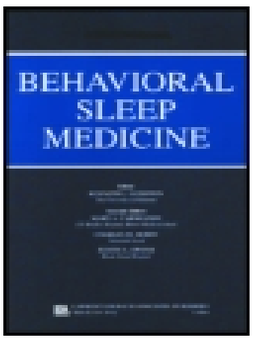

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Maternal Prenatal Depressive Symptoms and Infant Sleep Problems: The Role of Infant Temperament and Sex

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ABSTRACT

Objectives: We aimed to analyze whether (1) infant temperament mediates the impact of maternal prenatal depressive symptoms on infant sleep problems and (2) the mediation role of infant temperament was moderated by the infant's sex.

Methods: The sample was comprised of 172 mother-infant dyads. Mothers completed self-reported measures of prenatal and postnatal depressive symptoms, infant temperament (negative affectivity, surgency/extraversion, and orienting regulation), and sleep problems.

Results: While controlling for maternal postnatal depressive symptoms, our results revealed that (1) infant negative affectivity at two weeks partially mediated the impact of maternal prenatal depressive symptoms on sleep anxiety at six months, and (2) this mediation is independent of the infant's sex.

Conclusions: Our findings provided evidence that negative affectivity can be an early specific marker of sleep anxiety and can partially explain the negative impact of maternal prenatal depressive symptoms on further sleep problems in the infant.

Introduction

The study of sleep during infancy is crucial, as sleep problems may compromise infant further development and family functioning. Infant sleep problems are associated with lower social and cognitive development during preschool age (e.g., difficulties in preschool adjustment; Vaughn et al., 2015), and with more behavioral (e.g., externalizing problems and attention-deficit hyperactivity disorder) and emotional problems (e.g., internalizing problems) during childhood (Hemmi et al., 2011; Sivertsen et al., 2015). Moreover, sleep problems tend to persist across child development (Byars et al., 2012; Meltzer et al., 2014; Williams et al., 2017). Although sleep problems tend to decrease during infancy, they persist from infancy to early childhood in 21% of children (Byars et al., 2012), which can put them at higher risk to present sleep problems in later childhood (Meltzer et al., 2014; Williams et al., 2017). Infant sleep problems are also associated with poorer family functioning (El-Sheikh & Kelly, 2017), namely with poorer sleep quality (Kouros & El□Sheikh, 2017; Piteo et al., 2013; Sharkey et al., 2016), increased fatigue in the mothers (Dennis & Ross, 2005), more parental depressive symptoms (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017), and lower marital quality (Rhoades et al., 2012; Stores, 2009).

Maternal prenatal depressive symptoms are consistently associated with infant sleep problems (Gerardin et al., 2011; Martini et al., 2017; Nevarez et al., 2010). Infants whose mothers have more prenatal depressive symptoms sleep fewer hours, have lower sleep efficiency, have more night wakings

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(Armitage et al., 2009; Nevarez et al., 2010), and present increased difficulties in initiating or maintaining sleep (Field et al., 2007; Gerardin et al., 2011; Martini et al., 2017).

Fetal programming theory (FPT; Barker, 2004; Glover, 2011; Glover et al., 2018) is an important framework to understand the impact of maternal prenatal depressive symptoms on infant development. FPT argues that exposure to an adverse prenatal event (e.g., maternal prenatal depressive symptoms) may lead to a reprogrammation of the fetus and to long-term consequences on infant development and health (Barker, 2004; Glover, 2011), namely the emergence of sleep problems. The biological changes occurring in embryotic and fetal environments related to depressive symptoms may negatively interfere with infant development throughout the lifespan, particularly when occurring in sensitive stages of fetal development (Barker, 2004; Glover, 2011; Gustafsson et al., 2018). Sex differences in fetal programming are reported, with boys and girls presenting different outcomes after exposure to a prenatal adverse environment (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). When exposed to a prenatal adverse environment, male fetuses can present more negative developmental outcomes than female fetuses (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018).

Differential susceptibility theory (DST; Belsky et al., 2007; Belsky & Pluess, 2009) can contribute to explain these differences. It postulates that infants are differently susceptible to the exposure to either positive or negative environments, with more consequences to their further development. Particularly, the sex of the infant can be a marker of differential susceptibility to the impact of maternal prenatal depressive symptoms on infant sleep problems (Netsi et al., 2015). The negative impact of maternal prenatal depressive symptoms on infant sleep problems seems to be higher in boys (Dias & Figueiredo, 2020; Netsi et al., 2015).

Literature also provides evidence that exposure to a prenatal adverse environment is differently associated with boys' and girls' temperament (Sutherland & Brunwasser, 2018). Temperament refers to the behavioral expression of individual reactivity and self-regulation (Rothbart et al., 2011), comprising three major dimensions (1) surgency/extraversion (e.g., approach and vocal reactivity), (2) negative affectivity (e.g., fear and sadness), and (3) orienting regulation (e.g., duration of orienting and soothability (Gartstein & Rothbart, 2003). Maternal prenatal stress is associated with more irritable temperament in boys, but not in girls (Simcock et al., 2017). In a previous study, boys with a more difficult temperament at six months and who were exposed to maternal prenatal depressive symptoms presented more sleep problems at 18–24 months (Netsi et al., 2015). Infant temperament is also associated with both infant sex and sleep problems (Blair et al., 2012; Kaley et al., 2012; Netsi et al., 2015; Sorondo & Reeb-Sutherland, 2015). More recently, a study reported that infant temperament (particularly infant negative affectivity) mediates the association between maternal prenatal depressive symptoms and infant sleep problems at two years old (Kim et al., 2020). Thus, our hypothesis is that analyzing early in infant development the temperament characteristics of boys may help to explain their higher vulnerability to the impact of maternal prenatal depressive symptoms on sleep problems. Our study can contribute to advance the knowledge on this hypothesis by analyzing (1) infant temperament early after birth as a mediator in the impact of maternal prenatal depressive symptoms on sleep problems and (2) if this impact is higher in boys than in girls. Thus, our aims are to analyze whether (1) infant temperament mediates the impact of maternal prenatal depressive symptoms on infant sleep problems and (2) the mediation role of infant temperament is moderated by the infant's sex.

