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Research paper

Associations between mothers' and fathers' depression and anxiety prior to birth and infant temperament trajectories over the first year of life: Evidence from diagnoses and symptom severity

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ABSTRACT

Background: Developmental shifts in infant temperament predict distal outcomes including emerging symptoms of psychopathology in childhood. Thus, it is critical to gain insight into factors that shape these developmental shifts. Although parental depression and anxiety represent strong predictors of infant temperament in cross-sectional research, few studies have examined how these factors influence temperament trajectories across infancy.

Methods: We used latent growth curve modeling to examine whether mothers' and fathers' anxiety and depression, measured in two ways – as diagnostic status and symptom severity – serve as unique predictors of developmental shifts in infant temperament from 3 to 12 months. Participants included mothers ($N = 234$) and a subset of fathers ($N = 142$). Prior to or during pregnancy, both parents were assessed for lifetime diagnoses of depression and anxiety as well as current severity levels. Mothers rated their infants' temperament at 3, 6, and 12 months of age.

Results: Mothers' depression and anxiety primarily predicted initial levels of temperament at 3 months. Controlling for mothers' symptoms, fathers' depression and anxiety largely related to temperament trajectories across infancy. Lifetime diagnoses and symptom severities were associated with distinct patterns.

Limitations: Infant temperament was assessed using a parent-report measure. Including an observational measure would provide a more comprehensive picture of the infants' functioning.

Conclusions: These results indicate that mothers' and fathers' mental health are uniquely associated with infant temperament development when measured using diagnostic status and/or symptom severity. Future studies should examine whether these temperament trajectories mediate intergenerational transmission of risk for depression and anxiety.

1. Introduction

1.1. Temperament

The study of early temperament continues to generate interest because of the importance of emerging reactivity and regulation, which set the stage for later social-emotional development. 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" (Rothbart et al., 2011, p. 207). Although temperament is relatively stable, it develops rapidly over the first year of life (Braungart-Rieker et al., 2010; Gartstein and Hancock, 2019). Yet, most published studies have examined temperament at discrete time points, precluding our understanding of its development

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across infancy. Temperament trajectories are imperative to investigate further, as they have been linked with distal outcomes such as emerging symptoms of childhood psychopathology (Gartstein et al., 2010).

Previous research suggests that despite support for coherent temperament factors, development patterns significantly vary across the fine-grained dimensions within factors (Gartstein and Hancock, 2019). Examining temperament development at the factor level may obscure divergent patterns that could help to identify children at higher risk for later emotional and behavioral difficulties, making it critical to consider trajectories at the fine-grained level (Bridgett et al., 2013; Gartstein et al., 2010). With this emerging understanding regarding the importance of fine-grained infant temperament trajectories, a key next step involves gaining insight into contextual factors that shape this development across the first year of life to inform preventive interventions.

1.2. Depression and anxiety in mothers

Cross-sectional research has identified maternal depression and anxiety as strong predictors of infant temperament, i.e., greater negative emotionality and lower regulatory capacity, especially during early and middle infancy (Erickson et al., 2017; Korja et al., 2017; Rouse and Goodman, 2014). However, studies of infant temperament at a single timepoint preclude addressing predictors of developmental shifts in reactivity and regulation. Of the few published studies that took the latter approach, most have considered the role of mothers' depression and anxiety symptom levels during the postpartum period on temperament development (Gartstein and Hancock, 2019; Wu, 2021). These studies suggest that mothers' postpartum depression and anxiety symptom levels uniquely alter fine-grained aspects of temperament development, highlighting the importance of examining these predictors separately.

Cross-sectional research has demonstrated the importance of timing with respect to maternal mental health effects on infant socio-emotional development (Erickson et al., 2017; Rogers et al., 2023), indicating longitudinal studies are needed to determine the unique contributions of mothers' depression and anxiety before birth to offspring temperament trajectories, informing our understanding of developmental processes. In the single published study examining these associations, internalizing symptoms during pregnancy did not relate to infant temperament development (Erickson et al., 2019). Instead, prenatal symptoms were more predictive of initial levels of negative emotionality and regulation at 3 months, suggesting that in-utero effects may be more salient during early infancy through pathways such as fetal exposure to increased cortisol (Van den Bergh et al., 2020), reduced placental blood flow (Huizink et al., 2004), and changes in maternal inflammation (Beijers et al., 2014).

Although over 20 % of women report having a lifetime history of depression or anxiety (Hasin et al., 2018; McLean et al., 2011), fewer studies have examined the influence of these diagnoses on socio-emotional functioning during infancy (Aktar et al., 2017). Preconception depression and anxiety have been suggested to impact offspring through mechanisms including genetics, disruptions in mother-infant interactions, and by increasing the risk of recurrence during the perinatal period (Aktar et al., 2017; Bind et al., 2021; Goodman and Tully, 2009; Spry et al., 2020). It is critical to further investigate the role of depression and anxiety prior to conception on infant socio-emotional development, given these diagnoses have been found to relate to unique characteristics even in the absence of currently elevated symptoms (Bäzner et al., 2006; Ingram and Siegle, 2002) and predict child outcomes relative to postpartum symptom levels (Foster et al., 2008). However, no known studies have considered whether experiencing a lifetime history of depression or anxiety influences infant temperament trajectories, which would aid in the development of screening and treatment recommendations for a population of women who may often be overlooked by providers, especially if they fail to endorse elevated symptoms during the perinatal period.

1.3. Depression and anxiety in fathers

Fathers' mental health has also been found to predict adverse socio-emotional development during childhood, including internalizing and externalizing problems (Connell and Goodman, 2002). Yet, limited studies have examined how paternal anxiety and depression influence infant temperament. Using a longitudinal design, Potapova et al. (2014) demonstrated that fathers with greater internalizing symptoms at 4 months postpartum endorsed elevated negative affect in their 6-month-old infants. A cross-sectional study similarly found a positive association between paternal depression and infant fussiness at 6 months (Davé et al., 2005).

We found no published longitudinal studies examining the extent to which fathers' depression or anxiety prior to birth predicts temperament trajectories across infancy. Prior to conception, depression and anxiety in fathers has been suggested to contribute to epigenetic changes in their gametes (Rodgers et al., 2015). A lifetime history of these diagnoses may also confer risk through genetic liability and impaired parenting interactions (Aktar et al., 2017; Fisher et al., 2021). During the perinatal period, fathers experiencing depression and anxiety may indirectly disrupt infant temperament development by providing their partners with less support (Fisher et al., 2021). Thus, an important next step is to investigate the influence of paternal depression and anxiety prior to birth on temperament development, as fathers' psychopathology predicts a range of emotional and behavioral difficulties in their children after controlling for maternal symptoms (Fisher et al., 2015). Determining the unique role of paternal depression and anxiety on infant temperament development has the potential to aid in informing recommendations for fathers, who are not routinely included in prevention efforts.

