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Prenatal internalizing symptoms as a mediator linking maternal adverse childhood experiences with infant temperament

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ABSTRACT

Background: Maternal adverse childhood experiences are known to significantly influence offspring development. However, mediators linking maternal early-life adversity with infant temperament remain largely unknown.
Aims: The current study investigated whether prenatal internalizing symptoms mediate the association between maternal adverse childhood experiences and infant temperament at two months. Maternal sensitivity/responsiveness during the postpartum period was also examined as a moderator of these associations.
Study design: We used a repeated-measures design, with self-report measures administered during pregnancy. Self-report and observational data were also collected at 2 months postpartum.
Subjects: The study included a community sample of 64 pregnant women and their infants.
Outcome measures: Participants completed measures assessing their early-life adversity and current depression/anxiety symptoms. At two months postpartum, mothers reported on their infant's temperament and participated in a parent-child interaction task designed to assess maternal sensitivity/responsiveness.
Results and conclusions: Maternal adverse childhood experiences indirectly predicted poor self-regulation during early infancy via prenatal internalizing symptoms. Maternal sensitivity/responsiveness was also found to moderate the association between maternal adverse childhood experiences and certain aspects of infant regulatory capacity and positive affectivity at two months. This research has implications for mental health screening procedures during pregnancy and the development of early intervention programs.

1. Introduction

1.1. Adverse childhood experiences

More than 50% of women have experienced at least one instance of early-life adversity [1]. The well documented, within-generation effects of adverse childhood experiences include an increased risk for health conditions from diabetes to depression [2,3]. However, more recent research suggests that the negative consequences associated with adverse childhood experiences can be transmitted between generations [4,5]. Children born to mothers with early-life adversity are at an increased risk for a multitude of poor health and developmental outcomes [6].

Maternal adverse childhood experiences are also negatively associated with infant socioemotional outcomes, including temperament [4,7]. According to the psychobiological model, temperament is defined as "constitutionally based individual differences in reactivity and self-regulation in the domains of affect, activity, and attention" [8]. Reactivity refers to the expression of both positive and negative emotions, whereas self-regulation encompasses processes such as attention that are used to modulate this reactivity. Individual differences in reactivity and self-regulation first appear during infancy and, despite having a strong genetic component, are largely shaped by environmental factors. These factors include those operating in utero, such as maternal adverse childhood experiences [4,9]. For example, McDonnell and Valentino [9] found that mothers reported an increase in maladaptive socioemotional outcomes among 6-month-old infants exposed to maternal early-life adversity (e.g., crying, difficulty recovering from

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distress).

The extant literature suggests that infants exposed to maternal adverse childhood experiences have alterations in their temperament, which could have long-term implications for their subsequent development [4,9]. However, previous research has not examined the role of maternal early-life adversity on infant temperament prior to four months. During the first few months of life, individual differences can be observed in aspects of temperament such as approach, distress proneness, positive affect, and attentional orienting [10]. Non-optimal development in these domains during early infancy predicts later psychopathology [11,12]. For example, Morales et al. [11] demonstrated that low positive affect in young infants was associated with internalizing problems in mid to late childhood. Thus, it is critical to better understand how risk factors such as maternal adverse childhood experiences impact temperament development as early as two months, as this would allow for early identification of profiles indicative of risk for symptoms/disorders, and related impairments. Many previous studies have examined the role of specific forms of maternal early-life adversity on infant outcomes [13], but recent research has emphasized the value of investigating the cumulative effect of maternal adverse childhood experiences on offspring socioemotional development [14]. The current work contributes to understanding how this compound risk is associated with temperament development.

1.2. Adverse childhood experiences, internalizing symptoms, and temperament

The pathways by which maternal adverse childhood experiences may be associated with infant temperament remain under-studied; however, maternal internalizing symptoms represent a strong candidate. Because women with early-life adversity commonly report depression or anxiety during pregnancy, it is important to consider whether prenatal internalizing symptoms may serve as a mediator linking maternal adverse childhood experiences with poor developmental outcomes in infancy [15]. Women with early-life adversity may face a higher probability of developing internalizing symptoms during the perinatal period for a variety of reasons. For example, adverse childhood experiences put women at greater risk for encountering additional adverse experiences in adulthood, such as intimate partner violence. These types of experiences in adulthood were shown to predict the onset of antenatal depression [16]. According to the Developmental Origins of Health and Disease (DOHaD) theory, prenatal internalizing symptoms may adversely influence temperament by inducing physiological alterations in the developing fetus that can have long-lasting implications for subsequent physical and mental health [17].

There are mixed findings in the extant literature regarding whether internalizing symptoms during pregnancy are linked to both maternal adverse childhood experiences and developmental outcomes in offspring [5,9,18]. One study conducted by Letourneau et al. [5] found that prenatal depression/anxiety mediated the association between maternal adverse childhood experiences and offspring internalizing problems at two years-of-age. In contrast, other studies have failed to establish these relationships, finding either non-significant results or a more prominent role for postpartum internalizing symptoms [9,18]. We could not locate a study which investigated whether this pathway applies to infant temperament. Examining these associations for temperament is important because it manifests early in development and has been shown to serve as an initial marker for future emotional and behavioral difficulties [19].

1.3. Role of parent-child interactions

Because the adverse effects associated with maternal early-life adversity and prenatal internalizing symptoms persist into the postpartum period in the form of caregiving behaviors, it is critical to consider parent-child interactions when examining socioemotional functioning during infancy. Previous research has demonstrated that maladaptive parenting strategies used by mothers with these risk factors predict impaired self-regulation during early childhood [20]. Conversely, sensitive parenting has been linked with increased manifestations of positive affect [21], and is protective more broadly (e.g., leading to more secure attachment; [22]). It is therefore important to evaluate whether increased maternal sensitivity buffers against the negative consequences of maternal adverse childhood experiences and prenatal internalizing symptoms for infant temperament, as better understanding these relations can lead to the development of more targeted parenting interventions.

