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Regular Article

Maternal depressive symptoms and infants' emotional reactivity: The moderating role of mothers' prenatal cry processing

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Abstract

Exposure to maternal depressive symptoms (MDS) may have a pertinent role in shaping children's emotional development. However, little is known about how these processes emerge in the early postpartum period. The current study examined the direct and interactive associations between MDS and cry-processing cognitions in the prediction of infant negative emotionality and affective concern. Participants were 130 mother-child dyads (50% female) assessed at three time points. During the second trimester of pregnancy, expectant mothers completed a procedure to assess responses to video clips of distressed infants and reported about MDS. Mothers also reported about MDS at 1- and 3-months postpartum. At age 3 months, infants' negative emotionality and affective concern responses were observed and rated. We found no direct associations between MDS and both measures of infant emotional reactivity. However, MDS interacted with cry-processing cognitions to predict affective concern and negative emotionality. Overall, MDS were related to increased affective concern and decreased negative emotionality when mothers held cognitions that were more focused on their own emotions in the face of the infant's cry rather than the infant's emotional state and needs. Clinical implications for early screening and intervention are discussed.

Keywords: Cry-processing; empathy; infancy; maternal depression; negative emotionality

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Maternal perinatal depression is a major public health concern, with a global pooled prevalence of 14%–17% (Liu et al., 2022; Wang et al., 2021). Perinatal maternal depressive symptoms (MDS) have been associated with a plethora of children's social-emotional difficulties and early markers of psychopathology, such as heightened negative emotionality (Gustafsson et al., 2018; Guyon-Harris et al., 2016; Madigan et al., 2018). However, most of this research has focused on children's outcomes after the first 6 months of life, and little is known about adjustment during the early postpartum period. Young infants rely strongly on external regulation provided by their primary caregivers (Sameroff, 2010), who usually take exclusive responsibility for childcare during the first months of life, making this an optimal time frame to intervene when necessary. Thus, identifying mechanisms that can buffer the negative implications of perinatal MDS for children's early social-emotional adjustment has important implications for tailoring early prevention initiatives.

Social-information-processing theories of parenting suggest that women's responses to infant cry stimuli may have an important role in shaping the course of postpartum MDS and children's subsequent functioning (Leerkes & Augustine, 2019). Drawing from this perspective, in the current study we focus on one aspect of social information processing, namely, *cry processing*, a multifaceted structure which refers to the identification, attributions, emotions, and general beliefs about infant cry (Leerkes et al., 2015, 2022; Leerkes & Qu, 2017). We specifically examine the direct and interactive associations between MDS and cry processing assessed during the prenatal and postnatal periods and two aspects of infants' emotional reactivity at 3 months of age (i.e., negative emotionality and affective concern).

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Maternal depressive symptoms and infant emotional reactivity

Extensive literature has shown that MDS are associated with various adverse child outcomes, such as behavior problems (Goodman et al., 2011; Murray et al., 2011), emotional difficulties (Cutrona & Troutman, 1986; Hoffman et al., 2006) and poor cognitive functioning (Grace et al., 2003). The onset of MDS is also a critical factor to consider in this process, as certain cognitive and emotional developmental milestones are time sensitive (Field, 2010; Hay et al., 2001; Lovejoy et al., 2000; Martins & Gaffan, 2000; Sohr-Preston & Scaramella, 2006). For example, the onset time of MDS predicted children's emotion regulation, with later onset predicting fewer difficulties in regulatory capacities (Maughan et al., 2007). In the past two decades, attention has also been drawn to the prevalence, antecedents, and implications of *prenatal* MDS (Barker et al., 2011; Luoma et al., 2001). A wide range of child outcomes have been related to prenatal MDS, such as child negative emotionality (Babineau et al., 2015; Field et al., 2009), externalizing problems (Barker et al., 2011), and developmental delay (Deave et al., 2008). Moreover, prenatal depression is a well-established risk factor for postpartum depression (Beck, 2001).

Due to the vast impact of maternal prenatal and postnatal depressive symptoms (Ertel et al., 2010; Evans et al., 2012; Luoma et al., 2001), there is considerable impetus to examine depressive symptoms at both time points and examine the risks for each timing onset for children's emotional functioning. Examining prenatal depressive symptoms can help identify, track, and later shape early interventions, to attenuate the negative effects of prenatal depressive symptoms on children (Wu et al., 2021).

Emotional reactivity in infancy

Emotional reactivity refers to the tendency to experience emotional arousal and respond to changes in the environment (Rothbart & Bates, 2006). Emotional reactivity varies between individuals in valence (positive or negative emotion), intensity (high vs. low volume), and duration. In addition, emotional reactivity can result from different stimuli – both in the external and internal environment, such as novel stimuli or physical changes. Although aspects of emotional reactivity undergo rapid developmental changes during early childhood that are considered (Leerkes et al., 2012) constitutional in origin, research suggests that environmental factors, particularly early caregiver behaviors, can also shape children's emotional reactivity (Blandon et al., 2010; Braungart-Rieker et al., 2010; Spinrad & Stifter, 2002). In the current study we focus on two aspects of emotional reactivity that have been associated with MDS in older children, namely negative emotionality, and affective concern for others.

Negative emotionality

Negative emotionality is a temperamental dimension that refers to the tendency to react with high frustration, sadness, fear, or other negative feelings in response to external and internal environmental changes (Putnam et al., 2008; Rothbart & Bates, 2006; Zenter & Bates, 2008). Manifestations of negative emotionality are evident from birth and exhibit linear increases during the first two years of life (Bridgett et al., 2009; Lipscomb et al., 2011; Partridge & Lerner, 2007). Although temperamental dimensions such as negative emotionality are theorized to have a strong genetic basis (Buss & Plomin,1984; Rothbart & Bates, 1998), individual differences in negative emotionality can also be explained, in part, by parent–child bidirectional processes. For example, increases in child negative emotionality were associated with simultaneous increases in over-reactive parenting behaviors and decreases in maternal parenting efficacy (Lipscomb et al., 2011).