1.4. Diagnosis vs symptom severity

Most of the published literature has characterized parental depression and anxiety as either meeting diagnostic criteria for these conditions, exceeding a certain cutoff score on a symptom scale that signals clinical levels of symptomatology, or as symptom severity scores (e.g., Field, 2010; Gartstein and Hancock, 2019). Of the few published studies that have included more than one approach to characterizing depression or anxiety, most have demonstrated minimal differences in the prediction of various infant outcomes, suggesting that reporting high symptom levels may be as salient as meeting criteria for depression or anxiety, perhaps due to both resulting in functional impairment (Goodman et al., 2011; Goodman and Tully, 2009). However, one recent study found elevated maternal depression and anxiety symptoms during the perinatal period but not clinical diagnoses to be significantly associated with infant development at 12 months. In contrast, neither metric in fathers was a significant predictor of infant outcomes (Rogers et al., 2023). Notably, this study used a community sample of parents with a low prevalence of clinical levels of depression and anxiety, which may have contributed to the reported findings. Given mixed results in the extant literature, further studies are needed using perinatal samples with higher rates of diagnostic cases to elucidate the impact of clinical diagnoses versus symptom severity measures on infant socio-emotional development to inform mental health screening protocols.

1.5. The current study

The current study simultaneously investigated both mothers' and fathers' depression and anxiety assessed prior to birth on developmental shifts in temperament across infant ages 3 to 12 months. We examined anxiety and depression in two ways, specifically as lifetime diagnostic status and symptom severity collected prior to or during pregnancy (hereafter described as "prenatal"). We planned to consider anxiety and depression separately because of unique effects implicated in the literature, unless contraindicated by strong associations, in which case we

opted to rely on composite distress scores instead.

This study extends the current research on infant temperament by addressing a number of important gaps. First, we considered the influence of both parents' depression and anxiety on temperament trajectories across infancy, which to our knowledge has not been examined to date. This design enabled us to determine the unique contribution of paternal mental health to infant temperament development, which has not been studied sufficiently yet has the potential to inform treatment recommendations for fathers as well as theories related to intergenerational transmission of risk. Second, we focused on fine-grained temperament dimensions because these have been shown to differentially predict later developmental outcomes and will thus be more informative in designing prevention programs for children born to parents with depression or anxiety relative to the overarching factors (Gartstein et al., 2012). Finally, we took advantage of a longitudinal design to consider both lifetime psychiatric diagnoses and prenatal symptom severity, examining each in relation to infant temperament development. This approach provides the opportunity to determine the potential value of the distinction between clinical diagnoses and symptom severity levels, as well as between distal and proximal measures. Of note, we utilized a sample of women with a higher rate of clinical depression and anxiety relative to previous research (Aktar et al., 2017; Rogers et al., 2023), increasing our power to detect significant effects of lifetime diagnoses in particular on infant temperament development. Moreover, by sampling women with lifetime major depression and generalized anxiety diagnoses, we increased the likelihood that fathers would also have elevated depression and anxiety given both assortative mating and the stressors associated with being the partner of an individual with psychopathology (Joutsenniemi et al., 2011; Mathews and Reus, 2001).

We hypothesized that mothers' lifetime major depression and generalized anxiety diagnoses would predict initial levels of temperament at 3 months of age, specifically greater negative emotionality as well as lower positive affectivity and regulatory capacity. These expectations are consistent with studies indicating that maternal internalizing symptoms measured before birth are linked with temperament during early infancy (Erickson et al., 2019; Korja et al., 2017). We also hypothesized that these diagnoses would predict greater increases in negative emotionality as well as slower growth in positive affectivity and regulatory capacity across infancy (Gartstein and Hancock, 2019; Wu, 2021). We further expected prenatal severity measures to result in similar patterns of effects for mothers as the lifetime diagnoses, given known associations between these measures (Goodman et al., 2011; Goodman and Tully, 2009).

As mentioned previously, there is limited research on how fathers' depression or anxiety relates to infant temperament, and published studies have not examined fathers' depression or anxiety as predictors of temperament trajectories across infancy. We hypothesized that fathers' lifetime major depression and generalized anxiety diagnoses would predict similar temperament patterns to that of mothers, given common underlying mechanisms of intergenerational transmission for both caregivers, including genetics and parenting practices (Fisher et al., 2021; Goodman and Gotlib, 1999). In contrast, we expected prenatal symptom severity in fathers to have a lesser impact on temperament relative to mothers given knowledge of the role of in-utero mechanisms in the influence of mothers' prenatal symptoms (Van den Bergh et al., 2020).

2. Methods

2.1. Participants

For this report, we selected 234 women and their infants from a larger project, *Perinatal Stress and Gene Influences: Pathways to Infant Vulnerability*, a prospective, longitudinal investigation that oversampled for women at risk for perinatal depression due to previous episodes of clinically significant depression and/or anxiety. A subset of fathers who were partners of women in the study also participated ($n = 142$; 61 %). That is, only fathers who were coupled with participating women were included in the study.

Participants were recruited from a women's mental health program in a university psychiatry department, local obstetrical and mental health practitioners, and media announcements. Women were eligible for this project if they were <16 weeks gestation based on their last menstrual period (LMP) and between the ages of 18 and 45 at enrollment. Women were excluded for active suicidality or homicidality, having psychotic symptoms, meeting DSM-IV criteria for bipolar disorder, schizophrenia, an active eating disorder, an active substance use disorder within 6 months before the LMP, a positive urine drug screen, and/or having an illness requiring treatment that could influence infant outcomes (e.g., epilepsy, asthma, autoimmune disorders, anemia, or abnormal thyroid stimulating hormone concentrations).

We included mothers who participated in one or more temperament evaluations (at 3, 6, or 12 months of age) and selected one infant randomly from each of 8 twin pairs, resulting in the final sample ($N = 234$). Eligible mothers versus those without any temperament data did not significantly differ on depressive symptoms or demographic variables including maternal age, race, marital status, education level, and socioeconomic status. Consenting and nonconsenting fathers coupled with eligible mothers also did not significantly differ on these demographic variables, maternal symptom severity levels, or infant sex.