1.4. Study aims

The first goal of the current study was to investigate the direct association between maternal adverse childhood experiences and infant temperament at two months, as previous research has not examined these associations in early infancy. Fine-grained aspects of temperament (i.e. specific subscales), as opposed to overarching factors, were considered because these have been shown to be uniquely predictive of later developmental outcomes [23]. Traits related to positive affectivity and regulatory capacity were considered in the present analyses because few studies have examined their association with maternal early-life adversity. These aspects of temperament have been linked with later emotional and behavioral difficulties, making it critical to better understand how they are associated with maternal adverse childhood experiences [11,12]. Negative emotionality has been studied in the context of adverse childhood experiences, and the present study provides an opportunity to conduct replication of this existing research [24]. It was hypothesized that maternal adverse childhood experiences would predict greater negative emotionality as well as reduced positive affectivity and regulatory capacity at a fine-grained level.

Previous studies indicate that prenatal internalizing symptoms may serve as a mediating factor linking maternal early-life adversity with socioemotional outcomes. However, this pathway has not yet been examined for infant temperament specifically. The second goal of the current study was to address whether maternal early-life adversity is adversely associated with the development of infant temperament via prenatal internalizing symptoms. Internalizing symptoms during pregnancy were expected to mediate the association between maternal adverse childhood experiences and infant temperament at two months, with more severe symptoms associated with higher negative emotionality but lower positive affectivity and regulatory capacity for the specific subscales.

The final goal was to assess whether greater maternal sensitivity/responsiveness during the postpartum period plays a protective role in the presence of the above adversities, moderating the hypothesized indirect effect. Specifically, maternal adverse childhood experiences and prenatal internalizing symptoms were predicted to be associated with greater negative emotionality as well as decreased infant positive affectivity and regulatory capacity at a fine-grained level among mothers with lower, but not higher, sensitivity/responsiveness.

2. Methods

2.1. Participants

Women ($N = 64$) were recruited during their third trimester of pregnancy from the Southwest Washington and the Eastern Washington/Idaho areas using social media and by distributing flyers to local OB/GYN offices. They are representative of a community sample where most women do not have clinical levels of depression and anxiety. In order to meet eligibility criteria, participants needed to be 18 years or older, fluent in English (because a number of measures had not been translated) and could not be diagnosed with heart disease or taking cardiac medications, as a larger study included measures of heart rate

variability. Additionally, participants were excluded if their infant was diagnosed with a cardiac defect or a neurodevelopmental condition, with the latter exclusion a function of temperament-related effects [25]. Infants ranged from 1.43 to 27.57 weeks at the two-month visit.

Prenatal survey data was not collected for five participants (7.81%). Seven participants were lost to attrition between the prenatal and two-month visit (10.93%). These women were lost to attrition due to factors such as difficulty with the time commitment required for participation and moving out of state. Across the variables included in the current analyses, missing data was classified as missing at random using Little's MCAR test ($\chi^2 = 215.44$, $p = .65$). The Washington State University Institutional Review Board approved each phase of the study, and informed consent was obtained. Demographic information is presented in Table 1.

2.2. Procedure and measures

2.2.1. Adverse childhood experiences

Eligible participants were asked to complete the Adverse Childhood Experiences Questionnaire during their third trimester of pregnancy. This questionnaire is a 10-item self-report measure in which respondents indicate whether they have been exposed to a series of adverse experiences between birth and the age of 18, including physical, verbal, and sexual abuse as well as physical and emotional neglect [26,27]. The Adverse Childhood Experiences Questionnaire has strong psychometric properties, including excellent internal consistency and convergent validity [28]. In the current study, this questionnaire had good internal consistency ($\alpha = 0.82$). Participants were categorized as having 0, 1, 2 or 3 or more adverse childhood experiences in order to create a cumulative measure of early-life adversity. This approach is consistent with previous research, which has classified participants as having 0, 1, 2, 3, or 4 or more adverse childhood experiences [5,6]. Given scores above 3 occurred infrequently in the current sample, they were recoded to a value of 3 so that final scores ranged from 0 to 3.

Table 1
Descriptive statistics for sample demographics.

Variable	N	Mean	SD	Range	Percentage
Maternal age	58	30.52	4.32	22–39	
Weeks gestation	57	31.63	3.00	27–39	
Maternal race	59				
American Indian/Alaska Native					1.7%
Asian American					5.1%
Hispanic or Latina					6.8%
Native Hawaiian or Pacific Islander					1.7%
White					81.4%
Other					3.4%
Maternal education	59				
High school or GED					3.4%
Some college					5.1%
Associate's degree					8.5%
Bachelor's degree					45.8%
Master's degree					18.6%
Doctorate or professional					13.6%
Other					5.1%
Total family income	57				
No income					1.8%
$5000–14,000					3.5%
$15,000–29,000					8.8%
$30,000–44,000					15.8%
$45,000–59,000					21.1%
$60,000–74,000					17.5%
$75,000 or higher					31.6%
Work status	59				
Full-time					45.8%
Part-time					16.9%
Unemployed					1.7%
Full-time homemaker					27.1%
Full-time student					3.4%
Other					5.1%
Partner status	58				
Engaged					3.4%
Married or living together					91.4%
Separated or divorced					3.4%
Living apart					1.7%
Parity	58				
Primiparous					63.8%
Multiparous					36.2%
High risk status	57				
No					91.2%
Yes					8.8%
Gestational age at birth	53	39.18	1.62	32.86–41.71	

2.2.2. Perinatal internalizing symptoms

The Edinburgh Postnatal Depression Scale (EPDS; [29]) and State-Trait Anxiety Inventory (STAI; [30]) were also administered during the third trimester of pregnancy. The EPDS is a 10-item self-report measure of depressive symptoms that has been previously validated with perinatal samples [31]. Scores range from 0 to 30, with higher scores reflecting greater symptom severity. The STAI is comprised of two self-report scales measuring state and trait anxiety, respectively. Each scale includes 20 items, which are combined to yield a composite anxiety score ranging from 20 to 80. Higher scores on this composite are indicative of more severe symptomatology. Both the EPDS and STAI have been found to display strong psychometric properties [29,30]. In the current study, both the EPDS ($\alpha = 0.84$), and STAI state subscale ($\alpha = 0.89$) had good internal consistency, while the STAI trait subscale ($\alpha = 0.93$) demonstrated excellent internal consistency. Scores from the EPDS and STAI were standardized and then averaged in order to create a composite measure of internalizing symptoms during pregnancy [32]. Their correlation was $r = 0.76$, $p < .001$ in the current sample.