Accumulating evidence suggests that prenatal and postnatal MDS are both associated with heightened negative affect during infancy (see Spry et al., 2020 for review and meta-analysis). Several mechanisms have been suggested to explain these associations, including in utero exposure to stress hormones, pro-inflammatory cytokines, or microbiota (Chan et al., 2018; Glover, 2011; Gustafsson et al., 2018; Van den Bergh et al., 2020) as well as postnatal exposure to less optimal parent–infant interactions and broader relational environments (Goodman et al., 2011). However, these direct associations are modest in size and there is also substantial variability in these links across studies (Spry et al., 2020). Importantly, many studies that have reported positive associations between MDS and infant negative emotionality have relied on maternal report measures of infants' affect. These measures are subject to report bias and may not accurately reflect infants' emotional state. Studies that have employed observed measures of negative emotionality have shown an inconsistent pattern of results, with some showing positive associations (Shapiro et al., 2018) and some showing no significant associations (Savory et al., 2020; Nolvi et al., 2019). This highlights the need to examine factors that can attenuate the relationship between MDS and infant negative emotionality, to better understand the origins for these inconsistent findings.

Affective concern for others

Affective concern for distressed others is a fundamental aspect of human nature, laying the foundation for the development of empathy and prosocial behavior (Davidov et al., 2021; Eisenberg et al., 2014; Zahn-Waxler et al., 2018; Vaish & Grossmann, 2022). This emotional response signifies feelings of sorrow or worry about a distressed other, that stem from the apprehension of another's emotional state that is different from one's own emotional state (Eisenberg et al., 2014). It is theorized that affective concern emerges when the observer can regulate the arousal generated by the others' distress (Davidov et al., 2013). In the case of hyper-arousal, a different affective response emerges, characterized by self-focused anxious feelings with a desire to alleviate one's own distress (i.e., self or personal distress). Distinguishing between these two emotional responses is crucial, given their distinct associations with subsequent empathy and prosocial behavior abilities (Eisenberg et al., 2014; Spinrad et al., 2022). Traditional developmental theories of empathy-related responding have suggested that affective concern surfaces during the second year of life, whereas in early infancy the affective responses to others' distress (Glover, 2011) are limited to self-distress or emotion contagion (Hoffman, 1975, 2001). However, growing evidence challenges this developmental timeline (Abramson et al., 2019; Davidov et al., 2021; Liddle et al., 2015; Roth-Hanania et al., 2011; Spinrad et al., 2022; Vaish & Grossmann, 2022). For example, Roth-Hanania et al. (2011) found that affective concern (reflected by concerned facial expressions, vocalizations, and gestures) in response to maternal simulations of distress and a peer distress videotape were observed among 8- and 10-month-old infants. These emotional responses were distinct from self-distress reactions, that were rarer and included irritability or jerkiness, facial expressions of wariness or fear, or vocalizations such as whimpering or full-blown crying (Roth-Hanania et al., 2011). In a longitudinal study, Davidov et al. (2021) found that these affective concern responses were evident as early as 3 months of age, and that higher levels of affective concern predicted higher prosocial behavior at age 18 months. Manifestations of affective concern during infancy have also been associated with less externalizing behaviors in boys and higher social competence at age 36 months (Paz et al., 2021).

Stern & Cassidy (2018) suggest that mutually responsive secure relationships provide the foundation for the development of empathy. They postulate that this process occurs through various mechanisms, including cognitive structures that guide behavior (i.e., components of internal working models), self-regulation abilities that allow identification with the distress of others' without feeling personal distress, and neurobiological processes that regulate biological and behavioral responses to others' distress. Therefore, exposure to MDS may lead to disruptions in the development of empathic responses in children through reduced sensitive caregiving, poor affective regulation abilities, and attachment insecurity (Stern & Cassidy, 2018). Mothers with depression were found to be less sensitive during interactions with their infants (Bernard et al., 2018) and employ maladaptive emotion socialization strategies. For example, mothers with a history of depression showed less positive emotion to their children's positive expressions and were less likely to respond

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contingently to children's expression of distress (Shaw et al., 2006). MDS have also been related to higher use of non-supportive emotion socialization practices, such as self-distress, punishment, and minimization (Lins et al., 2023; Premo & Kiel, 2016). Finally, maternal depression has been associated with a higher risk for insecure infant attachment (Barnes & Theule, 2019). Indeed, there is evidence that children of mothers diagnosed with depression exhibit lower affective responses than children of non-depressive mothers in various contexts such as simulations of maternal and experimenter distress and infant cry (Apter-Levy et al., 2013; Jones et al., 2000). In addition, the neuronal pattern of affective response to others' pain differed between children of chronically depressed mothers and children of non-depressed mothers. Specifically, using magnetoencephalography, Pratt et al., 2017 found that children of chronically depressed mothers showed greater difference in alpha power between viewing painful and non- painful pictures compared with controls, which was localized to the posterior superior temporal gyrus (pSTG). This finding could imply that children of mothers with chronic depression terminate processing of others' pain earlier than children of healthy mothers (Pratt et al., 2017).

However, some studies have found that children exposed to MDS exhibit heightened responsiveness to maternal distress. For example, elevated MDS have been associated with increased affective coordination between mothers and infants. This means that mothers with high levels of depression and their infants are highly attuned to and overly reactive to each other's emotional states (Beebe et al., 2012). In a study of preschool-aged children, boys of mothers diagnosed with depression were observed to intervene more in response to their mothers' sadness compared to boys of non-depressed mothers (Radke-Yarrow et al., 1994). This pattern of results is consistent with the notion that some children may be more affected by the negative emotional states that are common in mothers with depression, such as sadness, withdrawal, and irritability. These children may tend to "adopt" these emotional states and consistently try to understand their mothers' emotions and the reasons for fluctuations in their emotions (Tully & Donohue, 2017; Zahn-Waxler & Van Hulle, 2012).