2.2. Procedure

Both women and participating partners completed a baseline visit prior to 34 weeks gestation during which they were administered measures evaluating their lifetime history of depression and anxiety as well as current severity levels. Mothers reported on infant temperament at 3, 6, and 12 months postpartum. These ages were selected to cover the range of infant development, beginning during early infancy (Gartstein and Rothbart, 2003) through major developmental shifts occurring in the second half of the first year of life (Gartstein and Hancock, 2019). Given we were able to capture temperament development during mid and late infancy through the collected time points, we omitted the 9-month evaluation to minimize participant burden. Mothers and participating partners completed an informed consent protocol. All procedures were approved by the (Davis et al. 2019) Institutional Review Board (protocol number: IRB00004249).

2.3. Measures

2.3.1. Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First et al., 1995)

The SCID is a semi-structured diagnostic interview designed to assess Axis I disorders of the Diagnostic and Statistical Manual- Fourth Edition (DSM-IV; American Psychiatric Association, 1994). The full SCID was administered at the initial baseline visit to capture lifetime major depression and generalized anxiety for both mothers and fathers. Masters level clinicians administered the SCID, with reliability determined by a senior clinical psychologist who listened to the audio recordings of each interview and, after discussion with the interviewer, independently assigned diagnoses; additional details can be found in Emory University.

2.3.2. Hamilton rating scale for depression and Hamilton rating scale for anxiety

At the baseline visit, a research interviewer administered the Structured Interview Guide for the 17-item Hamilton Rating Scale for Depression (HRSD; Hamilton, 1960; Williams, 1988) and the Hamilton Rating Scale for Anxiety (HRSA; Hamilton, 1959) to capture mothers' and fathers' depression and anxiety symptom severity, respectively, at study entry. Overall scores for the HRSD range from 0 to 52, and overall scores for the HRSA range from 0 to 56. For both measures, higher scores

indicate more severe symptomatology. Quarterly inter-rater reliability assessments were conducted to ensure maintenance of *kappa* statistics ≥0.8 on clinician-administered instruments.

2.3.3. Infant behavior questionnaire-revised

The Infant Behavior Questionnaire-Revised (IBQ-R; Gartstein and Rothbart, 2003) is an established parent-report of infant temperament. It produces 14 fine grained scales, shown to cluster into three factors: include negative emotionality (distress to limitations, fear, sadness, falling reactivity); positive affectivity (activity level, approach, smiling/laughter, vocal reactivity, perceptual sensitivity, high intensity pleasure); and regulatory capacity (duration of orienting, low intensity pleasure, cuddliness, soothability). In the current analyses, only the fine-grained scales were examined, given that these differentially predict later developmental outcomes (Gartstein et al., 2012) and have trajectories distinct from over-arching factors (Gartstein and Hancock, 2019). This approach also allowed us to reduce our overall number of tests to minimize type 1 error. Scores represent the means of the items that make up each scale, with higher scores indicating more of the attribute. The IBQ-R has strong psychometric properties including high internal reliability and convergent validity with laboratory-based observations (Gartstein and Bateman, 2008; Gartstein and Marmion, 2008; Gartstein and Rothbart, 2003). Internal consistency of the IBQ-R subscales in the present sample was generally good, with Cronbach's α values ranging from 0.71 to 0.89. Only infant activity level at 6 months was significantly higher in consenting fathers ($M = 4.53$, $SD = 0.81$) relative to non-consenting fathers ($M = 4.21$, $SD = 0.80$; $t(193) = -2.65$, $p = .01$).

2.3.4. Covariates

Specific covariates considered included mothers' age, race, marital status, education, and antidepressant use during pregnancy as well as infants' sex, gestational age, and Apgar score at delivery (Campbell et al., 2020; Eastwood et al., 2012; Erickson et al., 2019; Gartstein and Rothbart, 2003; Pesonen et al., 2006; Vaughn et al., 1987). At each pregnancy follow up visit, a study psychiatrist completed a detailed weekly tracking sheet on the women's use of psychotropic medications, from which we derived a score to index antidepressant use. Demographic questionnaires at study entry determined women's race, education, age, and marital status. Birth outcomes were extracted from medical records.

2.4. Analyses

Latent growth curve models were estimated using Mplus (Muthén and Muthén, n.d.). Just-identified piecewise models were used to model trajectories for each of the IBQ-R fine-grained scales. Specifically, given that the time points of assessments were 3, 6, and 12 months, after an intercept factor (with loadings of 1 to all time points) two slope factors were included: the first with loadings of 0, 3, 3 capturing change from 3 to 6 months, and the second with loadings of 0, 0, 6 capturing change from 6 to 12 months. While having only two time points per interval does not allow for assessing intra-interval linearity, in our case we were modeling the average monthly rate of change between successive time points, thus neither assuming nor trying to test the linearity associated with that change process. Such piecewise models were chosen for this study as they provide the opportunity to model uneven developmental shifts in temperament, which commonly occur across infancy (Hancock et al., 2013).

First, growth curve models were analyzed to determine which candidate covariates should be included in analyses involving the mental health variables. Covariates were retained if they demonstrated significant associations (α = 0.01) with any of the temperament scores. An alpha of 0.01 was used to account for the high number of tests performed to identify candidate covariates. Next, lifetime diagnoses and severity scores were examined using separate models to examine their influence on the temperament scales at infant age 3 months as well as change from 3 to 6 and 6 to 12 months. We found substantial correlations between the anxiety and depression severity variables (mother: $r = 0.82$, $p < .001$; father: $r = 0.85$, $p < .001$); thus, we resorted to our alternative strategy creating a prenatal distress composite for both mothers and fathers. To create a composite measure of prenatal distress, HRSD and HRSA scores at the baseline visit were standardized and averaged together (Gartstein et al., 2016). Lifetime major depression and generalized anxiety were analyzed separately because these scores were not highly correlated for either mothers or fathers. For both the lifetime diagnoses and severity scores, maternal and paternal scores were analyzed simultaneously, enabling us to discern their unique contributions to temperament parameters. By including both maternal and paternal predictors in the same growth curve models, we were able to accommodate for the interdependence of these variables. Using this statistical approach, partners are not treated as different cases but rather as part of the same case. This enabled us to account for the unique contributions of each partner as well as their shared variance on infant temperament. Along with the demographic covariates previously mentioned, fetal age at the baseline visit was included as a covariate in the distress severity analyses to control for potential differences in collection timing. Given lifetime diagnoses are stable across time, we did not control for collection timing in these analyses. See Figs. 1 and 2 for path diagrams depicting these models.

All models were just-identified, thus by default a perfect fit is conveyed by related indicators. As a result, emphasis shifts to estimating, testing, and comparing each model's parameters. Robust maximum likelihood estimation known to be robust to non-normality was used with full information maximum likelihood (FIML) accommodating missing data 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 (Enders, 2013). Due to concerns regarding ensuring adequate statistical power, no corrections for multiple tests were performed. Effect sizes for significant predictors were determined using the standardized beta coefficients (Muthen, n.d.). We were also interested in describing whether effect sizes differed between the lifetime depression and anxiety diagnoses for each of the temperament scales and thus compared the 95 % confidence intervals for the standardized coefficients. We focused on comparisons wherein the confidence intervals for these diagnoses did not overlap, considering these to differ with a greater level of confidence.