Method

Procedures

We contacted the Ethical Commissions of two public hospitals in the Northern Portugal and, after their approval, we contacted 536 women at the third pregnancy trimester who met the inclusion criteria. We excluded from the study women not reading or writing Portuguese, with multiple

gestations, gestational complications, or with psychiatric medication intake, aiming to avoid potential obstetric and psychiatric confounders. Pregnant women were about the study's purposes and procedures and invited to participate. Four hundred and eighty-five pregnant women agreed to participate in the study and signed an informed consent form. At the third pregnancy trimester, mothers completed self-reported measures of their socio-demographic characteristics and depressive symptoms. At two weeks postpartum, mothers were contacted by e-mail to complete online self-reported measures of infant socio-demographic and biometric characteristics and delivery information, and of infant temperament. Mothers were contacted again by e-mail at six months postpartum (M = 24.35 weeks, SD = 6.21) to complete online self-reported measures of depressive symptoms and infant sleep problems. We included in the study only infants born at term and with normal birth weight. Of the 485 mothers who completed measures at the third pregnancy trimester, 203 completed the measures at two weeks, and 268 mothers completed the online measures at six months. We included in the analyses women that completed all the measures at all the assessment waves (n = 172).

Measures

Socio-demographic characteristics. We used a Socio-demographic Questionnaire to collect maternal demographic (age, ethnicity, marital status, occupational status, socio-economic level, years of schooling) and obstetric data (type of delivery), and infant socio-demographic (sex, birth order) and biometric data (resuscitation at birth, birth weight, birth length). We measured socio-economic level with the Graffar scale (Graffar, 1956) Scale of Professional Classification using three levels: high, medium, and low.

Maternal prenatal and postnatal depressive symptoms. We used the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) to assess maternal prenatal and postnatal depressive symptoms. The EPDS is a self-report instrument used to assess depressive symptoms within the previous seven days. It includes 10 items scored on a 4-point Likert-type scale. The EPDS is widely used and its validity to screen both maternal prenatal and postnatal depressive symptoms is demonstrated in previous studies (e.g., Korhonen et al., 2012; Ogbo et al., 2018; Waldie et al., 2015), including in Portuguese samples (Figueiredo & Conde, 2011b; Figueiredo et al., 2017; Tendais et al., 2014). A cutoff of 10 is optimal to screen for maternal prenatal and postnatal depression (Areias et al., 1996; Figueiredo & Conde, 2011a). The EPDS showed good internal consistency in our sample when applied during pregnancy (ω = .86) and during the postpartum period (ω = .84).

Infant temperament. We used the Infant Behavior Questionnaire-Revised (IBQ-R; Gartstein & Rothbart, 2003) assess infant temperament. This instrument is comprised of 191 items scored on a 7-point Likert-type scale, where parents report their infants' temperament characteristics. It was designed to assess temperament in infants aged between 3 and 12 months (Gartstein & Rothbart, 2003) and is comprised of 14 scales of temperament (activity level, approach, cuddliness, distress to limitations, duration of orienting, falling and reactivity, fear, high intensity pleasure, low intensity pleasure, perceptual sensitivity, sadness, smiling and laughter, soothability, and vocal reactivity), computed in three dimensions: (1) surgency/extraversion, (2) negative affectivity and (3) orienting regulation. The Portuguese version of the IBQ-R has good internal consistency and construct validity (Costa & Figueiredo, 2018), even when the IBQ-R was applied to infants aged two weeks (Dias et al., 2021). In the adaptation and validation of the IBQ-R for infants with two weeks (Dias et al., 2021), the three dimensions of the IBQ-R presented adequate internal consistency and the factor structure remain stable across the different ages (Dias et al., 2021). In our study, the IBQ-R dimensions showed acceptable to good internal consistency (ω's ranging between .59 and .70), similar to the internal consistency found in previous studies (Costa & Figueiredo, 2018; De Lauzon-Guillain et al., 2012).

Infant sleep problems. We used the Children's Sleep Habits Questionnaire – Infant Version (CSHQ-I; Dias et al., 2018a) to assess infant sleep problems. This instrument is an adapted version of the Children's Sleep Habits Questionnaire – CSHQ (Owens et al., 2000), administered to the parents in Portuguese language. The CSHQ-I is a retrospective questionnaire used for

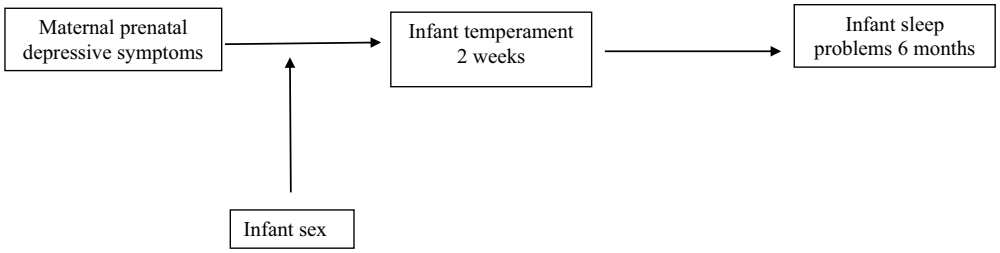


Figure 1. Proposed conceptual diagram of the moderated mediation model.