Cry-processing as a moderator

The social-information-processing (SIP) perspective suggests that individuals draw upon their knowledge, experiences, and emotional states to process and interpret cues of a social partner which all shape their subsequent responses in social encounters (Crick & Dodge, 1994; Lemerise & Arsenio, 2000). Leerkes et al. (2015, 2022) have applied the SIP perspective to the study of parenting and coined the term *cry processing* (CP) to reflect the identification, attributions, emotions, and general beliefs about infant cry. In their research, they differentiate between *infant-oriented CP*, which focuses the child's needs, desires, and wellbeing, and includes accurate distress detection, empathy, and positive beliefs about crying and *mother-oriented CP,* which is driven by the mother's needs and wellbeing, including reactions such as anger, anxiety, and negative beliefs about crying (Leerkes et al., 2012). Mothers' infant-oriented CP in the prenatal period have been related to sensitive responses to crying in the postnatal period as reflected in prompt and appropriate responses to infant cues, particularly distress cues (Leerkes & Augustine, 2019). On the contrary, mother-oriented CP predicted mothers' negative, intrusive, or withdrawal responses to infants' distress (Leerkes, 2010). Mother-oriented CP may also lead to feelings of anxiety, anger, and helplessness in response to infants' negative emotions (Leerkes, 2010), which may augment depressive symptoms in the postpartum period. However, while previous research focused on the direct effects of CP (Leerkes, 2010, Leerkes et al., 2012, 2015), in the current study we propose that this structure can also act as a moderating factor in the associations between MDS and infant outcomes. The integrative model for the transmission of risk to children of depressed mothers (Goodman & Gotlib, 1999) suggests several mediating and moderating mechanisms that can explain the associations between MDS and the development of psychopathology and other disorders in children, such as exposure to maternal maladaptive behaviors, cognition and affect, the course and timing of the depression and child characteristics. In the current study we focus on prenatal CP as a potential moderator of the associations between prenatal MDS and infants' emotional reactivity. We suggest that infant-oriented CP can attenuate this association, as these processes enable mothers to provide sensitive caregiving and model empathic behavior in the face of infants' distress (Hechler et al., 2019), which lay the foundations for the development of empathic concern in children (Stern & Cassidy, 2018). On the contrary, mother-oriented cry processing can exacerbate this association as it can lead mothers to focus on their own negative emotions and provide less effective soothing (Leerkes et al., 2011), resulting in higher levels of infants' negative emotionality.

The current study

The current study addressed the need to better understand how prenatal and postnatal MDS are related to children's emotional functioning in early infancy. Given prior research showing inconsistent findings regarding the effects of MDS on children's negative emotionality and empathy-related responses (Apter-Levy et al., 2013; Radke-Yarrow et al., 1994; Spry et al., 2020), we suggest that these associations are complex and involve interactions among several child- and family-level characteristics. Informed by the social-information-processing (SIP) perspective (Leerkes & Augustine, 2019), we propose maternal CP cognitions as a key factor in moderating the associations between MDS and infants' emotional reactivity. We hypothesized that prenatal and postnatal MDS would predict infants' greater negative emotionality (H1) and lower affective concern (H2) at age three months. We further hypothesized that the association between MDS and infant affective concern will be moderated by infant-oriented CP. Specifically, higher infant-oriented CP will attenuate the association between MDS and infant affective concern (H3). Finally, the association between MDS and infant negative emotionality will be moderated by mother-oriented CP. Specifically, higher mother-oriented CP will exacerbate the association between MDS and infant negative emotionality (H4). An additional goal was to provide a preliminary examination into whether the effects of MDS vary according to time of exposure (prenatal vs. postnatal). We did not suggest specific hypotheses about potential timing differences due to insufficient empirical evidence about our specific outcomes.

Method

Participants

Participants were mothers and children enrolled in the (omitted for review) study, a longitudinal study following mothers and

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Table 1. Participants' demographic characteristics

	M	*SD*	*Range*
Child biological sex			
Female	35.3%		
Mothers' age (years)	30.96	4.23	20–45
Child age at T3 (months)	3.47	.56	2.67–5.3
Mothers' education (percent)			
High-school diploma	14%		
Professional training	11%		
B.A degree	44.1%		
Graduate degree	30.9%		
Number of children in the family	1.92	1.004	1–6
Family Status (percent)			
In a relationship or married	96.8%		
Separated or divorced	1.3%		
Single	1.9%		
Family monthly income			
Up to 3,500 NIS	2.3%		
3,501-6,000 NIS	4.7%		
6,001-8,500 NIS	13.5%		
8,501-12,500 NIS	15.2%		
12,501-20,000 NIS	40.9%		
20,001-40,000 NIS	21.6%		
Above 40,000 NIS	1.8%		
Mothers' country of origin			
Israel	76.9%		
Former Soviet Union	17.9%		
South America	3%		
United States	2.2%		
Mothers' psychiatric diagnoses			
Depression and/or anxiety	6.66%		
Mothers' use of psychotropic medication			
SSRI	3.7%		
SNRI	0.74%		

Note. NIS = new Israeli Shekel, the Israeli national currency.

children from the prenatal period through the first two years of life in Israel. Mothers were recruited during the second trimester of pregnancy through social media platforms and the obstetrics and gynecology division at (omitted for review). Women were included in the study if they were physically healthy, above 21 years, with no substance abuse report, and without diagnosed psychiatric conditions besides major depressive disorder and anxiety disorders ($N = 177$). All infants participating in the study were born at term without medical complications, except one infant born preterm that was excluded from the study. For the current study we used participants who had data collected at three time points ($N = 130$): the second trimester of pregnancy (T1), one month postpartum (T2), and 3 months of children's age (T3). Participants' demographics are exhibited in Table 1.

Procedure

The Helsinki Review Board at (omitted for review) approved the study protocol, and participants signed consent forms before data collection. At T1 (second trimester), participants completed a procedure to assess responses to video clips of infants in distress and reported about their depressive symptoms during a home visit. At T2 (1-month postpartum), mothers reported about their depressive symptoms in an online questionnaire. At T3 (3-months postpartum), data were collected and videotaped during home that included a task designed to elicit infants' frustration and a simulation of maternal (Zahn-Waxler et al., 2018) distress. In addition, mothers completed questionnaires that included demographic information and depressive symptoms. After each home visit, mothers received a gift voucher (valued at about 25$). In March 2020, COVID-19 home confinement regulations were first implemented, and in-person data collection was put on hold. In June 2020, these regulations were temporarily amended with the decrease in infection rates, and we managed to collect data from the remaining participants. As we aimed to administer the tasks in a similar manner to the pre-COVID data collection period, no significant changes were made in the study protocol. During the assessments the research assistants wore masks, turned on the camera, and left the room allowing mothers to complete the tasks without wearing masks.

Measures

Maternal depressive symptoms (MDS; second trimester, 1- and 3-months postpartum)

MDS were assessed using The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987). The EPDS is a brief self-report measure of prenatal and postnatal depressive symptoms over the past week (e.g., 'have felt sad or miserable'). Each item is scored on a scale ranging between 0 and 3 (0 = Rarely or none of the time; 3 = all of the time). Items were summed, with higher scores indicating proneness to depression (*Cronbach α* coefficients ranged from .81 to .84), with the suggested cutoff score being 13 and above (Cox et al., 1987). In the current study 7.6% of participants scored above the cutoff score at T1, 7.8% at T2 and 1.6% at T3.