3. Results

Descriptive statistics were computed for all predictors included in the growth curve models (see Table 1). Both mothers and fathers were largely Caucasian, college-educated, and living with their partner. Of note, 70.9 % of mothers met diagnostic criteria for depression in their lifetime, whereas 14 % percent of women did not have a lifetime history of major depression or generalized anxiety disorder, consistent with the study's recruitment strategy of targeting women at risk for perinatal depression due to previous mood difficulties.

Means and other descriptive statistics for the temperament fine-grained scales at each time point are provided in Supplemental Table 1. None of the scales indicated any problems with non-normal skew or kurtosis.

Across the variables included in the current analyses, missing data was classified as missing at random using Little's MCAR test ($\chi^2 = 1255.54$, $p = .99$). Missing data occurred when participants failed to attend planned assessments. Some participants also did not complete certain measures at the baseline visit due to practical considerations such as not having adequate time for all the interviews.

3.1. Covariate models

Growth curve models examining associations between the candidate

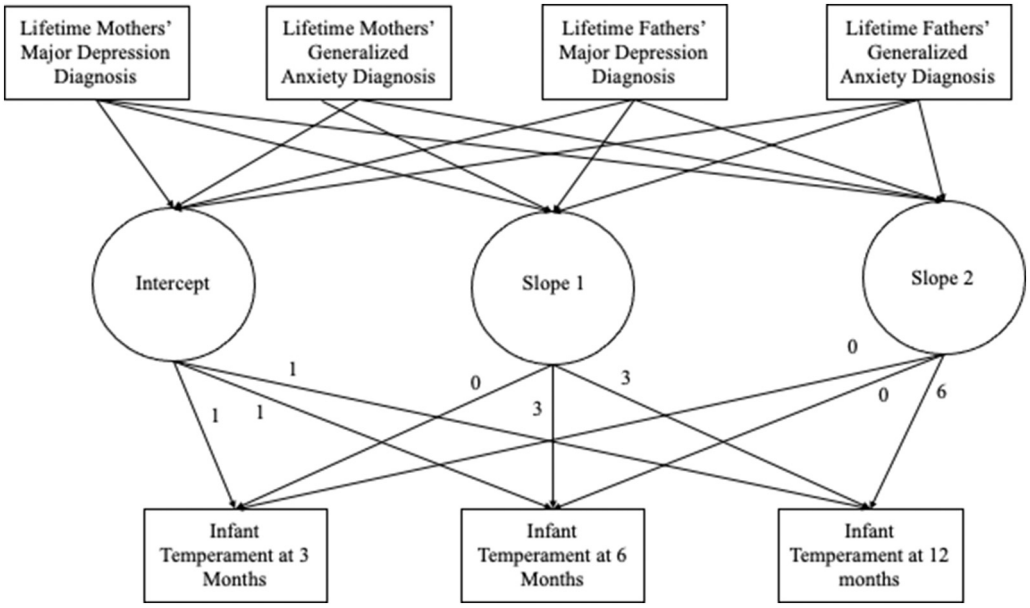

Fig. 1. Path Diagram Depicting Model for Mothers' and Fathers' Lifetime Major Depression and Generalized Anxiety Diagnoses Predicting Infant Temperament at 3-, 6-, and 12-Months of Age.

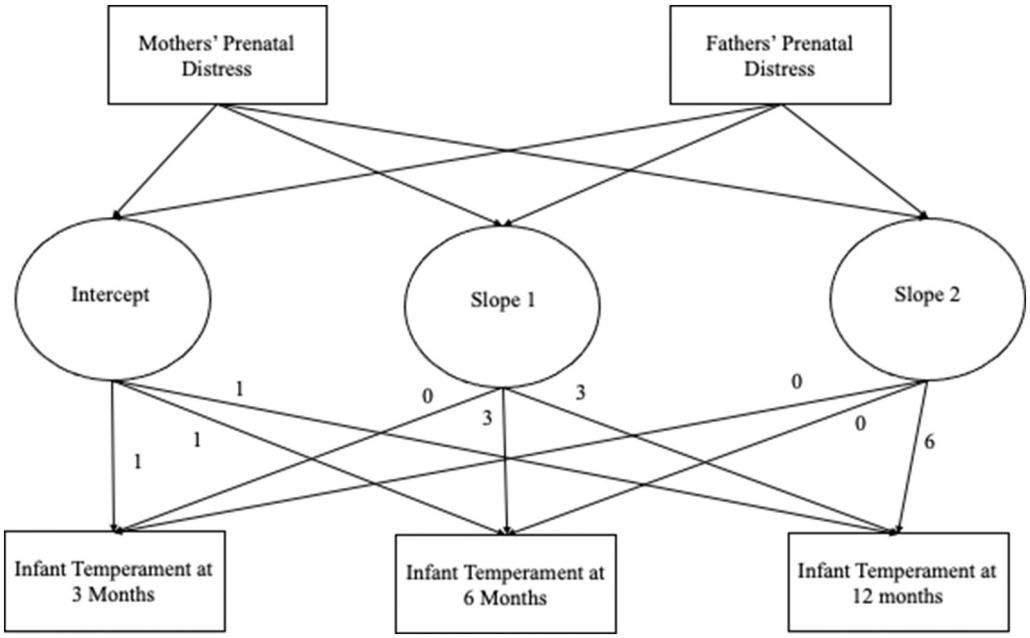

Fig. 2. Path Diagram Depicting Model for Mothers' and Fathers' Prenatal Distress Predicting Infant Temperament at 3-, 6-, and 12-Months of Age.

covariates and temperament scales are presented in Supplemental Table 2. Only covariates that were significantly associated with temperament scores at $p < .01$ were retained in later analyses.

3.2. Lifetime diagnoses

Results from the growth curve models evaluating mothers' and fathers' lifetime major depression and generalized anxiety as predictors of infant temperament development are presented in Table 2. All significant predictors had small effect sizes.

3.2.1. Mothers

Lifetime major depression in mothers was associated with lower *High Intensity Pleasure* ($\beta = -0.16$) and *Smiling* ($\beta = -0.13$), as well as greater *Sadness* ($\beta = 0.16$) at infant age 3 months. This diagnosis also predicted a greater increase in *High Intensity Pleasure* ($\beta = 0.14$) from 3 to 6 months of age. It did not significantly relate to infant regulatory capacity.