2.2.3. Infant temperament outcomes

At two months postpartum, mothers were administered the Infant Behavior Questionnaire-Revised (IBQ-R; [33]). The IBQ-R is an established parent-report of infant temperament that uses a fine-grained approach consistent with the psychobiological model. It consists of 191 items that each have a 7-point Likert response scale ranging from 'Never' to 'Always.' The IBQ-R demonstrates satisfactory cross-rater agreement, test-retest reliability, and internal consistency [33,34]. Scales related to positive affectivity (activity level, approach, smiling/laughter, vocal reactivity, perceptual sensitivity, high intensity pleasure), regulatory capacity (duration of orienting, low intensity pleasure, cuddliness, soothability, falling reactivity), and negative emotionality (distress to limitations, fear, sadness) were examined in the present analyses. In the current study, most of the scales comprising the IBQ-R had good to excellent internal consistency ($\alpha = 0.80–0.98$). Only perceptual sensitivity scale was found to have poor internal consistency ($\alpha = 0.53$) and was thus not considered in hypothesis testing.

2.2.4. Parent-child interactions

Participants completed a mother-infant interaction task at their home when their infants were two months. Mothers were instructed to interact with their infant for 10 min as they would normally. These interactions were video-recorded and later coded for maternal sensitivity/responsiveness using a seven-point Likert scale [35]. High maternal sensitivity/responsiveness ratings were assigned when mothers responded in a warm, prompt, and supportive manner by engaging in behaviors such as using gentle techniques to bring the baby from a drowsy to an alert state. Low maternal sensitivity/responsiveness was defined by the absence of these behaviors as well as intrusive actions (e.g., engaging the infant despite withdrawal cues). Inter-rater reliability (>0.60) was determined by computing Intra-Class Correlations (ICCs) for independently rated training cases, with 20% of the sample double coded to ensure inter-rater agreement, as in prior research (e.g., [36]).

2.3. Analyses

Prior to addressing the primary aims of the study, descriptive statistics and correlational analyses were performed using the Statistical Package for the Social Sciences software [37]. Structural equation modeling was then conducted in MPlus [38]. Observed-variable path models were used to test for mediation, specifically the indirect effect of maternal adverse childhood experiences on infant temperament at two months via internalizing symptoms during pregnancy (Fig. 1). These models also assessed the direct effects of maternal adverse childhood experiences and prenatal internalizing symptoms on infant temperament. Each of the temperament scales were evaluated using separate models. Moreover, the moderating role of maternal sensitivity/responsiveness at two months was examined using moderated mediation (Fig. 2). Moderation was assessed by adding the following two interaction terms to the simple mediation models: 1) the product of maternal adverse childhood experiences and maternal sensitivity/responsiveness; and 2) the product of prenatal internalizing symptoms and maternal sensitivity/responsiveness. Post hoc analyses were conducted for any significant interactions. Maternal sensitivity/responsiveness was divided into the following three groups for these analyses: low (1 SD below the mean), moderate (mean), and high (1 SD above the mean). Infant age and gender were entered as covariates, as each has demonstrated associations with infant temperament [33]. To preserve power, analyses were not performed to correct for running multiple models. These analyses were repeated with prenatal depression, state anxiety, and trait anxiety as separate predictors in place of the internalizing symptom composite.

Overall model fit was evaluated using the chi square value, root-mean-square error of approximation (study criterion $\leq$0.05), comparative fit index (study criterion $\geq$0.95), and standardized root-mean-square residual (study criterion $\leq$0.05). Maximum likelihood estimation was used, as all variables had a normal distribution, with effect size determined using the standardized beta coefficients [39]. Missing data were accommodated by using full information maximum likelihood estimation to maximize statistical power. This procedure estimates all parameters based on available data and has been shown to provide less-biased estimates compared to other approaches, such as multiple imputation, particularly for small, longitudinal samples [40]. The datafile and syntax for these analyses can be found at https://osf.io/8wzqs/?view_only=ba7ec206cd9446b882043481caf269b7 [41].

3. Results

3.1. Preliminary analyses

3.1.1. Correlational and descriptive analysis

Descriptive statistics were computed for each variable included in the path models and are presented in Table 2. Maternal adverse childhood experiences was associated with significant differences in internalizing symptoms during pregnancy, $F(3,54) = 3.11$, $p = .03$. Post hoc analyses revealed that women with three or greater adverse childhood experiences ($M = -0.64$; $SD = -0.92$) endorsed higher prenatal internalizing symptoms compared to those with 0 adverse childhood experiences ($M = -0.27$, $SD = 0.85$) ($p = .004$). Internalizing symptoms during pregnancy were negatively associated with infant falling reactivity at two months, $r(45) = -0.41$, $p = .005$. Maternal sensitivity/responsiveness was positively associated with duration of orienting, $r(44) = 0.35$, $p = .02$, low intensity pleasure, $r(43) = 0.32$, $p = .03$, and family income, $r(48) = 0.35$, $p = .02$. Moreover, infant age during the two-month visit was positively associated with vocal reactivity, $r(n) = 0.43$, $p = .003$.

3.2. Simple mediation analyses

All of the simple mediation models demonstrated a strong fit (i.e., non-significant chi-square value, CFI > 0.95, RMSEA < 0.05, and SRMR < 0.05). Models examining infant falling reactivity and soothability at two months yielded significant findings (see Fig. 3a and b). There was a positive association between maternal adverse childhood experiences and prenatal internalizing symptoms in both models ($\beta = 0.38$, $p = .002$). Greater internalizing symptoms during pregnancy predicted decreased falling reactivity ($\beta = -0.48$, $p = .003$) and soothability ($\beta = -0.31$, $p = .04$) with moderate effect sizes for both dependent variables. Maternal adverse childhood experiences did not directly relate to any of the temperament variables.