Cry processing (CP; second trimester)

Based on Leerkes et al. (2015), maternal CP was assessed using: (1) The Infant Crying Questionnaire (Haltigan et al., 2012) to measure infant cry beliefs; (2) Mothers' reported feelings and attributions about the infant's state after viewing two video clips of infants in distress.

Infant cry beliefs

Participants completed a shortened version of the Infant Crying Questionnaire (Haltigan et al., 2012), which assesses expectant mothers' beliefs about their future infants' crying on a 5-point scale. In the current study we administrated four sub-scales: Attachment (e.g., "*When your baby will cry . . . I will want to make my baby feel secure/cared for*"), Crying as Communication (e.g., "*When your baby will cry . . . I will think my baby is trying to tell me something.*"), Minimizing (e.g., "*When your baby will cry . . . I will want my baby to stop because I cannot get anything else done*") and Spoiling (e.g., "*When your baby will cry . . . I will want to let my baby cry it out so s/he doesn't get too dependent on me*"). All subscales were summed into two main scales: infant-oriented and

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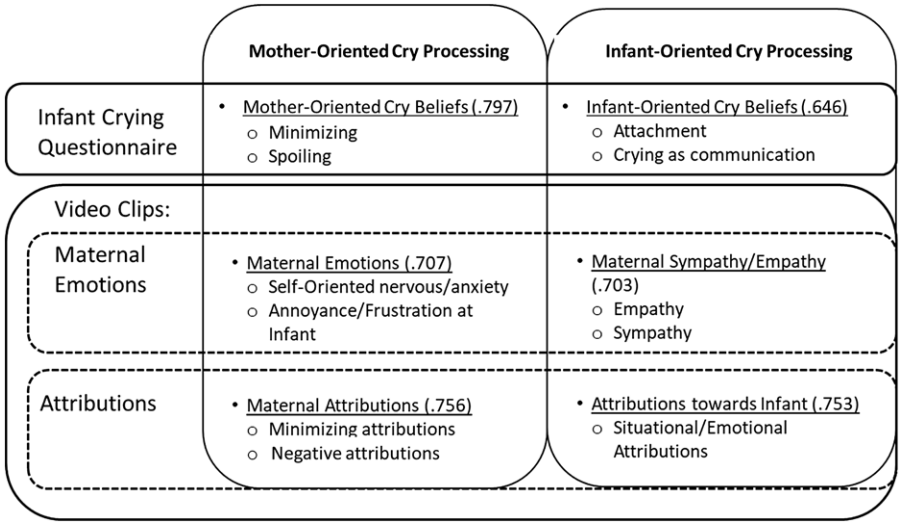

Figure 1. Cry-processing scales.

mother-oriented cry beliefs. Infant-oriented cry beliefs were calculated as the average of the attachment and crying as communication sub-scales ($\alpha = .664$). The mother-oriented cry-beliefs scale was calculated as the average of the minimizing and spoiling sub-scales ($\alpha = .807$).

Maternal emotions and attributions

Next, participants watched two 1-minute video clips of infants in distress during tasks designed to elicit fear and frustration. Both infants were approximately 18 months old (one female and one male) and were dressed in gender neutral clothing. The videos were recorded during standard temperament assessments: a novel toy approach procedure for the fear clip, and parental separation for the frustration clip (Goldsmith & Rothbart, 1999). After each clip, mothers answered several regarding: (a) Their own emotions during the video clip. Participants were asked to rate 20 statements on a 1–4-point scale ranging from "not at all" to "very strongly" (e.g., "*I felt sad for the baby*", "*I felt annoyed that the baby was demanding my attention*"); (b) Attributions about the child's state. Participants were asked to rate 18 statements on a 1–4-point scale ranging from one "strongly disagree" to four "strongly agree". Three attribution scores were calculated for each clip: minimizing attributions including five items (e.g., *having a bad day, in a bad mood*); negative attributions including seven items (e.g., *spoiled, difficult temperament*); and situational/emotional attributions including four items (e.g., *upset by the situation, no one was helping the baby*). Scores were averaged across the two videos. (c) The child's emotions during the video. Participants were asked to choose from a list containing 21 emotions and state how the baby felt (e.g., *happy, sad, bored, scared*). Then, they were asked to choose the primary emotion. In addition, they had to rate the infants' emotional state on a 1–7-point scale ranging from "high positive emotion" to "high negative emotion". Each scale was calculated as the mean of all the subscales (see Figure 1). The child's emotions questionnaire was summed to create *accurate distress detection* and was excluded from further analysis due to nonsignificant correlations with all other sub-scales in the infant-oriented scale (Leerkes et al., 2015).

A principal component analysis was conducted to calculate mother-oriented and infant-oriented CP using three scales each. Figure 1 illustrates the different sub-scales and scales for each questionnaire, with factor loading scores. The mother-oriented factor explained 56.8% of the variance, and the infant-oriented factor explained 49.2% of the variance, with loadings ranging from 0.64 to 0.79.

Infant negative emotionality (age 3 months)

Mothers and infants participated in a task designed to elicit infants' frustration. Mothers were asked to place their children on their abdomens for six minutes. Instructions were "please put your baby on his/her tummy and play with him/her as you normally do for six minutes or until you wish to end the interaction". In the current study the length of the frustration task ranged between 30 s to 6 minutes ($M = 3.73$ $SD = 1.76$).

Three trained research assistants rated infants' distress from the videotaped assessments using a 5-point scale (Zahn-Waxler et al., 1992) ranging from 0 to 4 with 0 = no distress (no distress expression), 1 = slight distress (visible distress manifested non-vocally through bodily postures or facial expressions), 2 = moderate distress (whimpering expressed vocally), 3 = pronounced distress (full-blown crying), and 4 = intense distress (intensive crying). Twenty percent of the videos were double coded for reliability: 10% were randomly selected and coded by all three coders to assess reliability, and 10% were coded during the coding process. The overall interrater reliability coefficient for the negative emotionality scale was 0.92. In the current study, 88% of the infants expressed some level of observed distress ($M = 2.39$, $SD = 1.26$) during this task.