Lifetime generalized anxiety in mothers predicted lower *Cuddliness* ($\beta = -0.23$) and *Low Intensity Pleasure* ($\beta = -0.14$) at infant age 3 months. This diagnosis was also associated with lower *Falling Reactivity* (i.e., distress recovery; $\beta = -0.15$) at 3 months of age. It did not predict infant positive affectivity.

When confidence intervals constructed around mothers' lifetime major depression and lifetime generalized anxiety effect sizes were considered, these were overlapping, thus failing to indicate notable differences between diagnostic categories.

Table 1
Descriptive statistics – growth curve predictors.

Variables	N	Percentage meeting diagnostic criteria	Mean	SD	Range
Mental health predictors					
Lifetime mothers' major depression diagnosis (SCID[1])	234	70.9			
Lifetime mothers' generalized anxiety diagnosis (SCID)	234	29.5			
Lifetime fathers' major depression diagnosis (SCID)	142	23.3			
Lifetime fathers' generalized anxiety diagnosis (SCID)	142	6.3			
Mothers' prenatal depression severity (HRSD[2])	179		12.44	7.15	0 to 37
Mothers' prenatal anxiety severity (HRSA[3])	163		10.58	5.58	0 to 29
Fathers' prenatal depression severity (HRSD)	121		5.93	4.75	0 to 24
Fathers' prenatal anxiety severity (HRSA)	121		4.67	3.91	0 to 15
	N	Percentage	Mean	SD	Range
Demographic predictors					
Mothers' age	234		33.78	4.51	20.70 to 44.5
Fathers' age	202		35.86	6.10	20.70–58.30
Mothers' race (non-white)	234	11.5			
Fathers' race (non-white)	226	9.8			
	N	Percentage	Mean	SD	Range
Mothers' education (college)	234	97.0			
Fathers' education (college)	228	99.0			
Marital status (married)	234	88.5			
Prenatal antidepressant use (yes)	234	72.6			
Fetal age when baseline measures collected					
Prior to pregnancy	112	47.9	−60.32	49.48	−241.7 to −0.6
During pregnancy	122	52.1	14.31	14.21	0.3 to 34.0
Infant sex (male)	234	52.1			
Gestational age at birth in weeks	234		38.09	2.14	29 to 42
5-Minute Apgar score	221		8.71	0.75	5 to 10

[1] Structured Clinical Interview for DSM-IV Axis I Disorders.
[2] Hamilton rating scale for depression.
[3] Hamilton rating scale for anxiety.

3.2.2. Fathers

Lifetime major depression in fathers was associated with lower initial levels of *Cuddliness* ($\beta = -0.19$). It was also linked with a slower increase in *Fear* ($\beta = -0.31$) and a greater decrease in *Low Intensity Pleasure* from 6 to 12 months of age ($\beta = -0.28$). Fathers' lifetime depression did not predict infant positive affectivity.

Fathers' lifetime generalized anxiety was associated with a greater increase in *Perceptual Sensitivity* from 6 to 12 months of age ($\beta = 0.23$). This diagnosis also predicted a slower decrease in *Soothability* from 6 to 12 months of age ($\beta = 0.33$). It was not associated with infant negative emotionality.

Confidence intervals for fathers' lifetime major depression and lifetime generalized anxiety effect sizes were non-overlapping for *Fear* and *Soothability*, suggesting markedly differing effects with respect to change parameters associated with these attributes.

3.3. Distress severity

Results from the growth curve models evaluating mothers' and fathers' prenatal distress on infant temperament are presented in Table 3. All significant predictors were associated with small effect sizes.

3.3.1. Mothers

Greater prenatal distress in mothers predicted higher *Activity* ($\beta = 0.36$), *Vocal Reactivity* ($\beta = 0.21$), *Distress to Limitations* ($\beta = 0.26$), and *Fear* ($\beta = 0.25$) at infant age 3 months. Prenatal distress in mothers was not associated with infant regulatory capacity.

3.3.2. Fathers

Higher prenatal distress in fathers was associated with a greater increase in *Distress to Limitations* from 3 to 6 months of age ($\beta = 0.23$). Prenatal distress in fathers did not predict infant positive affectivity or regulatory capacity.

4. Discussion

The present study aimed to elucidate predictors of temperament development during infancy. More specifically, we extend the current literature as the first study to simultaneously examine the influence of both mothers' and fathers' depression and anxiety on infant temperament development. Given fathers have largely been excluded from temperament research, this study addresses an important gap in the literature and has implications for preventative efforts. We also considered both lifetime diagnosis and symptom severity to determine the potential value of distinguishing between these metrics, which has rarely been investigated for fathers.

Maternal lifetime diagnoses largely related to initial temperament levels at 3 months of age as opposed to trajectories across time, suggesting that mothers' influence on temperament occurs early in development and then wanes across infancy. The present study represents the first known investigation to demonstrate that lifetime diagnoses of major depression and generalized anxiety in mothers predict distinct temperament patterns during early infancy. These findings highlight the importance of examining the unique influence of these predictors on infant temperament to inform treatment recommendations and theories related to intergenerational transmission of risk. Underlying mechanisms explaining these differences should be explored further in future studies. Parenting practices represent one key candidate for mediation, as emotional regulation difficulties from prior episodes of depression or anxiety may persist into the perinatal period, impairing mother-infant interactions. Mothers with a history of depression may have fewer positive interactions with their offspring (Forbes et al., 2004), causing their infants to exhibit greater distress and fewer positive emotions. In contrast, women with lifetime anxiety may model anxious behaviors and engage in overprotective parenting practices that prevent the development of adaptive self-regulation in their infants (Kaitz and Maytal, 2005).

Only mothers' lifetime major depression was linked with infant temperament development, specifically greater increases in enjoyment of novel activities from 3 to 6 months of age. These findings indicate that infants born to mothers with a lifetime history of depression may initially experience non-optimal levels of positive emotionality but start

Table 2
Mothers' and fathers' lifetime depression and anxiety diagnoses.