Furthermore, there was a significant indirect effect linking maternal adverse childhood experiences with falling reactivity via internalizing symptoms during pregnancy ($\beta = -0.18$, 95% CI [−0.35, −0.03]). That is, higher maternal adverse childhood experiences related to lower falling reactivity in the infant at two months through its prior association with prenatal internalizing symptoms. An indirect effect for soothability approached significance ($\beta = -0.12$, $p = .096$), with a small

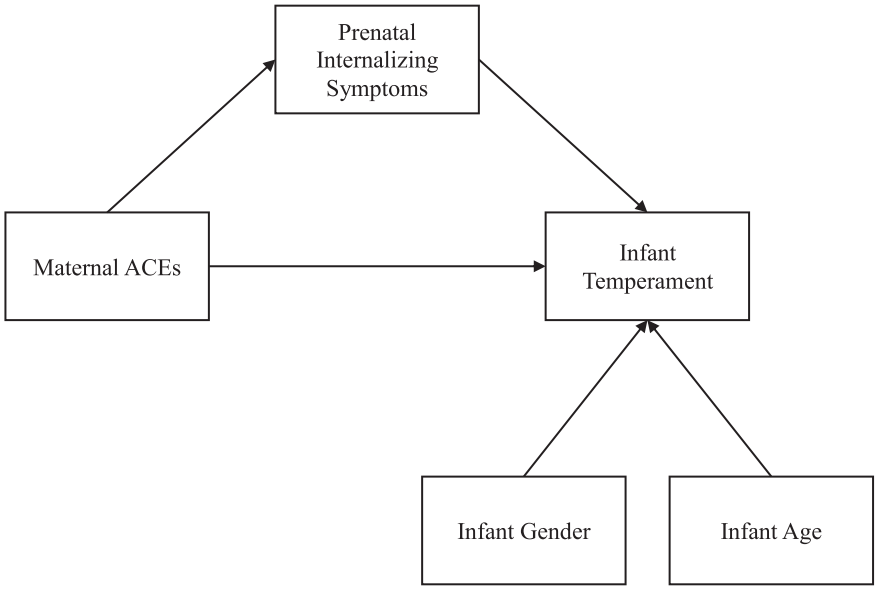

Fig. 1. Predicting infant temperament with maternal ACEs and prenatal internalizing symptoms.

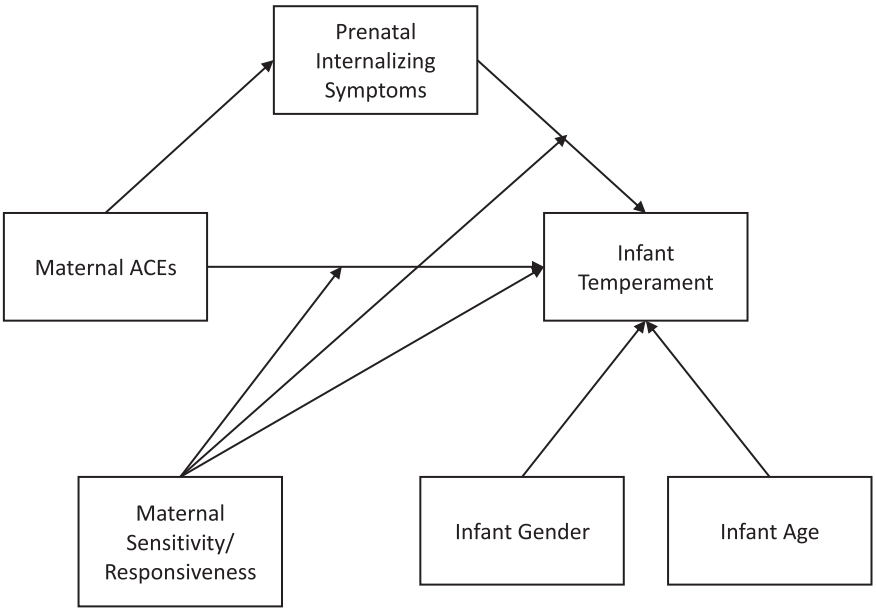

Fig. 2. Predicting infant temperament with maternal ACEs, prenatal internalizing symptoms, and maternal sensitivity/responsiveness.

Table 2
Descriptive statistics for variables of interest and covariates.

Variable	N	Mean	SD	Range	Percentage	Skew
Maternal adverse childhood experiences	59					0.51
0					47.5	
1					15.3	
2					15.3	
3					22.0	
Prenatal internalizing symptoms	58	0.00	−0.21	−1.42–2.19		0.59
Depression	58	6.63	4.21	0–17		0.61
Trait anxiety	58	37.05	9.98	22–61		0.43
State anxiety	58	37.38	8.87	25–63		0.78
Regulation	46	18.30	2.38	13.12–22.35		−0.05
Cuddliness	51	6.01	0.55	4.43–6.79		−0.96
Duration of orienting	47	2.87	1.33	1.00–6.78		0.91
Falling reactivity	51	4.80	0.97	2.55–6.25		−0.33
Low intensity pleasure	49	4.66	1.05	2.31–6.75		0.07
Soothability	51	4.84	0.83	3.11–6.94		0.44
Positive affectivity	42	19.87	5.38	8.58–34.43		0.32
Activity	51	3.45	0.78	1.73–5.54		0.49
Approach	44	2.94	1.19	1.00–5.92		0.35
High intensity pleasure	48	4.33	1.35	1.25–6.64		−0.40
Smiling/laughter	48	3.19	1.40	1.00–6.44		0.16
Vocal reactivity	46	3.24	1.24	1.00–5.57		−0.03
Negative emotionality	51	4.51	2.62	0.21–11.47		0.56
Distress to limitations	51	3.91	0.82	2.23–5.62		0.21
Fear	51	2.10	0.89	1.17–4.67		1.3
Sadness	51	3.30	1.03	1.33–5.44		0.25
Maternal sensitivity/responsiveness	54	5.35	1.36	1–7		−0.82
Infant gender	55					0.19
Female					54.5	
Male					45.5	
Infant age (weeks)	51	9.33	5.57	1.43–27.57		1.8

effect size characterizing both indirect effects.