Infant affective concern (age 3 months)

Distress simulation

Mothers and infants participated in a simulation of maternal distress that is widely used to assess affective concern in infants (Paz et al., 2021; Roth-Hanania et al., 2011; Zahn-Waxler et al., 1992; Zahn-Waxler et al., 1992). In the simulation, the mother displays distress in response to hurting her thumb for 60 s (30 s at high intensity and then at a lower intensity for another 30 s). Mothers were instructed not to make eye contact or talk to the infants during the simulation (except: "ouch, I hurt my thumb"). At the end of the simulation, mothers were instructed to look at the child, reassure him or her that she was alright, and smile.

Manipulation checks of the distress simulation were conducted by coding mothers' adherence to the task instructions on a scale ranging between 0 and 2 (0 = Acceptable, 1 = Slight deviations from

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protocol, 2 = Significant deviations from protocol). Significant deviations from protocol were coded for mothers whose cry simulation was unreliable (e.g., increased / decreased intensity, laughter) or did not reduce intensity as instructed. Three of the simulations were rated as 2. These simulations were discussed with the master coder. After carefully reviewing the simulations, 2 out of 3 simulations were excluded due to significant incredibility.

Coding

Infants' responses were filmed and later coded for affective concern based on the coding system developed for the MacArthur Longitudinal Twin Study (Zahn-Waxler et al., 1992). Affective concern was coded as a combination of intensity and duration of negative emotions through facial expression, body gestures, and vocal expressions. The coding scheme consists of a 7-point scale based on the original scale ranging from 0 to 3 with half points added to capture more subtle empathy manifestations in infants (Davidov et al., 2021). The coding reflected the following levels: 0 = absent affective concern; 0.5 = very fleeting (i.e., facial expression of concern is present, such as sobering, but it is very minimal); 1 = slight concern (i.e., slight change in facial expression, including sobering, brow furrow, or sad expression, for 10 s); 1.5 = somewhat concerned (i.e., moderate expression of concern, but relatively brief); 2 = Moderate concern (i.e., more pronounced sobering of expression or sad expression and/or the presence of a sympathetic facial expression, as manifested in drawn-down eyebrows and down-turned lips). Facial concern may include other features of concern, such as: sympathetic vocalizations, leaning or gesturing towards the victim; 2.5 = moderate strong concern (i.e., concern expressed for a long duration but with moderate intensity or expressed intensively but relatively briefly), and 3 = Strong concern (i.e., high intensity features of concern combining both facial and vocal expressions for most of the simulation).

Two trained research assistants coded infants' affective concern reactions. First, the coders were trained by a master coder and achieved reliability with her (ICC above .70) by coding 30 training videos. Then, 15% percent of the videos from the current study were randomly selected and coded by both coders to assess reliability. The interrater reliability coefficient for the affective concern scale was ICC = .78. Finally, an additional 10% of the videos were double coded during the coding process to ensure that ICC values remained above .75. Three participants were excluded due to poor simulation of the mother.

Covariates

We controlled for several possible confounds. First, because previous research demonstrated associations between maternal education and MDS (Horwitz et al., 2009), we controlled for maternal education in our analyses. Additionally, maternal sensitivity during distress and the duration of the dyadic interaction were controlled in the frustration task. It is known that maternal sensitivity during a stressful task can modulate or elicit the infant's response and that the length of the task can influence the infant's level of distress (Leerkes et al., 2012). For example, it is possible that an infant may be less frustrated after a two-minute task compared to a four-minute task.

Maternal education

Maternal education was reported on a 4-point scale (i.e., 1 – high school diploma, 2 – professional training, 3 – BA degree, 4 – Graduate degree).

Maternal sensitivity during distress

Maternal sensitivity refers to the ability to understand the child's responses and needs and act accordingly based on the caregiver's affect, timing, flexibility, acceptance, conflict resolution, and amount of interaction with the child. Sensitivity was coded based on the emotional availability scales (Biringen, 2008), on a 7-point scale, with higher scores reflecting higher sensitivity. Two coders coded the sensitivity scale with a reliability coefficient of .74, after coding 15% of the interactions.

Length of frustration task

Due to maternal preferences, there were differences in the length of time children were placed on their abdomen ($M = 3.73$, $SD = 1.76$), and in 20% of the cases the task was discontinued before the 6-minute time frame. Hence, the length of the frustration task was controlled for in the analysis.

Missing data

Six participants did not complete the EPSD questionnaire at T2. At T3, 14% of children ($n = 19$) had missing affective concern data due to poor video quality, maternal refusal to conduct the simulation or due to incredibility of the maternal distress simulation. In addition, 7.4% of the mothers did not answer the education level question ($n = 10$), and 4.4% did not complete the EPDS questionnaire ($n = 6$). We performed Little's Missing Completely at Random (MCAR; Little, 1988) test to assess the pattern of missing data. Results supported the assumption that the missing values are MCAR (χ^2 (85) = 95.92, $p = .19$). Therefore, data from 130 participants were used for the current study and maximum likelihood estimation was used to handle the missing data.

Analytic strategy

The analytic strategy involved estimating a series of path models using Mplus version 8.5 (Muthén & Muthén, 2021). To address the non-normality in our data, we used maximum likelihood with robust standard errors (MLR) estimation in all models. MLR estimation is beneficial in handling violations of normality assumptions as it modifies the standard errors calculation to account for non-normality, providing more accurate parameter estimates (Lai, 2018). Continuous predictors were mean-centered before the creation of the interaction terms. First, we examined hypotheses 1–2 by estimating a model in which child negative emotionality and affective concern at age 3 months were regressed on the study covariates, prenatal and postnatal MDS, and infant and mother-oriented CP. Negative emotionality and affective concern were allowed to covary. Next, we added four interaction terms to the model: (1) prenatal MDS * infant-oriented CP; (2) prenatal MDS * mother-oriented CP; (3) 1-month MDS * infant-oriented CP; (4) 1-month MDS * mother-oriented CP. Non-significant interactions were pruned from the final models for the sake of parsimony. Significant interactions were examined by evaluating simple slopes at average and ±1 standard deviations of cry processing (Aiken et al., 1991). In addition, the JohnsonNeyman technique was used to derive regions of significance for the conditional effects. The Johnson–Neyman technique allows us to see how the main effect varies across the full range of the values of a moderator in a single regression line (Johnson & Neyman, 1936).