Model	Intercept			Slope1[1]			Slope 2[2]		
	β	*p*	CI	β	*p*	CI	β	*p*	CI
Positive affectivity									
High Intensity Pleasure									
Lifetime mothers' major depression diagnosis	−0.16**	0.006	−0.28, −0.05	0.14*	0.02	0.02, 0.26	−0.01	0.90	−0.14, 0.12
Lifetime fathers' major depression diagnosis	−0.09	0.43	−0.32, 0.15	0.18	0.11	−0.05, 0.38	−0.10	0.41	−0.30, 0.16
Lifetime mothers' generalized anxiety diagnosis	−0.10	0.16	−0.23, 0.04	−0.02	0.83	−0.16, 0.12	0.15	0.10	−0.04, 0.32
Lifetime fathers' generalized anxiety diagnosis	−0.06	0.54	−0.26, 0.13	0.03	0.67	−0.11, 0.17	0.03	0.84	−0.23, 0.33
Apgar score	−0.02	0.79	−0.17, 0.14	0.006	0.94	−0.15, 0.17	0.20*	0.01	0.04, 0.33
Perceptual sensitivity									
Lifetime mothers' major depression diagnosis	0.03	0.73	−0.12, 0.16	0.04	0.64	−0.13, 0.19	−0.01	0.93	−0.17, 0.15
Lifetime fathers' major depression diagnosis	0.05	0.65	−0.15, 0.24	0.07	0.49	−0.14, 0.28	−0.11	0.34	−0.33, 0.13
Lifetime mothers' generalized anxiety diagnosis	−0.04	0.51	−0.17, 0.09	0.08	0.34	−0.08, 0.23	0.13	0.13	−0.04, 0.29
Lifetime fathers' generalized anxiety diagnosis	0.002	0.98	−0.18, 0.18	−0.10	0.18	−0.26, 0.04	0.23*	0.02	0.02, 0.40
Smiling/laughter									
Lifetime mothers' major depression diagnosis	−0.13*	0.04	−0.26, −0.01	0.12	0.07	−0.01, 0.25	0.03	0.67	−0.12, 0.18
Lifetime fathers' major depression diagnosis	0.03	0.78	−0.16, 0.21	−0.08	0.47	−0.29, 0.16	−0.08	0.46	−0.28, 0.13
Lifetime mothers' generalized anxiety diagnosis	−0.06	0.42	−0.20, 0.10	0.04	0.57	−0.11, 0.19	0.07	0.38	−0.09, 0.22
Lifetime fathers' generalized anxiety diagnosis	0.02	0.73	−0.10, 0.15	0.05	0.39	−0.07, 0.16	−0.01	0.95	−0.20, 0.19
Negative emotionality									
Falling reactivity									
Lifetime mothers' major depression diagnosis	−0.07	0.33	−0.21, 0.07	0.08	0.32	−0.07, 0.23	−0.08	0.28	−0.23, 0.07
Lifetime fathers' major depression diagnosis	0.03	0.74	−0.16, 0.21	0.06	0.56	−0.13, 0.26	−0.06	0.58	−0.27, 0.14

Model	Intercept			Slope 1[1]			Slope 2[2]		
	β	*p*	CI	β	*p*	CI	β	*p*	CI
Lifetime mothers' generalized anxiety diagnosis	−0.15*	0.04	−0.28, −0.01	0.002	0.97	−0.15, 0.14	0.07	0.39	−0.09, 0.23
Lifetime fathers' generalized anxiety diagnosis	0.02	0.84	−0.16, 0.18	−0.06	0.51	−0.25, 0.11	−0.06	0.64	−0.29, 0.17
Infant sex	−0.11	0.11	−0.25, 0.02	0.05	0.54	−0.11, 0.19	0.20*	0.01	0.04, 0.35
Fear									
Lifetime mothers' major depression diagnosis	0.08	0.22	−0.05, 0.19	0.03	0.67	−0.10, 0.16	−0.07	0.36	−0.24, 0.08
Lifetime fathers' major depression diagnosis	0.10	0.34	−0.11, 0.31	0.11	0.40	−0.15, 0.37	−0.31**	0.003	−0.50, −0.10
Lifetime mothers' generalized anxiety diagnosis	0.03	0.72	−0.11, 0.17	0.01	0.87	−0.13, 0.16	−0.13	0.06	−0.27, 0.01
Lifetime fathers' generalized anxiety diagnosis	−0.02	0.80	−0.13, 0.15	0.03	0.78	−0.12, 0.26	0.08	0.27	−0.05, 0.23
Gestational age at birth	−0.13	0.10	−0.30, 0.02	0.16*	0.03	0.02, 0.31	−0.05	0.60	−0.21, 0.13
Sadness									
Lifetime mothers' major depression diagnosis	0.16*	0.01	0.04, 0.28	−0.07	0.33	−0.21, 0.06	0.01	0.95	−0.15, 0.17
Lifetime fathers' major depression diagnosis	−0.08	0.44	−0.27, 0.13	0.02	0.89	−0.20, 0.25	−0.09	0.45	−0.34, 0.15
Lifetime mothers' generalized anxiety diagnosis	0.06	0.42	−0.08, 0.20	−0.004	0.96	−0.17, 0.15	−0.04	0.68	−0.20, 0.14
Lifetime fathers' generalized anxiety diagnosis	0.004	0.97	−0.20, 0.23	0.03	0.74	−0.14, 0.17	0.07	0.40	−0.08, 0.22
Mothers' race	0.06	0.44	−0.01, 0.22	0.01	0.95	−0.20, 0.18	−0.19*	0.01	−0.34, −0.06
Regulatory capacity									
Cuddliness									
Lifetime mothers' major depression diagnosis	−0.07	0.28	−0.19, 0.06	−0.03	0.68	−0.17, 0.12	0.02	0.81	−0.13, 0.17
Lifetime fathers' major depression diagnosis	−0.19*	0.03	−0.38, −0.04	0.07	0.53	−0.14, 0.29	0.02	0.87	−0.21, 0.25
Lifetime mothers' generalized anxiety diagnosis	−0.23***	<0.001	−0.35, −0.10	0.02	0.85	−0.13, 0.17	0.14	0.06	0.00, 0.28
Lifetime fathers' generalized anxiety diagnosis	0.003	0.98	−0.21, 0.18	0.10	0.16	−0.03, 0.25	0.11	0.35	−0.14, 0.33
Mothers' education	0.17	0.12	−0.04, 0.39	−0.15	0.05	−0.29, −0.01	−0.18**	0.004	−0.34, −0.07