3.3. Moderated mediation analyses

All of the moderated mediation models demonstrated a strong fit (i.e., non-significant chi-square value, CFI > 0.95, RMSEA < 0.05, SRMR < 0.05). Maternal sensitivity/responsiveness was found to moderate the direct path between maternal adverse childhood experiences and infant vocal reactivity at two months (see Fig. 4a). Specifically, there was a negative association between maternal adverse childhood experiences and infant vocal reactivity at high ($B = -0.40$, $p = .04$) but not moderate ($B = -0.03$, $p = .84$) or low levels ($B = 0.33$, $p = .27$) of maternal sensitivity/responsiveness. Finally, a significant interaction between prenatal internalizing symptoms and maternal sensitivity/responsiveness emerged in the model for infant activity ($B = 0.23$, $p = .03$; see Fig. 4b). Follow-up analyses demonstrated a positive association between prenatal internalizing symptoms and infant activity at high ($B = 0.54$, $p = .02$) but not moderate ($B = 0.23$, $p = .16$) or low ($B = -0.08$, $p = .70$) levels of maternal sensitivity/responsiveness. Both interactions were associated with a large effect size (vocal reactivity: $\beta = -1.49$;

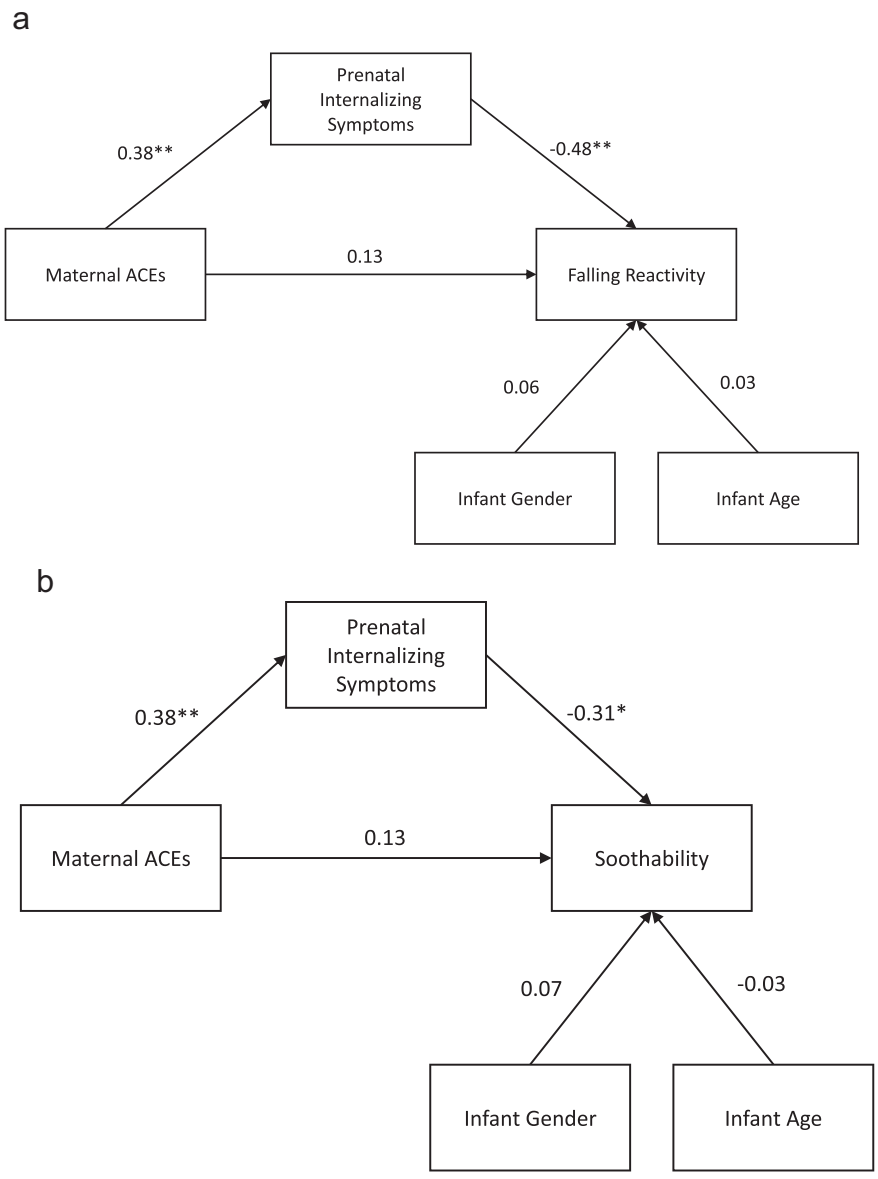

Fig. 3. a. Maternal ACEs-falling reactivity and path model. Values represent standardized path coefficients. Covariances are not depicted. Model fit = $\chi^2 = 0.23$ (2), $p = .89$, RMSEA = 0.00, CFI = 1.00, SRMR = 0.015. $^{**}p < .01$.
b. Maternal ACEs-soothability path model. Values represent standardized path coefficients. Covariances are not depicted. Model fit = $\chi^2 = 0.10$ (2), $p = .95$, RMSEA = 0.00, CFI = 1.00, SRMR = 0.010. $^{**}p < .01$, $^{*}p < .05$.

activity: β = 1.28).

Although maternal sensitivity/responsiveness did not moderate the association between prenatal internalizing symptoms and infant falling reactivity, exploratory analyses revealed moderation of the indirect effect of maternal adverse childhood experiences on infant falling reactivity via prenatal internalizing symptoms (see Fig. 4c). This indirect effect was present at low (B = −0.15, 95% CI [−0.64, −0.001]) and moderate (B = −0.16, 95% CI [−0.40, −0.03]) but not high levels of maternal sensitivity/responsiveness (B = −0.17, 95% CI [−0.41, 0.008]). That is, higher maternal adverse childhood experiences related to lower falling reactivity in the infant at two months through its prior effect on prenatal internalizing symptoms at only low and moderate levels of maternal sensitivity/responsiveness.