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Table 2. Means, standard deviations and correlations among primary study variables

		N	*M*	SD	1	2	3	4	5	6	7	8	9
1	Maternal education	130											
2	Prenatal MDS	130	5.18	4.26	.01								
3	MDS at 1-month	130	5.37	3.94	.11	.36**							
4	MDS at 3-months	124	3.77	3.28	−.04	.34**	.55**						
5	Infant-oriented CP	130	0	1.01	−.08	−.02	−.16	−.07					
6	Mother-oriented CP	130	0	1	.03	.26**	.3**	.11	−.22*				
7	Infant affective concern	112	1.19	0.71	−.28**	.12	.03	.06	.11	−.04			
8	Infant negative emotionality	130	2.38	1.25	−.09	−.06	−.05	−.01	−.05	−.09	−.05		
9	Maternal sensitivity	130	5.73	.67	.02	−.06	−.02	−.05	.17*	−.13	−.03	.02	
10	Duration of frustration task	126	3.73	1.76	.04	.05	.00	−.00	−.15	.08	.15	−.22**	.10

Notes. MDS = Maternal depressive symptoms, CP = Cry processing. *$p < .05$. **$p < .01$ ***$p < .001$.

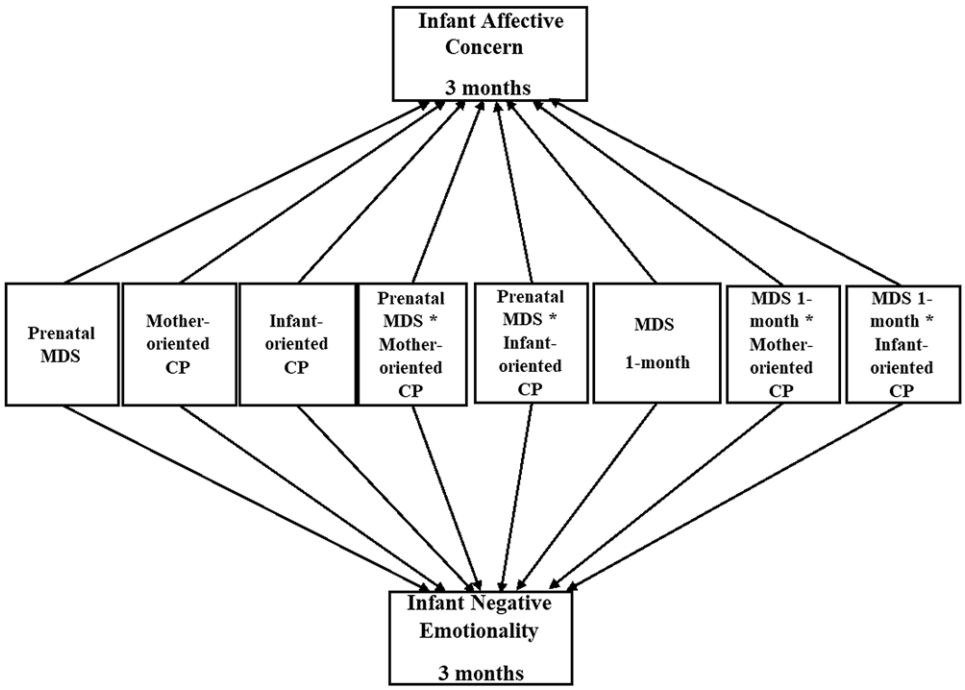

Figure 2. A graphic representation of the path model predicting infants' affective concern and negative emotionality. MDS = maternal depressive symptoms, CP = cry processing; the following covariates were included in the model but are not depicted in this figure for ease of presentation: maternal education, maternal sensitivity, duration of frustration task; all concurrent associations within predicters and within outcomes were estimated but are not presented.

Results

Descriptive statistics and bivariate correlations between observed variables are presented in Table 2. MDS scores at all three time points were positively correlated. Mother-oriented CP was positively correlated with prenatal MDS, and infant-oriented CP was negatively related to MDS at 1-month. Infant affective concern was negatively related to maternal education. Infant-oriented CP was positively correlated with maternal sensitivity at age 3 months.

Path models

First, children's affective concern and negative emotionality were regressed on study covariates, MDS, and CP variables. Predictors and covariates were allowed to covary, and the model was saturated. No main effects were found for infant-oriented CP, mother-oriented CP, and MDS in predicting infants' affective concern and negative emotionality. Maternal education predicted infants' affective concern ($\beta = -.30$, *S.E.* = .1 $p = .002$), and the duration of the frustrating interaction predicted negative emotionality ($\beta = .23$, *S.E.* = .09 $p = .01$). This model accounted for 9.8% of the variance in children's negative emotionality and 12% of the variance in children's affective concern.

Second, to test hypotheses 3−4, the four interaction terms were entered into the model (see Figure 2). This model demonstrated adequate fit to the data: $X^2(25) = 49.001$ $p = .002$; *RMSEA* = .03; *SRMR* = 0.06. The interaction term prenatal MDS * mother-oriented CP significantly predicted infant negative emotionality ($\beta = -.17$, $p = .03$), 95% CI [−.08, −.006]. In addition, the interaction term MDS 1-month * infant-oriented CP significantly predicted infant affective concern ($\beta = -.051$, $p = .007$), 95% CI [−.23, −.01]. This model accounted for 14% of the variance in children's negative emotionality and 18% of the variance in

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Table 3. Standardized coefficients for the path model predicting infants' affective concern and negative emotionality

	Affective concern		Negative emotionality	
Predictors	*Estimates*	*p*	*Estimates*	*p*
Prenatal MDS	.13	.13	−.006	.94
MDS 1-month postpartum	.16	.18	−.01	.92
MDS 3 months postpartum	−.1	.37	−.04	.66
Mother-oriented CP	−.08	.45	−.03	.71
Infant-oriented CP	.13	.15	−.09	.27
Prenatal MDS * Mother-oriented CP	.05	.55	−.17	.03**
Prenatal MDS * Infant-oriented CP	.11	.13	.02	.76
MDS 1-month * Infant-oriented CP	−.21	.007**	−.05	.43
MDS 1-month * Mother-oriented CP	−.03	.74	−.1	.24
Maternal Education	−.29	.004**	−.09	.3
Maternal sensitivity	−.02	.73	.12	.2
Duration of frustration task			−.24	.006**

Note. MDS = Maternal depressive symptoms, CP = Cry processing; *$p < .05$. **$p < .01$ ***$p < .001$.

children's affective concern. Standardized coefficients and standard errors for the final path model can be found in Table 3.