Model	Intercept			Slope 1[1]			Slope 2[2]		
	β	*p*	CI	β	*p*	CI	β	*p*	CI
Low intensity pleasure									
Lifetime mothers' major depression diagnosis	−0.11	0.09	−0.22, 0.02	0.10	0.16	−0.04, 0.24	−0.12	0.10	−0.26, 0.03
Lifetime fathers' major depression diagnosis	0.01	0.95	−0.20, 0.22	0.10	0.31	−0.10, 0.30	−0.28*	0.01	−0.48, −0.04
Lifetime mothers' generalized anxiety diagnosis	−0.14*	0.04	−0.27, 0.00	0.05	0.55	−0.11, 0.19	0.06	0.46	−0.10, 0.21
Lifetime fathers' generalized anxiety diagnosis	0.05	0.52	−0.10, 0.19	−0.07	0.47	−0.26, 0.11	0.13	0.21	−0.05, 0.36
Mothers' education	−0.004	0.97	−0.18, 0.18	−0.12	0.13	−0.28, 0.04	0.07	0.07	0.00, 0.15
Soothability									
Lifetime mothers' major depression diagnosis	0.01	0.93	−0.11, 0.13	−0.09	0.20	−0.22, 0.05	−0.03	0.70	−0.16, 0.12
Lifetime fathers' major depression diagnosis	0.07	0.51	−0.16, 0.27	−0.04	0.74	−0.23, 0.19	−0.21	0.051	−0.42, −0.002
Lifetime mothers' generalized anxiety diagnosis	−0.05	0.45	−0.18, 0.08	0.10	0.19	−0.05, 0.25	−0.08	0.30	−0.23, 0.07
Lifetime fathers' generalized anxiety diagnosis	−0.s02	0.76	−0.17, 0.14	−0.12	0.20	−0.29, 0.06	0.33**	0.002	0.08, 0.51

Note. The following covariates were included in each model if significantly related to the outcome: prenatal antidepressant use, mothers' race, mothers' education, mothers' age, marital status, infant sex, gestational age at birth, and Apgar score at 5 min. Only models where lifetime diagnoses significantly predicted temperament scores are presented.
[1] Slope 1 = 3–6 months.
[2] Slope 2 = 6–12 months.
[*] $p < .05$.
[**] $p < .01$.
[***] $p < .001$.

Table 3
Mothers' and Fathers' Prenatal Distress Severity.

Model	Intercept			Slope[1]			Slope[2]		
	β	*p*	CI	β	*p*	CI	β	*p*	CI
Positive affectivity									
Activity									
Mothers' prenatal distress	0.36***	<0.001	0.18, 0.56	−0.10	0.28	−0.29, 0.09	−0.01	0.95	−0.25, 0.23
Fathers' prenatal distress	−0.004	0.97	−0.23, 0.19	0.01	0.91	−0.23, 0.23	0.02	0.90	−0.26, 0.26
Prenatal antidepressant use	0.06	0.36	−0.08, 0.19	−0.09	0.27	−0.24, 0.07	0.20**	0.009	0.04, 0.35
Fetal age at baseline visit	−0.22*	0.04	−0.42, −0.02	0.08	0.35	−0.08, 0.25	−0.04	0.68	−0.22, 0.15
Vocal reactivity									
Mothers' prenatal distress	0.21*	0.02	0.04, 0.40	−0.17	0.07	−0.37, 0.01	0.04	0.67	−0.16, 0.22
Fathers' prenatal distress	−0.01	0.88	−0.20, 0.17	−0.002	0.99	−0.23, 0.23	0.10	0.45	−0.15, 0.35
Mothers' age	−0.24**	0.001	−0.38, −0.10	0.06	0.39	−0.07, 0.21	0.05	0.59	−0.12, 0.21
Marital status	0.11	0.16	−0.03, 0.27	−0.04	0.61	−0.19, 0.11	−0.24**	0.002	−0.40, −0.09
Fetal age at baseline visit	−0.21*	0.01	−0.38, −0.05	0.01	0.96	−0.18, 0.18	−0.05	0.61	−0.23, 0.13
Negative emotionality									
Distress to limitations									
Mothers' prenatal distress	0.26**	0.007	0.07, 0.44	0.002	0.99	−0.20, 0.19	0.001	0.99	−0.20, 0.19
Fathers' prenatal distress	−0.03	0.74	−0.22, 0.16	0.23*	0.04	−0.004, 0.43	−0.14	0.34	−0.41, 0.15
Fetal age at baseline visit	−0.10	0.25	−0.28, 0.07	−0.06	0.50	−0.23, 0.11	0.17	0.17	−0.09, 0.41
Fear									
Mothers' prenatal distress	0.25*	0.01	0.06, 0.44	−0.08	0.46	−0.27, 0.12	−0.08	0.47	−0.32, 0.14
Fathers' prenatal distress	−0.03	0.74	−0.20, 0.16	0.22	0.18	−0.14, 0.52	−0.09	0.52	−0.33, 0.17
Gestational age at birth	−0.11	0.13	−0.27, 0.03	0.15*	0.03	0.02, 0.29	−0.03	0.73	−0.20, 0.15
Fetal age at baseline visit	−0.03	0.64	−0.18, 0.09	−0.10	0.23	−0.26, 0.06	0.07	0.57	−0.16, 0.31

Note. The following covariates were included in each model if significantly related to the outcome: prenatal antidepressant use, mothers' race, mothers' education, mothers' age, marital status, infant sex, gestational age at birth, and Apgar score at 5 min. Only models where prenatal distress severity significantly predicted temperament scores are presented.
[1] Slope 1 = 3–6 months.
[2] Slope 2 = 6–12 months.
[*] $p < .05$.
[**] $p < .01$.
[***] $p < .001$.

to reach expected milestones by mid-infancy. Our results build on previous research by Campbell et al. (1995) who similarly found increased positive affect during the first 6 months of life among infants exposed to postpartum depression. This profile suggests infants of mothers with depression may demonstrate resilience in certain aspects of temperament development that could protect them against later adversity. This developmental pattern may also represent a compensatory mechanism with respect to primary caregivers, wherein infants whose mothers demonstrate limited positive affect increase in their expression of positive emotion over time to increase engagement with their caregivers.

Patterns of associations differed between mothers and fathers for the lifetime diagnoses, underscoring the importance of simultaneously examining the influence of both parents' mental health on infant temperament development. Compared to mothers, paternal lifetime diagnoses had more associations with non-optimal temperament trajectories across infancy, suggesting fathers play a more salient role later in development, perhaps due to having greater caretaking responsibilities during this time (Fisher et al., 2021). Paternal lifetime major depression was suggested to influence infant socioemotional functioning through parenting interactions. For example, fathers with a history of depression were shown to display impaired emotional expression during face to face interactions, including more neutral and less positive affect, which their infants may subsequently mirror (Aktar et al., 2017). This interactional style could explain why infants born to fathers with lifetime depression in the present study similarly displayed temperament profiles characterized by greater neutral affect from mid to late infancy.

Paternal lifetime generalized anxiety was associated with unique temperament patterns after controlling for history of depression, suggesting that it is also warranted to explore these diagnoses separately in fathers. Infants born to fathers with a history of anxiety were reported to display heightened sensitivity to environmental stimuli from 6 to 12 months of age, which may serve as a genetic marker for subsequent anxiety (Kozlova et al., 2020). Parent-child interactions may further explain these findings, as infants exposed to fathers with lifetime anxiety displayed increased gaze to caregivers, making them more likely to observe their parents using maladaptive coping strategies in response to stressors (Aktar et al., 2017). Repeated exposure to these situations may serve to subsequently increase infants' own vigilance to environmental stimuli. Fathers' lifetime anxiety also predicted infants' slower reduction of distress in response to soothing techniques from caregivers during mid to late infancy. Anxious parents may maintain proximity with their infant, inadvertently preventing them from developing more independent self-soothing strategies (Gartstein and Hancock, 2019).

