aversive, or avoid such behaviors in future (Kochanska & Asksan, 2006; Raine, Venables, & Mednick, 1997). Similarly, atypically high RSA may contribute to autonomic under-arousal and thereby convey greater risk for aggression and other EP during early childhood (Gao et al., 2017; Moore et al., 2018). Children who are less prone to attending to the cues of others, or who experience insufficient arousal to motivate their orientation and attention to salient events, are less likely to learn from such cues or events (Miller et al., 2017). Thus, children with high baseline RSA and high thresholds for arousal may take relatively less advantage of learning opportunities to modulate their problematic emotional and behavioral responses.

It is striking that a single assessment of parasympathetic activity in the preschool period could have implications for understanding IP and EP over the subsequent seven years, into late

childhood. The preschool years are a critical period for the development of autonomous, self-regulatory capacities (Calkins & Keane, 2004). To transition successfully to the demands of elementary school settings, young children need to manage the emotional and social challenges of novel settings, separating from parents for longer durations, and adjusting their behavior to get along with adults and peers (Hastings et al., 2008). Moderate RSA in the preschool period may provide an optimal balance of both internal regulatory efforts and sensitivity to the cues of adults and peers, supporting children's ability to flexibly adapt to cognitive and emotionally challenging situations in preschool settings, fostering their subsequent positive school attitudes, social competence, and academic readiness (Hastings et al., 2008). Conversely, preschoolers with more extreme tonic RSA may be less physiologically prepared to cope with the increasing demands faced over maturation, leading to a cascade of conflicted or distressing interactions that maintain or exacerbate their EP and IP over time.

We contend that low and high baseline RSA convey different implications for young children's physiological regulation that contribute to phenotypically similar profiles across development, in accord with the principle of equifinality (Cicchetti, 2008). Furthermore, this is evident for children without atypically extreme RSA. The positive associations of higher RSA and more EP and IP were evident at slightly above-average RSA, and the negative associations of lower RSA and more EP and IP were evident within 1 SD below average RSA. These patterns indicate that a parasympathetic-related susceptibility to developing problems was evident for a relatively large proportion of children in this sample. It is important to keep in mind that this was a targeted community sample, rather than a clinical sample (Beauchaine, 2001). While over 64% of our sample had higher than average ($T > 50$) IP at preschool-age, the majority of children were not evincing clinical levels of EP or IP at any of the four assessments. It was only at more

extremely low and high RSA that children were projected to have problems severe enough to be considered of clinical significance (Achenbach & Rescorla, 2000).

Although it is normative to see increases in IP and decreases in EP as children age (Bongers et al., 2004), this sample was intentionally recruited to over-represent early-emerging IP. Like some prior studies targeting young children at risk for future internalizing psychopathology (Degnan & Fox, 2007), we found that both the levels and inter-individual differences in IP were stable over time. In contrast, mean EP scores increased across assessments in our sample, from slightly below to slightly above age-normed population averages (Achenbach & Rescorla, 2000). Population studies and studies of children with highly elevated EP (i.e., disruptive behavior disorders) typically have shown a normative declining trajectory of EP (NICHD Early Child Care Research Network, 2004). Given the targeted recruitment strategy of this study, it will be particularly important for future studies to test the non-linear associations of baseline RSA with IP and EP over time in other samples, including both general community and clinically affected samples of children.

Mother's negative responses to emotions and children's problems

In addition to direct, non-linear associations of problems with RSA, BP differences in children's IP and EP were strongly and positively related to mothers' negative responses to their children's negative emotions, across childhood. This association was evident despite the fact that mothers were reporting overall low levels of NRE, likely reflecting normative variations in parents' emotion socialization in typically functioning families. Children whose emotions are ignored, magnified, or punished are likely to remain negative emotional arousal for longer (Eisenberg et al., 1999). Parental responses that intensify or prolong negative emotional arousal may be particularly pernicious during the preschool period, when children are still dependent on

their parents to help co-regulate and manage their emotions, and may be internalizing the parents' emotion practices into their self-regulation repertoires (Eisenberg et al., 1999).

Children displayed more IP when mothers engaged in more NRE both across children (BP), and for any given child across time (WP). Children whose expressions of negative emotions are subject to neglect or punishment may develop more IP because they gradually start suppressing emotional experiences of sadness, anger, or anxiousness, among others (Eisenberg et al., 1999). Parental use of magnifying strategies (i.e., elaboration on negative emotions, negative emotion emphasis) also has been found to predict increased IP in preschoolers (Hernandez et al., 2018), possibly because parents are exacerbating their children's distress or modeling ineffective self-regulation of emotion.