Simple slopes and regions of significance analyses

Infant negative emotionality

The significant interaction between prenatal MDS and mother-oriented CP predicting infant negative emotionality was first probed at high (+1 SD) and low (−1 SD) levels of mother-oriented CP (Figure 3). The association between MDS and infant negative emotionality was positive for mothers at low levels of mother-oriented CP ($b = .2$, $p = .04$) and negative for high levels of mother-oriented CP ($b = -.21$, $p = .02$). This association was nonsignificant for mothers with average levels of mother-oriented CP ($\beta = -.002$, $p = .94$). Johnson-Neyman analysis of regions of significance further indicated that the association between MDS and child negative emotionality was significant for all values of observed mother-oriented CP above and below 1 SD of the mean.

Infant affective concern

The significant interaction between 1-month MDS and infant-oriented CP predicting infant affective concern was first probed at high (+1 SD) and low (−1 SD) levels of infant-oriented CP (Figure 4). The positive association between MDS and infant affective concern was significant only for mothers at low levels of infant-oriented CP ($b = .15$, $p = .00$), and not for mothers with average or high levels of infant-oriented CP ($b = .03$, $p = .19$;

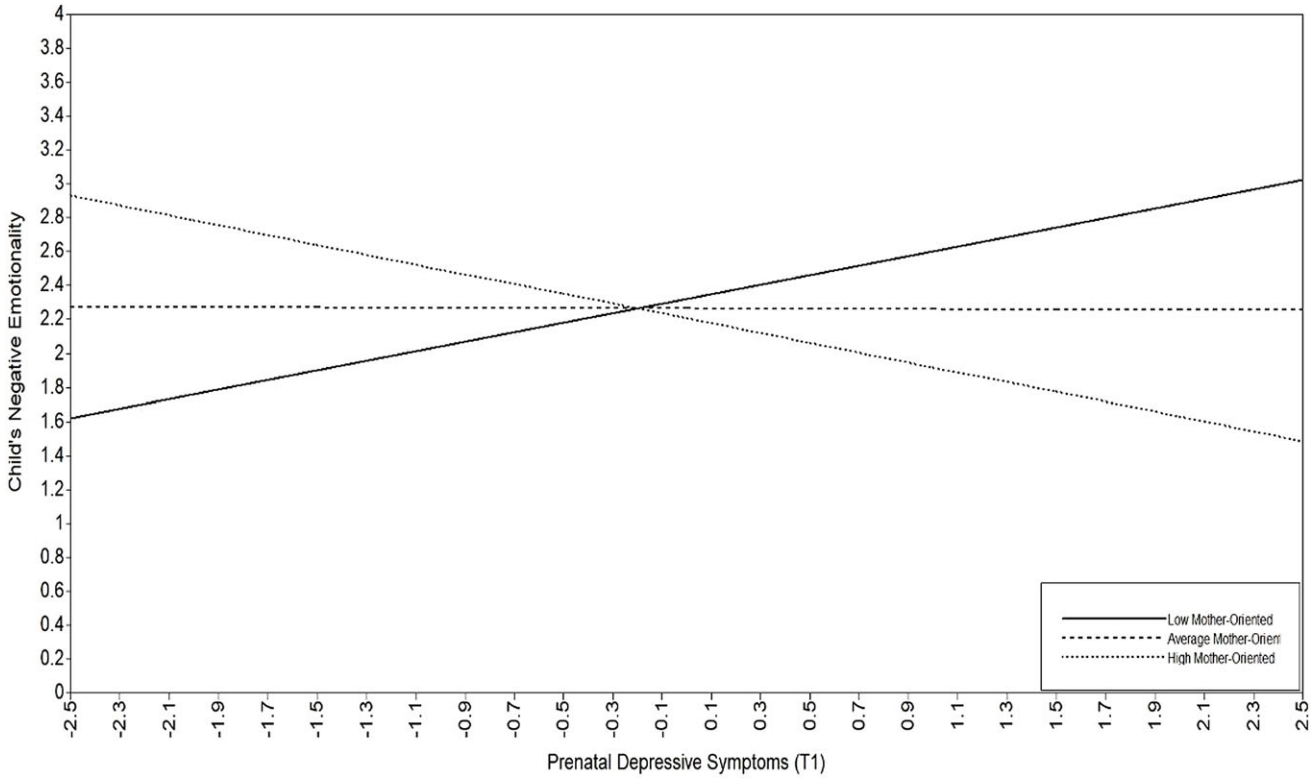

Figure 3. The links between prenatal MDS and infant negative emotionality at different levels of mother-oriented CP.

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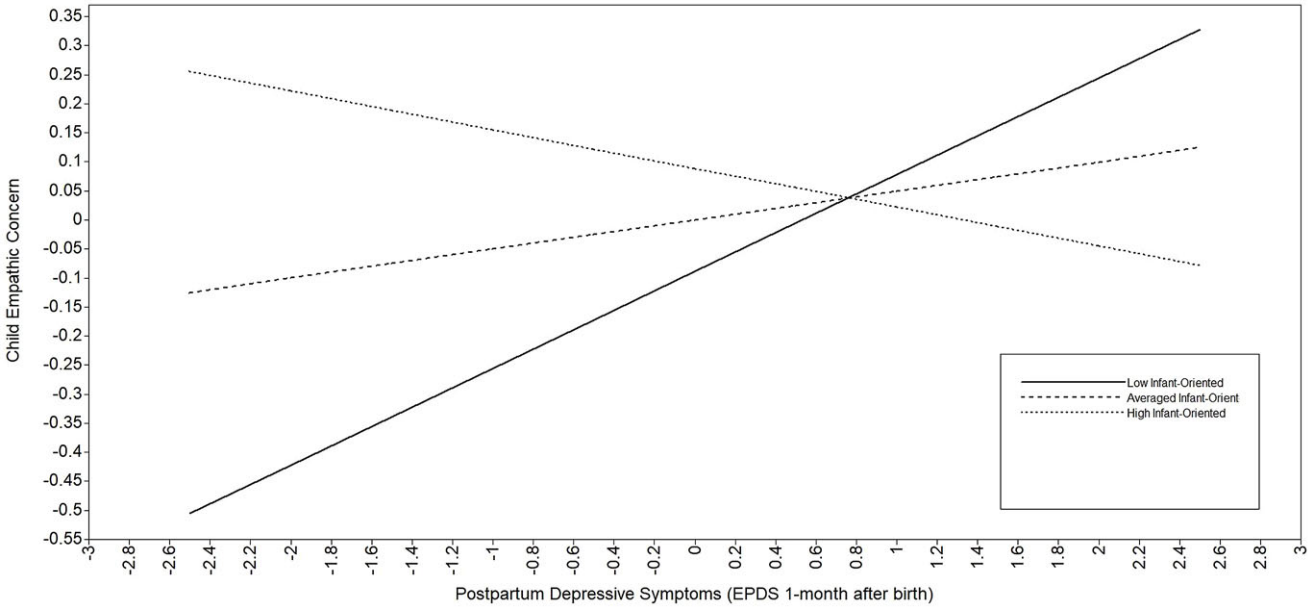

Figure 4. The links between postnatal depressive symptoms and child's affective concern at different levels of infant-oriented cry processing.