Our findings indicate that lifetime diagnosis and symptom severity have differing associations with temperament development across

infancy for both mothers and fathers, suggesting that they may operate via discrete mechanisms that should be examined further in future studies. For each parent, lifetime diagnoses were associated with a wider range of non-optimal temperament outcomes relative to prenatal symptom levels. This could be related to lifetime diagnosis representing a more chronic and impairing condition relative to prenatal symptom severity. Emerging research also suggests that mental health diagnoses prior to conception may alter parental gametes (Mitchell et al., 2016; Rodgers et al., 2015), resulting in epigenetic changes after fertilization that could have long-lasting impacts for offspring socioemotional development.

Although the present study contributes to our understanding of infant temperament development, several limitations are noted. First, temperament was assessed using a parent-report measure, which could have introduced bias, as mothers with elevated depression or anxiety symptoms may have rated their infants differently than those without these risk factors. The IBQ-R also demonstrates high convergent validity with laboratory-based observations of temperament (Gartstein and Bateman, 2008; Gartstein and Marmion, 2008). Future research should include an observational assessment of temperament to provide a more comprehensive picture of the infants' functioning. Second, there was variability in when parents' mental health measures were collected prior to birth, which we controlled for in the present analyses. Previous studies have demonstrated that depression and anxiety tend to be relatively stable across the perinatal period, suggesting that there may not be significant variability in symptomatology prior to birth (Gustafsson et al., 2021; Kee et al., 2021). Third, our sample largely consisted of college-educated, married participants who may have been buffered from life stressors that could adversely influence temperament development (Campbell et al., 2020). Although these sample characteristics facilitate interpreting our findings as being due to depression and anxiety relative to socio-demographic risks, replication with parents experiencing elevated socio-demographic risks is needed to determine whether these findings generalize to more diverse samples.

The present study also oversampled for women with previous episodes of depression and anxiety, resulting in a high percentage of mothers with these diagnoses during the preconception period. Therefore, our findings may not generalize to community samples of women with lower rates of these conditions. Given knowledge of assortative mating and the stressors associated with being the partner of an individual with depression or anxiety (Joutsenniemi et al., 2011; Mathews and Reus, 2001), the findings also may not generalize to community samples of fathers. Fourth, paternal depression and anxiety were only measured prior to birth. However, given many parents with depression and anxiety prior to birth continue to experience symptoms during the postpartum period, we expected these measures and related effects to be relatively stable across the perinatal period (Heron et al., 2004). Moreover, consenting and non-consenting fathers differed on infant activity levels at 6 months, suggesting that differences between these two groups may have influenced this temperament outcome. Our null findings for infant activity level at 6 months should therefore be interpreted with caution. Finally, the current analyses did not include parental psychopathology concurrent with the temperament time points, preventing us from examining between- versus within dyad associations. Repeated measures of parental psychopathology are needed to tease these associations apart.

Despite these limitations, our findings have important implications for providers as well as researchers. In particular, the current study suggests fathers would benefit from being screened for depression and anxiety as part of prenatal appointments and offered feasible, evidence-based treatment options. Although the American College of Obstetricians and Gynecologists currently recommends routine screenings for women during pregnancy, formal guidelines do not exist for their partners. Given that fathers appear to uniquely influence infant temperament development after controlling for mothers' symptoms, it is important to provide them with viable treatment options during the perinatal period. However, the current study suggests that mental health treatment during the prenatal period alone may not be sufficient to reduce the risk of adversity in offspring. Mental health screening should also routinely occur during the preconception period to identify individuals at an early age who may benefit from resources. Moreover, the results from this study can be used to inform early intervention and prevention programs to maximize development in infants born to parents with depression or anxiety prior to birth. Our study indicates that lifetime diagnoses and elevated symptom severities should be considered as risk factors for non-optimal temperament profiles during infancy, which previous research suggests may increase the risk of later emotional and behavioral difficulties. Pediatricians could closely monitor infants from this population during well child visits to determine whether they may benefit from resources such as more targeted parenting interventions. More long-term longitudinal research with follow-ups beyond infancy is also needed as recent studies suggest maternal psychopathology does not appear to significantly impact parent-report measures of emotional and behavioral problems during early and middle childhood (Olino et al., 2020, 2021). It would be useful to identify precise timing of potentially diminished risk and possible moderators.

In conclusion, the current study used a longitudinal, prospective design to demonstrate that mothers and fathers uniquely influence temperament development across infancy. Mothers' depression and anxiety measured prior to birth primarily predicted initial levels of temperament at 3 months. In fathers, these diagnoses were largely associated with developmental shifts in temperament across the first year of life. Lifetime diagnoses and symptom severities also predicted distinct trajectories, making it important to consider both metrics. These findings highlight the importance of considering the potential role of both mothers' and fathers' mental health on socioemotional development during early childhood. Additional research is needed to elucidate mechanisms underlying these associations. Temperament development relates to critical distal outcomes such as emerging symptoms of psychopathology, making it critical to study further to inform more effective interventions.

Contributors

Sherryl Goodman, Zachary Stowe, D. Jeffrey Newport, and Bettina Knight designed the larger study and participated in data collection. Jennifer Mattera, Sherryl Goodman, Allegra Campagna, and Maria Gartstein contributed to conceptualizing the present study. Jennifer Mattera undertook the statistical analysis and wrote the first draft of the manuscript. Gregory Hancock consulted on the statistical analyses. All authors contributed to and have approved the final manuscript.

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Declaration of competing interest

Ms. Knight's adult son works for Glaxo Smith Kline and has GSK stock options as part of his employment. Dr. Newport has received research support from Eli Lilly, Glaxo SmithKline (GSK), Janssen, the National Alliance for Research on Schizophrenia and Depression (NARSAD), the National Institutes of Health (NIH), Sage Therapeutics, Takeda Pharmaceuticals, the Texas Health & Human Services Commission, and Wyeth. He has served on speakers' bureaus and/or received honoraria from Astra-Zeneca, Eli Lilly, GSK, Pfizer and Wyeth. He has served on advisory boards for GSK, Janssen, and Sage Therapeutics. He

has served as a consultant to Sage Therapeutics. Neither he nor family members have ever held equity positions in biomedical or pharmaceutical corporations.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2023.09.023.

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