Our WP findings did not disentangle the direction of the associations between IP and NRE. It is possible that when mothers perceived children to have more IP, they felt more challenged by and were more rejecting of their children's emotions, or that children manifested more emotional problems on assessments when they experienced less parental support for their emotional needs. Alternatively, a third external stressor such as increased financial hardship or marital distress could have acutely undermined both maternal socialization practices and children's emotional adjustment. Our model cannot distinguish directional or causal processes in these associations. Rather, they show that there seem to be acute and temporally specific links between child rearing and child adjustment in addition to more pervasive and lasting patterns of associations between emotion socialization and IP. Although we found significant bivariate relations between EP and NRE at every measurement, we did not find WP effects of NRE during middle childhood over and above trait-like associations. It is possible that mild fluctuations in

parents' emotion socialization are not evocative enough to increase EP over and above longer-lasting patterns of association between socialization and children's adjustment.

Quadratic RSA by emotion socialization interactions

Perhaps most strikingly, we found significant interactions of quadratic RSA and WP differences in NRE for the prediction of both IP and EP across childhood, suggesting that the tendency for preschoolers with high and low baseline RSA to evince more or fewer problems varied from assessment to assessment as maternal NRE increased or decreased, respectively. In other words, children with low or high baseline RSA during the developmentally sensitive preschool period of maturing self-regulation capacities were particularly likely to subsequently show acute elevations in IP and EP when mothers engaged in greater use of NRE, relative to their usual emotion socialization practices. Baseline RSA has been considered an important source of individual differences in developing emotion regulation that goes hand-in-hand with children's evolving emotional relationship with their parents (Hastings & Kahle, 2019). Thus, the WP variations in RSA predicting IP and EP dependent on mothers' NRE could be seen as consistent with the goodness-of-fit model (Lerner et al., 1985), with mismatches between children's regulatory needs and mothers' socializing influences occurring on those occasions when mothers engaged in relatively stronger NRE, triggering problematic behaviors in physiologically sensitive children.

Children with low resting RSA at preschool-age may have had more problems on assessments when mothers reported more unsupportive parental responses to their negative affect because they had been physiologically prone toward hypervigilance and experiencing stronger arousal (Hastings et al., 2014; Suurland et al., 2017). Thus, their proneness toward problematic behaviors could have been acutely exacerbated on occasions when they were lacking both

internal (PNS) and external (NRE) sources of effective regulation (Hastings, Kahle, & Nuselovici, 2014). Likewise, preschoolers with high baseline RSA may have formed a tendency towards emotional suppression; their elevated IP on assessments when caregivers more strongly discouraged their expression of negative emotion may have resulted from mothers' NRE reinforcing the children's emotional over-regulation (Gross & Cassidy, 2019). Perhaps simultaneously, EP may have been elevated in these assessments because stronger maternal NRE met or passed the children's relatively high thresholds for arousal, with the children acting out in response to the aversive parenting behaviors (Kochanska & Aksan, 2006). Of course, recognizing that the analyses we applied cannot disentangle direction of effect, it is also plausible that mothers' stronger NRE were elicited by temporary increases in IP and EP being displayed by children who had less optimally balanced parasympathetic regulation as preschoolers.

Another possible explanation for the WP interaction effect could stem from Kogan and colleagues' (2013) suggestion that high RSA may index greater social engagement and orientation to others, making preschoolers more sensitive to, and likely to internalize, their parents' rejection of their emotional needs. Earlier research had suggested that infants with higher RSA may be more attentive to both positive and negative socialization (Porges et al., 1994), and high baseline RSA is related to difficulties more strongly for children in negative contexts (Bandon et al., 2008; Holochwost et al., 2014). However, studies have not provided direct evidence of infants with higher RSA being more emotionally attentive, and developmentally normative changes in negative and positive expressiveness from infancy to toddlerhood may have been misinterpreted as evidence of RSA moderating early emotion socialization (Beauchaine, 2001). Further, higher baseline RSA in adults is related to weaker

neural reactivity of the mirror neuron system in response to others' emotional expression (Miller et al., 2019), which would not be consistent with higher RSA reflecting greater sensitivity.