3.4. Depression and anxiety analyses

3.4.1. Simple mediation analyses

All the simple mediation models demonstrated a strong fit (i.e., non-significant chi-square value, CFI > 0.95, RMSEA <0.05, and SRMR <0.05). Maternal early-life adversity was positively associated with depression (β = 0.43, $p < .001$) and trait anxiety (β = 0.33, $p = .005$). Greater depression predicted decreased falling reactivity (β = −0.48, $p = .001$) and soothability (β = −0.33, $p = .03$). This same pattern was found for trait anxiety (falling reactivity: β = −0.44, $p = .009$; soothability: β = −0.34, $p = .02$).

There was a significant indirect effect linking maternal adverse childhood experiences with falling reactivity via depression symptoms during pregnancy (β = −0.21, 95% CI [−0.39, −0.05]). The indirect effect for soothability approached significance for both depression (β = −0.14, $p = .07$) and trait anxiety (β = −0.11, $p = .08$).

3.4.2. Moderated mediation analyses

All of the moderated mediation models demonstrated a strong fit (i.e., non-significant chi-square value, CFI > 0.95, RMSEA < 0.05, SRMR < 0.05). With state anxiety included in the model, there was a negative association between maternal adverse childhood experiences and infant vocal reactivity at high (B = −0.45 $p = .02$) but not moderate (B = −0.01, $p = .54$) or low levels (B = 0.25, $p = .35$) of maternal sensitivity/responsiveness. With depression included in the model, there was a positive association between prenatal depression symptoms and infant activity at high (B = 0.11, $p = .02$) but not moderate (B = 0.03, $p = .43$) or low (B = −0.50, $p = .34$) levels of maternal sensitivity/

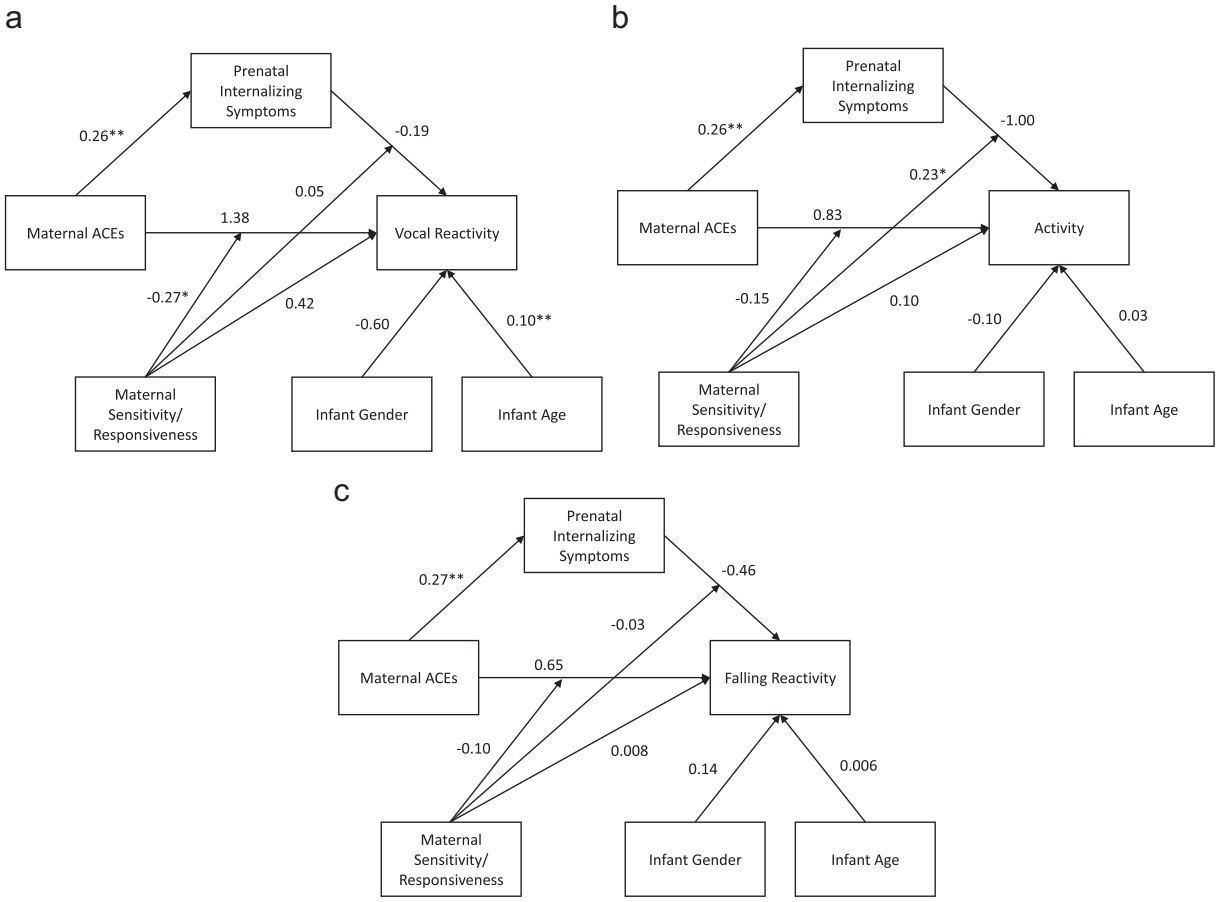

Fig. 4. a. Maternal ACEs-vocal reactivity path model with maternal sensitivity/responsiveness as a moderator. Values represent unstandardized path coefficients. Covariances are not depicted. Model fit = $\chi^2 = 0.27$ (2), $p = .87$, RMSEA = 0.00, CFI = 1.00, SRMR = 0.015. Effect of maternal ACEs on positive vocal reactivity was present at high (−0.40, $p = .04$) but not moderate (B = −0.03, $p = .84$) or low levels (B = 0.33, $p = .27$) of maternal sensitivity/responsiveness. $^{**}p < .01$, $^{*}p < .05$.
b. Maternal ACEs-activity path model with maternal sensitivity/responsiveness as a moderator. Values represent unstandardized path coefficients. Covariances are not depicted. Model fit = $\chi^2 = 0.31$ (2), $p = .86$, RMSEA = 0.00, CFI = 1.00, SRMR = 0.016. Effect of prenatal internalizing symptoms on activity was present at high (B = 0.54, $p = .02$) but not moderate (B = 0.23, $p = .16$) or low levels (B = −0.08, $p = .70$) of maternal sensitivity/responsiveness. $^{**}p < .01$, $^{*}p < .05$.
c. Maternal ACEs-falling reactivity path model with maternal sensitivity/responsiveness as a moderator. Values represent unstandardized path coefficients. Covariances are not depicted. Model fit = $\chi^2 = 0.32$ (2), $p = .85$, RMSEA = 0.00, CFI = 1.00, SRMR = 0.017. Indirect effect was present at low (B = −0.15, 95% CI [−0.64, −0.001]) and moderate (B = −0.16, 95% CI [−0.40, −0.03]) but not high levels of maternal sensitivity/responsiveness (B = −0.17, 95% CI [−0.41, 0.008]). $^{**}p < .01$, $^{*}p < .05$.