parents to report their infants' sleep habits and behaviors within a typical week across 33 items that are scored on a 3-point Likert-type scale. The CSHQ-I is comprised of 4 subscales: (1) bedtime resistance: the infant resistance to go to bed and recurrent night waking; (2) sleep anxiety: the infant anxiety related to sleep, sleep-disordered breathing, and parasomnias; (3) positive sleep habits: infant bedtime and morning waking routines; and (4) daytime sleepiness: the diurnal consequences from sleep problems. The scores of the CSHQ-I total scale and subscales are obtained by computing the mean of the items (scores ranging from 0 to 2). Higher scores in the CSHQ-I are indicative of more sleep problems. The CSHQ-I total scale and subscales have adequate internal consistency (Dias et al., 2018a). We followed the guidelines of the validation version for the administration of the CSHQ-I items (Dias et al., 2018a). In our study, the CSHQ-I total scale (ω = .81) and the subscales bedtime resistance (ω = .78) and sleep anxiety (ω = .70) presented good internal consistency. The positive sleep habits and daytime sleepiness subscales presented poor values of internal consistency. Thus, we do not include them in the analyses.

Statistical analysis

We first performed preliminary analyses on the study variables. We tested two mediation models using structural equation modeling (SEM) to analyze (1) whether infant temperament mediates the impact of maternal prenatal depressive symptoms on infant sleep problems. We included maternal prenatal depressive symptoms as an independent (exogenous) variable, infant temperament at two weeks as a mediator variable, and infant sleep problems (CSHQ-I total score at model 1 and bedtime resistance and sleep anxiety at model 2) at six months as dependent (endogenous) variables.

We tested two mediated moderation models using SEM (please see, Figure 1) to analyze (2) whether the mediation role of infant temperament was moderated by the infant's sex, We included maternal prenatal depressive symptoms, the infant's sex, and the interaction between them as independent (exogenous) variables, infant temperament at two weeks as the mediator variable, and infant sleep problems (CSHQ-I total score at model 1 and sleep anxiety at model 2) at six months as dependent (endogenous) variables. We tested the indirect effects with a bias correction of the confidence intervals: number of bootstrapped samples = 1000; Bias corrected confidence intervals = 95.

Maternal depressive symptoms at six months postpartum were included in the models to control their impact on the studied variables. Parity and maternal occupational status were also added as covariates in the tested models, as they were associated with the study variables. We performed the statistical analysis using SPSS and SPSS AMOS 26. Good model fit was considered according to the examination of indices of different classes: a non-significant chi-square (χ^2), Comparative Fit Index (CFI) ≥. 95, and Root Mean Square Error of approximation (RMSEA) < .05 (Kline, 2005).

Results

Participants' characteristics

The sample comprised 172 mother-infant dyads. Half of the infants were boys (50.0%). Most mothers were white (91.0%), married or cohabiting (81.8%), and employed (78.9%). More than half were aged between 25 and 34 years old (66.9%), had 12 or more years of schooling (64.3%), and belonged to a high socio-economic level (59.8%; assessed with the Graffar scale). Most infants were not resuscitated at birth (92.4%), had normal birth length ≥ 48 cm (77.9%), and were first born (88.4%). More than half were born by vaginal delivery (66.9%). There were no significant differences in the socio-demographic variables between boys and girls (see, Table 1).

We did not find differences between the analytic sample (n = 172) and the excluded participants (n = 313) on maternal age, ethnicity, marital status, occupational status, socio-economic level, years of schooling, type of delivery, infant resuscitation at birth, birth length and infant's sex, maternal prenatal depressive symptoms, infant temperament, and infant sleep problems. We found significant differences on parity, [$x^2(1) = 6.16$, $p = .013$]. The analytic sample was comprised of 88.4% of primiparous women while the excluded sample was comprised of 60.6% of primiparous women. Primiparous women were more likely to complete all the study measures.

Table 2 presents means and standard deviations of maternal prenatal depressive symptoms, infant temperament, and sleep problems for boys and girls. There were no differences between boys and girls in maternal prenatal depressive symptoms, infant temperament, and sleep problems, with the exception of orienting regulation at two weeks, [$F(1,170) = 4.55$, $p = .039$]. Boys presented more orienting regulation at two weeks than girls.

Table 2 also presents correlations between maternal prenatal depressive symptoms, infant temperament, and sleep problems. Infant negative affectivity at two weeks was significantly associated with

Table 1. Socio-demographic characteristics.

			Total	Boys	Girls	
			N = 172 %	*n = 86* %	*n = 86* %	x^2
Mother	Age	18–24	12.2	14.4	10.5	0.76
		25–34	66.9	64.5	69.8	
		35–44	20.9	22.1	19.8	
	Ethnicity	White	91.0	91.8	90.1	0.14
		Other	9.0	8.2	9.9	
	Marital status	Married/cohabiting	81.8	85.9	77.6	1.93
		Single/divorced/widow	18.2	14.1	22.4	
	Occupational status	Employed	78.9	79.1	78.8	0.00
		Unemployed/Household/student	21.1	20.9	21.2	
	Socio-economic level	High	59.8	65.2	54.1	1.61
		Medium	31.5	27.3	36.1	
		Low	8.7	7.6	9.8	
	Years of schooling	≤12	35.7	35.3	36.0	0.01
		>12	64.3	64.7	64.0	
Gestation	Resuscitation at birth	No	92.4	91.9	93.0	0.08
		Yes	7.6	8.1	7.0	
	Type of delivery	Vaginal	66.9	69.8	64.0	0.66
		Cesarean	33.1	30.2	36.0	
Infant	Length	< 48 cm	22.1	19.8	24.4	0.54
		≥ 48 cm	77.9	80.2	75.6	
	Birth order	First born	88.4	91.9	84.9	2.04
		Non-first born	11.6	8.1	15.1	
	Primary caregiver	Mother	97.6	97.7	97.5	0.00
		Other	2.4	2.3	2.5	
	Feeding method at 6 months	Exclusive breastfeeding	17.6	20.8	14.3	
		Partial breastfeeding	52.8	54.2	51.3	1.95
		Exclusive artificial feeding	29.6	25.0	34.3	

Table 2. Study's variables' means and standard deviations.