Based on the polyvagal perspective, children with moderate RSA might be less likely to experience increases in problems when mothers report more NRE because of an optimal balance between their physiological regulation of arousal while also being attentive to subtle emotional cues (Miller et al., 2017). These children could have the resources to cope with potential arousal from maternal NRE while not overlooking the extent to which these relatively modest negative responses to their expression of emotions might be communicating meaningful information. Alternatively, given positive correlations between quadratic RSA and NRE at two assessments, such that children with moderate RSA experienced less NRE, it is possible that the WP variance in NRE (fluctuations of NRE from assessment to assessment) was lower for children with moderate RSA and thus did not evoke poorer behavioral and emotional functioning.

Limitations

Our participants were oversampled for IP during preschool; therefore, our results may not extend to other populations. Although there was evidence that data were missing at random, this study had relatively high missingness of data at T2 and T4; the estimation procedures we used are robust to that level of missingness, but replication of these findings in larger samples with better retention across assessments will be important. Mothers reported both their NRE practices and their children's EP and IP potentially biasing our WP results by overestimating parameters in our models (common-method variance; Rowe & Kandel, 1997). However, even after considering shared-method variance, there is evidence that maternal reports still inform about children's maladjustment (Rowe & Kandel, 1997). Further, shared method variance cannot account for different associations between maternal reported NRE and IP and EP for children with varying

levels of RSA. Still, future research should aim to disentangle WP and BP effects by using multiple informants or observational procedures.

Although it is common practice to use non-evocative video, book, or other materials to keep young children still during assessment of baseline physiology, this may evoke mild parasympathetic activation (i.e., reduced RSA) due to allocation of attention (Zisner & Beauchaine, 2016). However, young children's RSA has not been found to differ across video baseline, audio-only baseline, and baseline without stimuli, with very high correlations of RSA across procedures (Utendale et al., 2014). Thus, it is unlikely that our findings for quadratic baseline RSA findings would differ had RSA been measured in a stimulus-free baseline condition, although this would be worth examining in future analyses. The sampling rate of the cardiac monitor was consistent with recommended practice for examination of heart rate variability at the time the data were collected (Berntson et al., 1997), although current best practices are for more intensive monitoring given subsequent technological advances in ambulatory recording capacity. Similarly, there have been recent discussions about narrower age-specific respiration bands for computing RSA (Shader et al., 2018). However, those recommended respiration bands have been derived primarily from studies of respiration in health care settings, which may not generalize to other contexts, and the bands used in this report continue to be used by many established labs (e.g., Dollar et al., 2020). It is unfortunate that RSA was not assessed in this study after the preschool period. Although individual differences in baseline RSA are moderately stable from toddlerhood to adolescence (Dollar et al., 2020), parasympathetic regulation also develops over this time. Further repeated-measures longitudinal research will be needed to determine whether associations between quadratic RSA and adjustment persist at later ages (Beauchaine & Zalewski, 2016). Finally, the PNS does not act in

isolation from other neurobiological regulatory systems. Looking at the conjoint influences of PNS and SNS regulation may shed additional light on the complex contributions of physiology and parental influences to the development of IP and EP.

Conclusions

Altogether, this study presents novel evidence about the unique non-linear contribution of baseline PNS activity to children's development of IP and EP across six years. Further, our data suggest that stable differences in maternal negative responses between-families are a strong contributor to children's increased EP and IP, and even though within-family changes in socialization occur during the course of middle childhood, they solely correspond with children's changes in IP and potentially shift the developmental course followed by children with high and low baseline RSA. Our results underscore the utility of examining both between-person and within-person processes when thinking about the impact of parental socialization of emotions and children's physiological regulation and mental health.

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Table 1.
Descriptive Statistics and Zero-order Correlations