responsiveness.

Greater number of maternal adverse childhood experiences related to lower falling reactivity in the infant at two months through ACEs effect on prenatal depression symptoms at only low and moderate levels of maternal sensitivity/responsiveness. The indirect effect was present at low (B = −0.18, 95% CI [−0.521, −0.01]) and moderate (B = −0.17, 95% CI [−0.37, −0.02]) but not high levels of maternal sensitivity/responsiveness (B = −0.15, 95% CI [−0.38, 0.04]).

3.5. Power analyses

Monte Carlo simulations were conducted to determine whether there was sufficient power to detect the above significant effects. These analyses demonstrated that power was 0.70 or higher for all significant effects, suggesting that presented analyses were sufficiently powered [38,42].

4. Discussion

4.1. Maternal adverse childhood experiences

The current study considered how maternal adverse childhood experiences and internalizing symptoms during pregnancy relate to infant temperament. More specifically, this study explored whether prenatal internalizing symptoms mediate the association between maternal early-life adversity and infant temperament at two months. Furthermore, because parenting practices can influence the development of infant temperament, maternal sensitivity/responsiveness was examined as a potential moderator of these associations. These aims address a gap in the extant literature, as no known studies have examined mediators and moderators of the association between maternal early-life adversity and temperament during early infancy.

The first goal of this study was to examine whether maternal adverse childhood experiences directly relate to infant temperament. It was hypothesized that greater maternal adverse childhood experiences would predict higher negative emotionality as well as reduced positive affectivity and self-regulation at two months postpartum. Maternal early-life adversity, however, did not directly relate to infant temperament. These findings are not in line with previous research that has found maternal early-life adversity to predict increased difficulty recovering from distress during infancy [4,24]. However, these earlier studies examined the role of maternal adverse childhood experiences with respect to infant temperament at about six months of age, when children are far more advanced in terms of emotional development and

regulation capabilities.

Increased maternal prenatal internalizing symptoms were associated with infants' reduced falling reactivity and soothability. That is, infants had more difficulty recovering from distress and could not easily be soothed by their caregivers, when their mothers reported more substantial symptoms of anxiety and depression. These results align with previous findings that demonstrate a positive association between prenatal depression/anxiety and non-optimal temperament profiles during infancy, such as poor self-regulation [43,44]. When depression and anxiety symptoms were analyzed separately, the above results only occurred for prenatal depression and trait anxiety, suggesting a lesser role of maternal state anxiety in emergence of self-regulation during early infancy. These findings are consistent with previous research, which has found depression and trait anxiety during pregnancy to be associated with poor self-regulation in infants [43,45,46]. Trait anxiety may have a greater influence on infant temperament relative to state anxiety by the virtue of being more stable and persisting into the postpartum period, potentially impacting contextual factors such as the parent-child relationship [43].

Prenatal internalizing symptoms may not have related to a wider range of temperament outcomes in this study, as this was a community sample with women who were not diagnosed with clinical levels of antenatal depression and anxiety [47]. It is also possible that soothability and falling reactivity represent the most critical aspects of regulatory functioning in early infancy [10,48], and thus were associated to a greater extent, compared to other temperament attributes. In sum, these results suggest that exposures such as prenatal depression/anxiety may have a greater association with infant temperament at two months than early-life adversity in the mother, at least for a community sample of women.

4.2. Mediating role of internalizing symptoms

The second goal of this study was to investigate whether maternal adverse childhood experiences were negatively associated with infant temperament via prenatal internalizing symptoms. Internalizing symptoms during pregnancy were expected to mediate the association between maternal early-life adversity and infant temperament at two months. This hypothesis was supported for falling reactivity and approached significance for soothability. That is, early-life adversity predicted increased depression/anxiety symptoms during pregnancy, which then directly related to infant temperament. These findings are consistent with studies that have found prenatal depression/anxiety symptoms to serve as a mediator between maternal early-life adversity and adverse outcomes during later infancy and childhood [5,6]. However, this is the first known study to demonstrate that maternal adverse childhood experiences relate to specific aspects of infant temperament via internalizing symptoms during pregnancy. Notably, these associations were only found for certain components of temperament, specifically an infant's ability to recover from distress. As already noted, falling reactivity and soothability manifest early in development and therefore may be more salient during early infancy compared to other temperament attributes [10,48]. Additionally, depression but not anxiety symptoms during pregnancy were found to serve as a significant mediator linking maternal early-life adversity with falling reactivity. These results suggest that prenatal depression uniquely mediates the role of maternal early-life adversity on certain aspects of self-regulation during early infancy, highlighting the importance of examining the unique role of depression and anxiety symptoms during the perinatal period. Overall, the present findings are consistent with previous research demonstrating maternal adverse childhood experiences to be associated with infant self-regulation, though indirectly based on the results of this study [4,7].