	3rd trimester *M (SD)*			2 weeks *M (SD)*			6 months *M (SD)*		
	Boys	Girls	*F*	Boys	Girls	*F*	Boys	Girls	*F*
Maternal depressive symptoms	7.20 (4.50)	6.84 (4.38)	0.51				5.03 (3.77)	4.71 (3.83)	0.56
Surgency/extraversion				3.15 (0.84)	3.03 (0.86)	0.92			
Negative affectivity				2.84 (0.70)	2.87 (0.79)	0.07			
Orienting regulation				4.56 (1.04)	4.22 (1.00)	4.55*			
Bedtime resistance							0.67 (0.42)	0.67 (0.41)	0.00
Sleep anxiety							0.14 (0.21)	0.17 (0.20)	0.76
CSHQ-I total score							0.41 (0.22)	0.40 (0.21)	0.12
	(1)	(2)	(3)	(4)	(5)	(6)			
(1) Maternal prenatal depressive symptoms									
(2) Surgency/extraversion 2 weeks	.083								
(3) Negative affectivity 2 weeks	.307***	.261***							
(4) Orienting regulation 2 weeks	.015	.444***	−.030						
(5) Bedtime resistance 6 months	.072	−.050	.318***	−.167*					
(6) Sleep anxiety 6 months	.313***	.095	.284***	−.100	.368***				
(7) CSHQ-I total score 6 months	.191**	−.010	.360***	−.165*	.905***	.610***			

M = Mean; *SD* = Standard Deviation; * $p < .05$; ** $p < .01$; *** $p < .001$

both maternal prenatal depressive symptoms and infant sleep problems at six months (all $p < .001$). There were no correlations between the remaining infant temperament characteristics (surgency/extraversion and orienting regulation) at two weeks and both maternal prenatal depressive symptoms and infant sleep problems at six months. Thus, we tested only infant negative affectivity at two weeks as a mediator in the models.

In the present sample, 26.7% of the mothers were above the cutoff (EPDS ≥ 10) for depression at the third pregnancy trimester and 9.9% at six months postpartum. Of the 26.7% prenatally depressed mothers at the third pregnancy trimester, 26.1% were still depressed at six months postpartum. We found significant associations between parity and maternal prenatal depressive symptoms, [*Wald* = 3.26, $\beta = 4.21$, OR = 1.30, $p = .001$]. Multiparous women were more likely to present higher prenatal depressive symptoms. We also found significant associations between maternal occupational status and infant negative affectivity, [*Wald* = 0.25, $\beta = 1.08$, OR = 0.39, $p = .007$] (please see, Table 1). Employed mothers were more likely to report lower negative affectivity on their infants. Therefore, we added parity and maternal occupational status in the tested models. We found no associations between the remaining socio-demographic and biometric variables of mothers and infants and the study variables.

The mediation role of infant temperament in the impact of maternal prenatal depressive symptoms on infant sleep problems

CSHQ-I total score

Total links: Maternal prenatal depressive symptoms did not predict infant CSHQ-I total score at six months, $\beta = .01$, $p = .087$. Total and indirect links: After linking maternal prenatal depressive symptoms to infant negative affectivity and infant negative affectivity to the CSHQ-I total score, the model indicated that maternal prenatal depressive symptoms significantly predicted more infant negative affectivity at two weeks, $\beta = .05$, $p < .001$ (path a) and infant negative affectivity at two