Variables	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
1. Age	3.50	0.75	2.07	4.92	--															
2. Gender (male)	45.9%				-.07	--														
3. B-RSA	5.39	1.36	2.36	9.51	.22*	-.09	--													
4. QB- RSA	1.85	2.65	0.00	16.94	.16	-.11	.13	--												
5. NRE _{T1}	1.49	0.33	1.04	2.41	.06	-.04	.20*	.19*	--											
6. IP _{T1}	50.17	10.98	29.00	76.00	-.05	-.01	.02	.22*	.39**	--										
7. EP _{T1}	48.30	10.8	28.00	69.00	-.09	-.02	.08	.22*	.35**	.72**	--									
8. NRE _{T2}	1.43	0.29	1.00	2.37	-.14	.08	-.11	.07	.64**	.21*	.26*	--								
9. IP _{T2}	48.84	10.74	29.00	76.00	.04	.02	.11	.09	.29*	.61**	.53**	.20	--							
10. EP _{T2}	46.01	10.46	28.00	69.00	-.11	-.04	.17	.15	.38**	.50**	.70**	.32*	.71**	--						
11. NRE _{T3}	1.38	0.27	1.00	2.11	-.08	-.09	.06	.24*	.57**	.35**	.37**	.59**	.27*	.29*	--					
12. IP _{T3}	50.71	10.83	33.00	77.00	-.01	-.17	.12	.42**	.35**	.53**	.50**	.19	.41**	.33**	.35**	--				
13. EP _{T3}	51.85	10.24	33.00	78.00	.03	-.18	.13	.35**	.25*	.42**	.58**	.13	.38**	.53**	.29**	.57**	--			
14. NRE _{T4}	1.44	0.32	1.04	2.48	.11	-.14	-.04	.11	.59**	.26*	.36**	.55**	.22	.30*	.69**	.12	.35**	--		
15. IP _{T4}	49.16	10.16	33.00	76.00	-.11	-.15	.11	.37**	.27*	.52**	.59**	.14	.54**	.52**	.23	.68**	.63**	.21	--	
16. EP _{T4}	49.40	12.26	33.00	80.00	.02	-.14	.29	.33**	.22	.43**	.59**	.16	.48**	.62**	.29*	.53**	.88**	.35**	.71**	--

Note: $N = 133$; * $p < .05$; ** $p < .01$ (all tests were 2-tailed).

Table 2.*Parameter Estimates for Multilevel Model of IP and EP as a Function of Quadratic RSA*

Predictor	Model 1: Quadratic RSA									
	Internalizing problems					Externalizing problems				
	<i>CI</i> ₉₅					<i>CI</i> ₉₅				
	Estimate	(SE)	Lower	Upper	β	Estimate	(SE)	Lower	Upper	β
Fixed effects										
Intercept	50.37***	0.79	48.81	51.67		49.86***	0.85	48.19	51.25	
Time	0.13	0.14	-0.25	0.56	0.04	0.58***	0.15	0.33	1.20	0.15
Age	-1.63	1.06	-3.70	0.45	-0.16	-2.33*	1.12	-4.51	-0.14	-0.16
Linear Baseline RSA	0.56	0.63	-0.67	1.79	0.07	1.00	0.65	-0.27	2.27	0.12
Quadratic Baseline RSA	1.43***	0.39	0.70	2.19	0.30	1.34**	0.40	0.56	2.13	0.28
Random effects ([variances])										
<u>Level 2 (between-person)</u>										
Intercept	56.20***	9.84	36.91	75.49		72.73***	10.91	51.35	94.11	
Time	--	--	--	--		0.97***	0.27	0.44	1.51	
Intercept by time	--	--	--	--		2.14*	0.89	0.41	3.88	
EP with IP						49.69***	9.05	31.12	65.88	
<u>Level 1 (within-person)</u>										
Residual EP with IP						20.66***	3.11	14.57	26.75	
Residual	49.90***	4.54	41.01	57.37		30.64***	3.41	23.95	37.33	
<u>Fit Statistics</u>										
-2 Log Likelihood									-3035.63	
AIC									6111.25	
BIC									6196.40	

Note. Estimates are unstandardized. Significant effects are shown in bold. * $p < .05$. ** $p < .01$. *** $p < .001$

Table 3.

Parameter Estimates for Multilevel Model of IP and EP as a Function of Quadratic RSA and Time-varying Maternal Negative Responses to Emotions (Main effects)

Predictor	Model 2: Main effects									
	Internalizing problems					Externalizing problems				
	<i>CI</i> ₉₅					<i>CI</i> ₉₅				
	Estimate	(SE)	Lower	Upper	β	Estimate	(SE)	Lower	Upper	β
Fixed effects										
Intercept	50.26***	0.77	48.75	51.78		49.73***	0.82	48.13	51.33	
Time	0.19	0.13	-0.07	0.46	0.05	0.64***	0.15	0.33	0.94	0.16
Age	-1.54	1.03	-3.56	0.49	-0.11	<i>-1.91^t</i>	1.07	-4.01	0.18	-0.13
Linear Baseline RSA	0.65	0.66	-0.60	1.93	0.08	0.65	0.67	-0.64	1.93	0.08
Quadratic Baseline RSA	1.26**	0.42	0.44	2.07	0.25	1.20**	0.42	0.37	2.03	0.23
Between-person NRE	10.83***	2.86	5.22	16.44	0.29	12.43***	2.93	6.69	18.17	0.32
Within-person NRE	5.04*	2.33	0.47	9.61	0.08	1.89	2.17	-2.36	6.15	0.03
<hr/>										
Random effects ([variances])	<i>CI</i> ₉₅					<i>CI</i> ₉₅				
	Estimate	(SE)	Lower	Upper		Estimate	(SE)	Lower	Upper	
<u>Level 2 (between-person)</u>										
Intercept	51.08***	9.13	33.18	68.98		62.24***	9.88	42.88	81.60	
Time	--	--	--	--		1.06**	0.29	0.72	3.20	
Intercept by time	--	--	--	--		2.21*	0.88	0.89	1.64	
EP with IP						41.24***	8.07	25.43	57.05	
<u>Level 1 (within-person)</u>										
Residual EP with IP						18.87***	3.07	12.86	24.88	
Residual	43.73***	4.14	35.61	51.85		29.81***	3.55	22.84	36.77	
<u>Fit Statistics</u>										
-2 Log Likelihood									-2801.71	
AIC									5653.41	
BIC									5751.72	