4.3. Maternal sensitivity/responsiveness

The final goal of this study was to determine whether maternal sensitivity/responsiveness buffers against the negative outcomes associated with maternal adverse childhood experiences and prenatal internalizing symptoms on infant temperament. Maternal early-life adversity and internalizing symptoms during pregnancy were anticipated to be linked with greater negative emotionality but decreased positive affectivity and regulatory capacity among mothers with low levels of sensitivity/responsiveness. Although sensitivity/responsiveness was found to moderate the relationship between maternal adverse childhood experiences and infant vocal reactivity at two months, there was a negative association at high levels of this variable. That is, sensitive and responsive mothers with more adverse childhood experiences had infants with lower levels of vocal reactivity. Previous research suggests that mothers with early-life adversity utilize more self-focused caregiving strategies and consequently withdraw during interactions with their infants [49]. Infants born to mothers with early-life adversity may therefore display positive emotions more frequently in order to attract attention from their caregivers and repair ruptures in communication [50]. At higher levels of maternal sensitivity/responsiveness, mothers may already be attuned to their needs so that infants no longer need to use this strategy. It would be valuable to explore these processes further in future research to help inform parenting interventions for this population.

Moreover, maternal sensitivity/responsiveness moderated the association between prenatal internalizing symptoms and infant activity at two months. Specifically, among mothers who used sensitive and responsive parenting practices, fewer internalizing symptoms during pregnancy were associated with lower activity levels in the infant. These findings suggest that only low prenatal internalizing symptoms, especially depression during pregnancy, in combination with high maternal sensitivity/responsiveness during the postpartum period predict reduced locomotor activity. Maternal sensitivity/responsiveness may be important for decreasing infant activity levels, as these mothers may use more appropriate strategies to calm their active babies [21]. Increased locomotor activity has been shown to raise the likelihood of externalizing problems during childhood, [19], making it critical for mothers who did not experience depression or anxiety during pregnancy to still utilize sensitive and responsive parenting practices.

Lastly, the indirect effect linking maternal adverse childhood experiences with falling reactivity via prenatal internalizing symptoms was only present at low and moderate levels of maternal sensitivity/responsiveness. These findings suggest that higher levels of maternal sensitivity/responsiveness may attenuate the association between maternal adverse childhood experiences and falling reactivity in the infant at two months, as hypothesized. As mentioned previously, infants born to mothers with early-life adversity appear to have trouble managing their distress due to exposure to internalizing symptoms during pregnancy, especially prenatal depression. Highly sensitive/responsive mothers may help their infant more easily recover from negative emotions by quickly responding to their needs and using appropriate techniques to soothe their baby [20]. However, mothers with low or moderate levels of sensitivity/responsiveness may use ineffective approaches or even fail to notice their infant's distress [51]. Although young infants rely on their caregivers for emotional support, sensitive/responsive parenting may also facilitate the development of their own regulatory strategies, such as orienting away from distressing stimuli in their environment [52]. Thus, maternal sensitivity/responsiveness contributes to the infant's own ability to recover from distress, with implications for later development, as infants with greater self-regulation are less likely to develop internalizing and externalizing symptoms during childhood or adolescence [50]. However, this finding should be viewed as preliminary given the interaction between prenatal internalizing symptoms and maternal sensitivity/responsiveness was not statistically significant, perhaps due to a relatively small sample size

negatively impacting statistical power.

4.4. Strengths and limitations

This was the first known study to investigate whether prenatal internalizing symptoms serve as a mediator linking maternal early-life adversity with infant temperament. The strengths of this study include examining the association between cumulative maternal adverse childhood experiences and infant temperament as opposed to the unique role of individual forms of early-life adversity and assessing temperament at two months, allowing for the early identification of non-optimal profiles among children born to mothers with early-life adversity. In addition, an observational measure of maternal sensitivity/responsiveness was obtained, reducing the influence of confounding variables associated with self-reports of parenting, such as depressive symptomatology.

This study also had several limitations. First, the sample size was relatively small, and several participants were lost to attrition, which could have further limited the power of these analyses. However, statistical techniques were used to maximize power despite the small sample and missing data. Second, because this was a community sample, most of the women did not have clinically significant levels of internalizing symptoms during pregnancy. Nevertheless, this was an appropriate population to sample because many women experience elevated internalizing symptoms during pregnancy but do not meet criteria for a clinical diagnosis, making it critical to understand whether infants born to lower risk mothers display non-optimal temperament profiles. Third, this sample was fairly homogeneous in terms of demographic factors such as race/ethnicity and education. A majority of participants identified as white and had at least a college-level education. Thus, results of this study should be generalized with care, especially to women from diverse backgrounds. Fourth, we did not collect a measure of adversity in mothers at two months postpartum, which could represent another predictor of infant temperament and should be explored further in future studies [53]. Fifth, we did not control for postpartum internalizing symptoms. This choice was based on our interest in the prenatal period specifically and because the sample size limited the number of variables supported by the models. In addition, some studies examining the role of prenatal indicators of maternal psychological distress have not included postpartum symptoms in analyses due to high collinearity [54]. In our sample, the correlation between prenatal and postpartum internalizing symptoms resembled that in van der Wal et al. [54] ($r = 0.60$), supporting this approach. Lastly, temperament was assessed using a parent-report measure, the Infant Behavior Questionnaire-Revised (IBQ-R). Although the IBQ-R demonstrates strong psychometric properties, addition of an observational assessment of temperament would provide a more comprehensive picture of the infants' functioning.

4.5. Conclusions

The results of this study indicate that pregnant women with adverse childhood experiences have a higher risk of developing prenatal internalizing symptoms, which can increase the risk for non-optimal temperament profiles during early infancy. Thus, women with early-life adversity would benefit from being routinely screened for depression and anxiety during pregnancy. Moreover, sensitive/responsive parenting was found to protect against certain adverse outcomes associated with maternal adverse childhood experiences, suggesting that psychoeducation regarding these practices should be provided to mothers with early-life adversity as well as other caregivers in the family. Delivering parenting interventions during infancy is critical, as this could help to prevent the development of later behavioral and emotional difficulties in childhood.

CRediT authorship contribution statement

Jennifer Mattera: Original Draft Preparation, Formal Analysis; **Sara Waters**: Conceptualization, Methodology, Writing Review and Editing; **SuYeon Lee**: Writing Review and Editing; **Christopher Connolly**: Conceptualization, Writing Review and Editing; **Maria Gartstein**: Conceptualization, Methodology, Writing Review and Editing.

Declaration of competing interest

None.

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