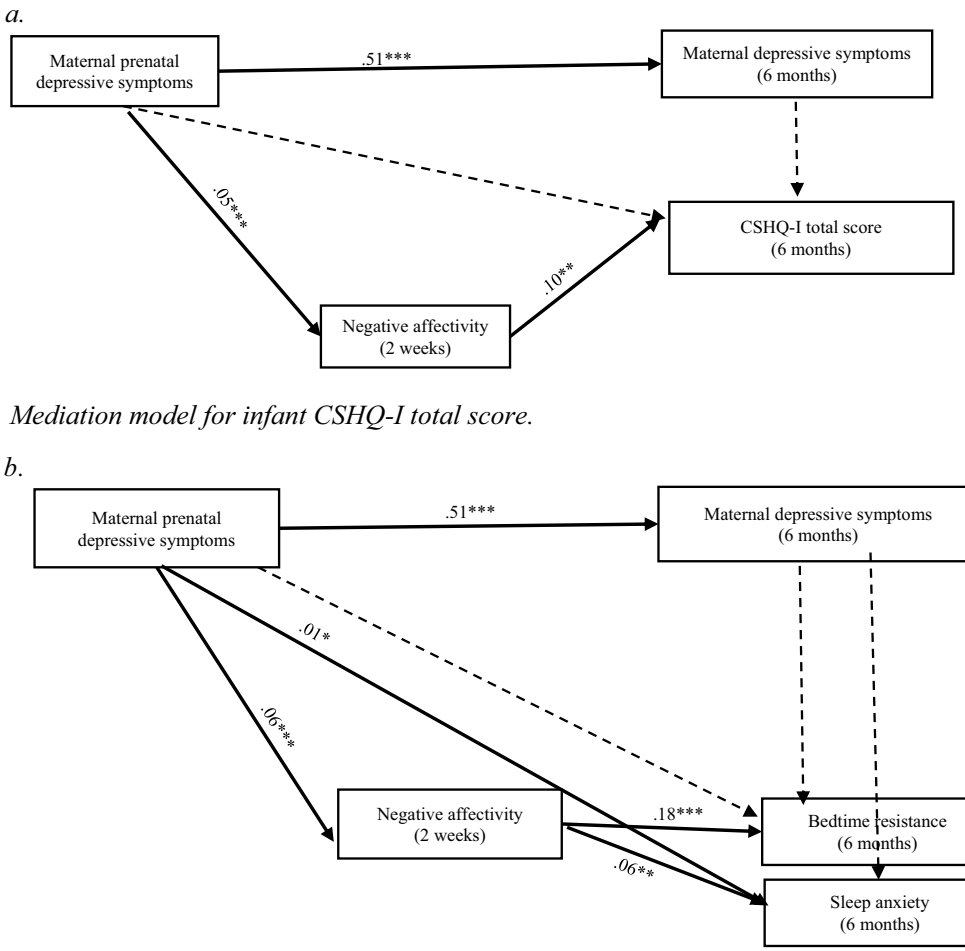


Figure 2. Mediation model for infant CSHQ-I total scale and sub-scales. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. Only β of significant paths were reported. (a) Mediation model for infant CSHQ-I total score. (b) Mediation model for infant bedtime resistance and sleep anxiety. * p < .05; **p < .01; ***p < .001

weeks significantly predicted more CSHQ-I total score at six months, $\beta = .10$, $p < .005$ (path b; see, Figure 2a). These results noted the presence of indirect links between maternal prenatal depressive symptoms and infant CSHQ-I total score at six months via infant negative affectivity at two weeks. In the total model (when paths a, b and c are considered), maternal prenatal depressive symptoms did not predict CSHQ-I total score at six months, $\beta = .00$, $p = .477$ (path c). The values for the fit model were: χ^2 (7) = 5.04, $p = .655$; CFI = 1.00; RMSEA = .00. Table 3 presents the results from the bias-corrected tests of the indirect links.

Seep anxiety and bedtime resistance

Total links: Maternal prenatal depressive symptoms significantly predicted more infant sleep anxiety, $\beta = .01$, $p = .007$, and did not predict bedtime resistance, $\beta = .01$, $p = .597$, at six months. Total and indirect links: After linking maternal depressive symptoms to the hypothesized mediator and the hypothesized mediator to sleep anxiety and bedtime resistance, the model indicated that maternal prenatal depressive symptoms significantly predicted more infant

Table 3. The mediation role of infant temperament in the impact of maternal prenatal depressive symptoms on infant sleep problems.

	Mediation model					
	Indirect effects	SE	Bootstrapp Indirect effects	Bias SE	Bias correct Estimate	CI 95%
Maternal prenatal depressive symptoms – Negative affectivity	0.05***	0.01	0.05	0.00	0.05**	[0.02-.0.08]
Negative affectivity – CSHQ-I total score	0.10***	0.02	0.10	0.00	0.10**	[0.05-.0.15]
Maternal prenatal depressive symptoms – CSHQ-I total score	0.00	0.00	0.00	0.00	0.00	[−0.01-.0.01]
Maternal prenatal depressive symptoms – Negative affectivity	0.05***	0.01	0.05	0.00	0.05**	[0.02-.0.08]
Negative affectivity – Bedtime resistance	0.18***	0.04	0.18	0.00	0.18**	[0.09-.0.27]
Maternal prenatal depressive symptoms – Bedtime resistance	−0.00	0.00	−0.00	0.00	−0.00	[−0.02-.0.01]
Maternal prenatal depressive symptoms – Negative affectivity	0.05***	0.01	0.05	0.00	0.05**	[0.02-.0.08]
Negative affectivity – Sleep anxiety	0.06**	0.02	0.06	0.00	0.06*	[0.01-.0.13]
Maternal prenatal depressive symptoms – Sleep anxiety	0.01*	0.00	0.01	0.00	0.01*	[0.00-.0.02]
	Moderation by the infant's sex					
Maternal prenatal depressive symptoms – Negative affectivity	0.05***	0.01	0.05	0.00	0.05**	[0.02-.0.08]
Sex – Negative affectivity	−0.04	0.10	−0.04	0.00	−0.04	[−0.23-.0.16]
Maternal prenatal depressive symptoms x sex – Negative affectivity	0.00	0.01	0.00	0.00	0.00	[−0.03-.0.03]
Negative affectivity – CSHQ-I total score	0.10***	0.02	0.10	0.00	0.10**	[0.05-.0.15]
Maternal prenatal depressive symptoms – CSHQ-I total score	0.00	0.00	0.00	0.00	0.00	[−0.01-.0.01]
Sex – CSHQ-I total score	−0.04	0.03	−0.04	0.00	−0.04	[−0.00-.0.01]
Maternal prenatal depressive symptoms x sex – CSHQ-I total score	0.01	0.00	0.01	0.00	0.01	[−0.03-.0.03]
Maternal prenatal depressive symptoms – Negative affectivity	0.05***	0.01	0.05	0.00	0.05**	[0.02-.0.08]
Sex – Negative affectivity	−0.04	0.10	−0.04	0.00	−0.04	[−0.23-.0.16]
Maternal prenatal depressive symptoms x sex – Negative affectivity	0.00	0.01	0.00	0.00	0.00	[−0.03-.0.03]
Negative affectivity – Sleep anxiety	0.06**	0.02	0.06	0.00	0.06*	[0.01-.0.13]
Maternal prenatal depressive symptoms – Sleep anxiety	0.01*	0.00	0.01	0.00	0.01*	[0.00-.0.02]
Sex – Sleep anxiety	−0.06*	0.03	−0.06	0.00	−0.06*	[−0.10-.0.01]
Maternal prenatal depressive symptoms x sex – Sleep anxiety	0.01	0.00	0.00	0.00	0.01	[−0.00-.0.01]