Note. Estimates are unstandardized. Significant effects are shown in bold. **p* < .05. ***p* < .01. ****p* < .001

Table 4.

Parameter Estimates for Multilevel Model of IP and EP as a Function of Quadratic RSA and Time-varying Maternal Negative Responses to Emotions (Interaction effects)

Predictor	Model 2: Main effects							
	Internalizing problems				Externalizing problems			
	<i>CI</i> ₉₅				<i>CI</i> ₉₅			
	Estimate	(SE)	Lower	Upper	Estimate	(SE)	Lower	Upper
Fixed effects								
Intercept	50.17***	0.78	48.64	51.70	49.58***	0.82	47.98	51.18
Time	0.17	0.13	-0.09	0.43	0.63***	0.15	0.23	0.93
Age	-1.48	1.03	-3.49	0.54	-1.84 [†]	1.06	-3.892	0.23
Linear Baseline RSA	0.60	0.65	-0.67	1.86	0.60	0.65	-0.68	1.87
Quadratic Baseline RSA	1.24**	0.41	0.44	2.05	1.20**	0.42	0.38	2.01
Between-person NRE	11.05***	2.85	5.46	16.64	12.67***	2.90	6.98	18.37
Within-person NRE	6.02**	2.31	1.49	10.54	2.39	2.17	-1.86	6.64
Quadratic RSA x BP NRE	1.29	1.46	-1.57	4.15	1.99	1.45	-0.84	4.82
Quadratic RSA x WP NRE	3.39***	0.07	3.26	3.53	1.68***	0.06	1.56	1.79
<hr/>								
Random effects ([variances])	<i>CI</i> ₉₅				<i>CI</i> ₉₅			
	Estimate	(SE)	Lower	Upper	Estimate	(SE)	Lower	Upper
<u>Level 2 (between-person)</u>								
Intercept	51.33***	9.09	33.51	69.16	61.02**	9.70	42.00	80.04
Time	--	--	--	--	1.05**	0.29	0.06	1.63
Intercept by time	--	--	--	--	2.22*	0.87	0.51	3.92
EP with IP					40.77***	7.96	25.16	56.97
<u>Level 1 (within-person)</u>								
Residual EP with IP					18.22***	3.00	12.34	24.10
Residual	42.31***	4.03	34.41	50.21	29.54***	3.54	22.61	36.47
<u>Fit Statistics</u>								
-2 Log Likelihood								-2915.96
AIC								5891.93
BIC								6009.90

Note. Estimates are unstandardized. Significant effects are shown in bold. * $p < .05$. ** $p < .01$. *** $p < .001$. [†] $p = .08$

Figure 1. Quadratic line and 95% confidence intervals fit to multilevel factor scores to represent relation between baseline RSA at preschool age and average, mother-reported IP across seven years, controlling for time, age and the covariance with EP. Shaded regions indicate regions of significance of the predictor, RSA.

Figure 2. Quadratic line and 95% confidence intervals fit to multilevel factor scores to represent relation between baseline RSA at preschool age and average, mother-reported EP across seven years, controlling for time, age and the covariance with EP. Shaded regions indicate regions of significance of the predictor, RSA.

Figure 3. Interaction effect of quadratic baseline RSA and within-person maternal negative responses to emotions at low (-1 SD) and high (+1 SD) levels predicting variation in IP across four assessments.

Figure 4. Interaction effect of quadratic baseline RSA and within-person maternal negative responses to emotions at low (-1 SD) and high (+1 SD) levels predicting variation in EP across four assessments.