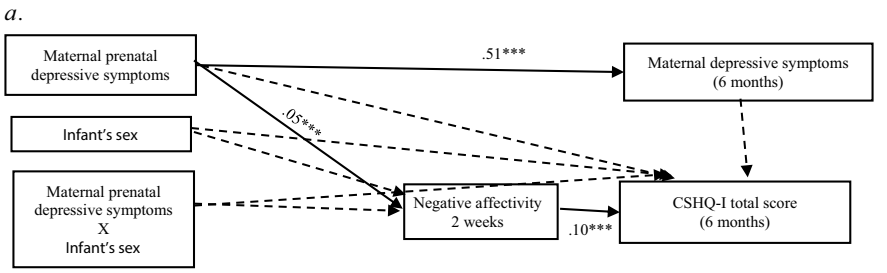
Number of bootstrapped samples = 1000; Bias corrected confidence intervals = 95; CI = Confidence intervals; SE = Standard Error
*$p < .05$; **$p < .01$; ***$p < .001$

negative affectivity at two weeks, $\beta = .05$, $p < .001$ (path a), and negative affectivity at two weeks significantly predicted more infant bedtime resistance, $\beta = .18$, $p < .001$, and sleep anxiety, $\beta = .06$, $p = .006$, at six months (path b; see, Figure 2b). These results noted the presence of indirect links between maternal prenatal depressive symptoms and infant sleep anxiety at six months via infant negative affectivity at two weeks. In the total model (when paths a, b and c are considered), maternal prenatal depressive symptoms remained a significant predictor of infant sleep anxiety at six months, $\beta = .01$, $p = .043$ (path c). These results suggest that infant negative affectivity at two weeks partially mediated the impact of maternal prenatal depressive symptoms on infant sleep anxiety at six months. The values for the fit model are: χ^2 (9) = 7.96, $p = .539$; CFI = 1.00; RMSEA = .00. Table 3 presents the results from the bias-corrected tests of the indirect links.

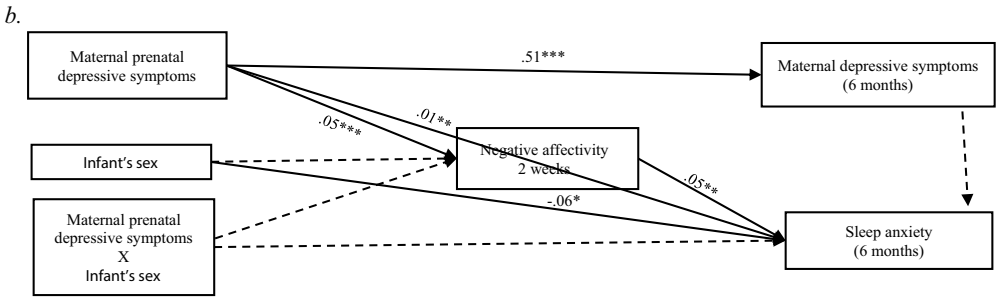
The mediation role of infant temperament in the impact of maternal prenatal depressive symptoms and infant sleep problems: moderation by the infant's sex?

CSHQ-total score

Total effects: Maternal prenatal depressive symptoms, $\beta = .01$, $p = .094$, infant's sex, $\beta = -.05$, $p = .125$, and the interaction between maternal prenatal depressive symptoms and infant's sex, $\beta = .01$, $p = .072$, did not predict infant CSHQ-I total score at six months. Total and indirect links: After linking maternal prenatal depressive symptoms to infant negative affectivity (hypothesized mediator) and infant negative affectivity to the CSHQ-I total score, the model indicated that maternal prenatal depressive symptoms significantly predicted more infant negative affectivity at two weeks, $\beta = .05$, $p < .001$ (path a). The infant's sex, $\beta = -.04$, $p = .731$, and the interaction between maternal prenatal depressive symptoms and the infant's sex, $\beta = .00$, $p = .905$, did not predict infant negative affectivity (path a). Additionally, infant negative affectivity at two weeks significantly predicted more CSHQ-I total score at six months, $\beta = .10$, $p < .001$ (path b; see, Figure 3a). These results noted the presence of indirect links between maternal prenatal depressive symptoms and infant CSHQ-I total score at six months via infant negative affectivity at two weeks. In the total model (when paths a, b and c are considered), maternal prenatal depressive symptoms, $\beta = .00$, $p = .505$, infant's sex, $\beta = -.04$, $p = .134$, and the interaction between maternal prenatal depressive symptoms, $\beta = .01$, $p = .063$, did not predict CSHQ-I total score at six months (path c).The values for the fit model are: χ^2 (12) = 7.32, $p = .836$; CFI = 1.00; RMSEA = .00. Table 3 presents the results from the bias-corrected tests of the indirect links.



Longitudinal path analysis model for infant CSHQ-I total score.



Longitudinal path analysis model for infant sleep anxiety.

Figure 3. Longitudinal path analysis model for infant CSHQ-I total scale and sleep anxiety in the total sample. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. Only β of significant paths were reported. (a) Longitudinal path analysis model for infant CSHQ-I total score. (b) Longitudinal path analysis model for infant sleep anxiety. * p < .05; **p < .01; ***p < .001

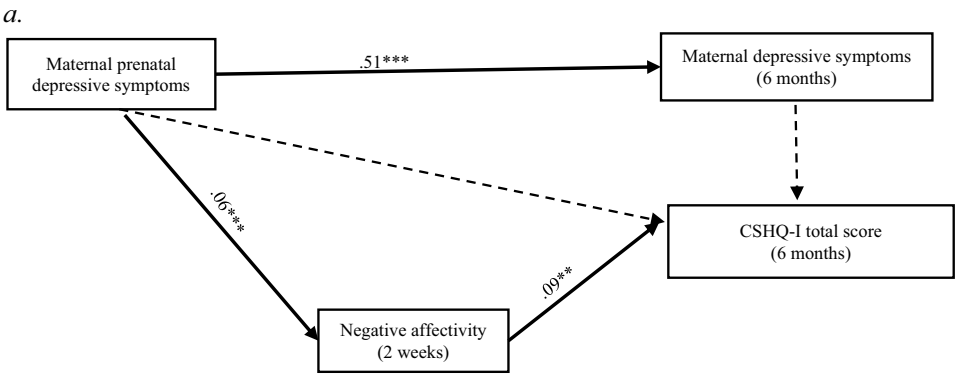


Figure 4. Longitudinal path analysis model for infant CSHQ-I total scale and sleep anxiety in boys. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. Only β of significant paths were reported. (a) Longitudinal path analysis model for infant CSHQ-I total score in boys. (b) Longitudinal path analysis model for infant sleep anxiety in boys. * p < .05; **p < .01; ***p < .001

Sleep anxiety

Total links: Maternal prenatal depressive symptoms, $\beta = .01$, $p = .007$, and the infant's sex, $\beta = -.06$, $p = .029$, significantly predicted infant sleep anxiety at six months. The interaction between maternal prenatal depressive symptoms and infant's sex did not predict infant sleep anxiety at six months, $\beta = .06$, $p = .062$. Total and indirect links: After linking maternal prenatal depressive symptoms to infant negative affectivity (hypothesized mediator) and infant negative affectivity to infant sleep anxiety, the model indicated that maternal prenatal depressive symptoms significantly predicted more infant negative affectivity at two weeks, $\beta = .05$, $p < .001$ (path a). The infant's sex, $\beta = -.04$, $p = .665$, and the interaction between maternal prenatal depressive symptoms and the infant's sex, $\beta = .00$, $p = .820$, did not predict infant negative affectivity (path a). Additionally, infant negative affectivity at two weeks significantly predicted more infant sleep anxiety at six months, $\beta = .05$, $p = .006$ (path b; see, Figure 3b). These results noted the presence of indirect links between maternal prenatal depressive symptoms on infant sleep anxiety at six months via infant negative affectivity at two weeks. In the total model (when paths a, b and c are considered), maternal prenatal depressive symptoms, $\beta = .01$, $p = .042$, and the infant's sex, $\beta = -.06$, $p = .031$, still predicted more infant sleep anxiety at six months, while the interaction between maternal prenatal depressive symptoms and the infant's sex did

not predict infant sleep anxiety at six months, $\beta = .01$, $p = .060$ (path c). These results suggested that the infant's sex did not moderate the impact of maternal prenatal depressive symptoms on infant sleep anxiety at six months (see Figures 4a and 4b). The values for the fit model are: χ^2 (11) = 7.04, $p = .796$; CFI = 1.00; RMSEA = .00. Table 3 presents the results from the bias-corrected tests of the indirect links.

Discussion

Our study provided evidence that infant negative affectivity at two weeks is a partial mediator of the impact of maternal prenatal depressive symptoms on sleep anxiety at six months, and this mediation role is independent of the infant's sex. Findings provided evidence of negative affectivity as a predictor of further infant sleep problems at six months, namely sleep anxiety. The results from our study are congruent with an extensive body of research reporting an association between infant temperament and sleep-wake behavior (Kaley et al., 2012; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015) and sleep problems (Kelmanson, 2004). Particularly, negative affectivity is described as a risk factor for infant developmental problems (Beijers et al., 2013; Gartstein & Rothbart, 2003; Putnam & Stifter, 2005). Our study provided evidence that negative affectivity is specifically associated with sleep anxiety. This temperament dimension comprises behaviors such as infant fussing, crying, distress, low mood, and the infant's rate of recovery from distress (Costa & Figueiredo, 2018; Gartstein & Rothbart, 2003). Previous studies have associated these dimensions with less sleep duration and more fragmented sleep during the night (e.g., DeLeon & Karraker, 2007; Gibson et al., 2012; Mindell & Lee, 2015). While presenting more dysregulated sleep-wake behaviors, infants with negative affectivity can face more difficulties in accomplishing the sleep developmental tasks, particularly self-soothing and sleeping through the night, and may be at more risk of presenting sleep problems, namely sleep anxiety. Negative affectivity is described in the literature as a major dimension of infants' temperament (Rothbart et al., 2011). Contrary to negative affectivity, we find that surgency/extraversion and orienting regulation did not mediate the impact of maternal prenatal depressive symptoms on infant sleep problems. Our findings provide evidence that negative affectivity may be an early marker of infant sleep anxiety, mediating the impact of maternal prenatal depressive symptoms on further sleep problems.

Although we have found no impact of the interaction between maternal prenatal depressive symptoms and infant sex on infant sleep problems, findings suggested the impact of infant sex on sleep problems. Boys may be more susceptible than girls to the emergence of sleep anxiety. DST (Belsky et al., 2007; Belsky & Pluess, 2009) proposes the infant's sex as a marker of differential susceptibility, and previous studies suggested that boys are more vulnerable than girls to the exposure of maternal prenatal depressive symptoms, presenting more sleep problems (Dias & Figueiredo, 2020; Netsi et al., 2015).

We may frame our findings within FPT (Barker, 2004; DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). Mothers with more prenatal depressive symptoms usually report poorer sleep quality, less prenatal care and poorer health habits, and dysregulated cortisol levels (Monk et al., 2013; Ruiz-Robledillho et al., 2015; Szpunar & Parry, 2018), which may alter the intrauterine environment, and consequently affect the neurobehavioral development and regulatory abilities of the infant (Davis et al., 2011; Figueiredo et al., 2017), leading to more difficulties in sleep regulation.

The impact of infant sex on sleep can also be related to sex differences in fetal programming (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). When exposed to an adverse prenatal environment, male and female fetuses were shown to respond differently to the maternal biological signs of stress (Clifton, 2010). While male fetuses were shown to make little adaptations to the adverse prenatal environment to maintain their growth, female fetuses were shown to make more adaptations to survive the adverse environment (Clifton, 2010). These different responses may lead to an increased vulnerability of male fetuses to fetal and neonatal morbidity and

mortality, maturational delays, and behavioral problems (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018), while the adaptations made by female fetuses may have consequences on their later development, in the emergence of internalizing problems (Hicks et al., 2019; Sandman et al., 2013; Sutherland & Brunwasser, 2018).

Strengths and limitations

We can acknowledge key strengths. Our study analyzed a longitudinal model to test if infant temperament dimensions explain the negative impact of maternal prenatal depressive symptoms on infant sleep problems. As we assessed temperament early after birth, assumptions regarding infant temperament with minimal post-birth environmental influences may be more easily performed. Additionally, as we assessed infant temperament at two weeks of age, mothers already had the opportunity to observe their infants in different situations, being able to provide a more accurate report of their infants' behaviors.

We should also acknowledge the major limitations. Considering the normative sociodemographic characteristics (e.g., most from middle-high socioeconomic status and white) of this Portuguese sample, the generalization of findings to mothers from different cultural and socioeconomic conditions should be taken with caution. We assessed all studied variables through maternal reports, which may have increased the common-shared variance. Also, previous studies report that depressed mothers can present more dysfunctional cognitions regarding infant sleep, namely cognitions regarding the need for maternal presence during the night and worries about their infants' needs during the night (Teti & Crosby, 2012). To overcome this limitation, we controlled the within-time correlations between maternal postnatal depressive symptoms and infant sleep problems in the analyses. We also may consider this a limitation, as parent-report measures may be biased by maternal perceptions and cognitions (Sadeh, 2015; Spruyt et al., 2008). Namely, a strong agreement between parent reports and direct measures has been reported in the assessment of sleep-wake behaviors during the day, while low agreement has been reported in the assessment of infant sleep-wake behaviors during the night (Asaka & Takada, 2011; So et al., 2007; Werner et al., 2008). Although parent reports may fail to record night wakings that were not signaled by the infant (Asaka & Takada, 2011; So et al., 2007), direct measures may record all the infant night wakings, including those that are not signaled and may comprise the acquisition of the self-soothing ability (Hall et al., 2015), an important sleep developmental task accomplished by the infant (Dias et al., 2018b; Figueiredo et al., 2016; Galland et al., 2012; Goodlin-Jones et al., 2001). We aimed to assess infant sleep problems and the CSHQ-I is one of the few existing measures in the literature to assess sleep problems during the first year of life. Regarding temperament, a strong agreement has been reported when measures are completed by the main caregiver of the infant (Rothbart, 2011). In our study, most mothers were the main caregiver of the infant. Additionally, the IBQ-R was designed to minimize parental bias by asking for the frequency of their infants' behaviors in specific situations occurring in the previous week/two weeks (Gartstein & Rothbart, 2003). We assessed maternal prenatal depressive symptoms only during the third pregnancy trimester. This may comprise a limitation considering that the impact of maternal prenatal depressive symptoms on infant temperament may have occurred earlier in pregnancy.

Implications for practice and research

Our study provided evidence that infant temperament early after birth, particularly negative affectivity, may contribute to explaining the impact of maternal prenatal depressive symptoms on infant sleep problems. Future studies may clarify the mediator role of infant temperament by performing a more multidisciplinary assessment of infant temperament, namely by assessing endophenotypic (e.g., fetal heart rate variability) and genotypic individual characteristics (e.g., 5-HTTLPR polymorphism). Further studies may also include important maternal variables (e.g.,

mother's sleep problems) that can also contribute to explaining the impact of maternal prenatal depressive symptoms on infant sleep problems.

We also found impact of the infant's sex on sleep problems. Future studies should be performed to analyze the characteristics that may impact boys' and girls' sleep problems. Future research may also analyze maternal prenatal depressive symptoms since early pregnancy to identify whether prenatal depressive symptoms in a particular trimester have a different impact on infant development.

Regarding clinical implications, our findings highlighted that intervening with infants with more negative affectivity can help to prevent the emergence of potential early sleep problems. Our results also highlight that interventions targeting infant's sleep problems should also target and intervene on mother's mental health problems. Promoting mothers' mental health, while helping them to regulate their infants' sleep could be cost-effective strategies to intervene on infant sleep problems. This result has important implications for clinical practice, considering that sleep problems early in infancy are usually precursors of later sleep (Byars et al., 2012; Meltzer et al., 2014; Williams et al., 2017), behavioral, social, emotional, and cognitive problems (Hemmi et al., 2011; Sivertsen et al., 2015; Vaughn et al., 2015), and were shown to be associated with parental difficulties, including poorer sleep quality and mental health problems, and lower marital quality (Kouros & El□Sheikh, 2017; Rhoades et al., 2012; Ystrom et al., 2017).

Conclusion

Our findings provided evidence of negative affectivity as an early specific marker of sleep anxiety that can partially explain the negative impact of maternal prenatal symptoms on further sleep problems in the infant. Findings also provided evidence of the impact of the infant's sex on sleep problems. More research is needed to better clarify these sex differences.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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