$b = -.09$, $p = .53$, respectively). Johnson-Neyman analysis of regions of significance further indicated that the association between MDS and infant affective concern was significant for all values of infant-oriented CP above −.27 SD of the mean (54.43% of the sample), well within the observed range of infant-oriented scores (−1.8 to 2.5, standardized scores).

Discussion

In line with the integrative model for the transmission of risk to children of depressed mothers (Goodman & Gotlib, 1999), the primary goal of the current study was to examine whether prenatal and postnatal MDS are related to two aspects of emotional reactivity during infancy: negative emotionality and affective concern. An additional goal was to examine whether maternal CP measured in the prenatal period moderated these associations. We found no evidence for direct associations between MDS and child emotional reactivity. However, MDS interacted with CP to predict affective concern and negative emotionality. Overall, MDS were related to increased affective concern towards mothers and decreased negative emotionality when mothers held CP cognitions that were more focused on their own emotions rather than the infant's emotional state and needs.

Infant negative emotionality

Prenatal and postnatal MDS did not directly predict infant negative emotionality at three months of age, contrary to our prediction and to previous research (Spry et al., 2020). Our sample characteristics may help explain these findings. Previous research has utilized clinical samples of mothers diagnosed with depression (e.g., Forman et al., 2007) or sampling methods that ensure a range of MDS (e.g., Nolvi et al., 2019), while our study used a community sample of mothers with relatively low levels of depressive symptoms. It is possible that the association between maternal depression and child outcomes is stronger in samples of more severe and chronic depression and may depend on the presence of additional risk or resilience factors (see Sutherland et al., 2022 for meta-analytic review). Although we did not observe a direct association between prenatal MDS and infant negative emotionality, we did find that mother-oriented CP moderated this association. However, the moderation pattern was not in the expected direction. Higher MDS predicted *higher* levels of child negative emotionality when mothers exhibited low mother-oriented CP, and *lower* levels of negative emotionality when mothers exhibited high mother-oriented CP. In other words, when infants have mothers who are more focused on their own distress, higher depressive symptoms were associated with lower negative emotionality. However, when infants had mothers who are more focused on the infants' needs, desires, and wellbeing, higher depressive symptoms were related to higher negative emotionality.

Possible explanations for these findings emerge when considering the context and focus of our negative emotionality measurement. In our study, we focused on frustration reactions during a dyadic task in which mothers placed their infants in an uncomfortable position and were asked to interact with them during this time. Elevated levels of frustration in this context can reflect an adaptive communicative response on behalf of the infant toward the caregiver (Bell & Ainsworth, 1972). Mothers who experience elevated depressive symptoms and a tendency to focus on their own negative emotions in the face of infants' distress may not be able to respond sensitively and alleviate their infants' distress. In turn, infants may learn that expressions of frustration are not effective in engaging their mothers' and soothing their distress. These repeated regulatory failures are likely to result in infants viewing their mothers as inconsistent or unreliable (Tronick & Reck, 2009). Infants may develop a sense of learned helplessness regarding their ability to engage their mother using cry and exhibit less negative emotionality in the context of the mother–child interaction.

Infant affective concern

Prenatal and postnatal MDS were also not directly related to infants' manifestations of affective concern. This finding is not surprising considering the mixed pattern of results in previous

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research, with some studies finding that children of mothers with elevated depressive symptoms have lower levels of affective concern (Apter-Levy et al., 2013), some finding higher levels (Radke-Yarrow et al., 1994), and others finding no significant differences (Tully & Donohue, 2017) compared to children of mothers with low depressive symptoms. However, we found a significant interaction between 1-month MDS and infant-oriented CP in the prediction of infant affective concern. Contrary to our hypothesis, higher MDS predicted higher affective concern for mothers with low infant-oriented CP (i.e., low focus on the infant's emotions and needs). This finding might be surprising and non-intuitive at first. However, our findings can be interpreted considering the empathy as a "risky strength" hypothesis (Tone & Tully, 2014). According to the risky strength hypothesis, while empathy is an important emotional ability that is associated with positive outcomes, complex interplays among intraindividual and interindividual factors can increase risk for excessive affective concern that can be maladaptive. Infants of mothers with high depressive symptoms likely carry a genetic disposition for physiological hyperarousal and/or negative thinking. When exposed to MDS and related parenting behaviors and cognitions, such as low focus on the infant's emotions and needs, these infants may become hypervigilant toward their caregivers' emotional states as evident in increased affective concern toward their mothers' distress. These early tendencies can later evoke excessive interpersonal guilt and potentially skew children's empathic development trajectory toward problematic outcomes (Tully & Donohue, 2017). Findings from the current study can reflect the initial process by which MDS and maladaptive cry cognitions elicit elevated affective concern in infants. However, future longitudinal studies are needed to better understand whether these early manifestations of concern confer increased risk for depression and internalizing outcomes in children.

Timing of exposure to MDS

Whereas both prenatal and postpartum MDS have been independently related to problematic child outcomes, research comparing the strength of the associations between different exposure periods overall suggests no differences in magnitude between the prenatal and early postnatal periods (e.g., Brennan et al., 2008; Hentges et al., 2020; Pearson et al., 2013). Although we did not find direct associations between prenatal and postnatal MDS in the prediction of infant emotional reactivity, the moderated associations differed between the two exposure periods. First, only prenatal MDS were interactively related to infants' negative emotionality. These findings can be explained considering the developmental origins of health and disease hypothesis (DOHaD; Gluckman et al., 2010). The DOHaD suggests that women's emotional states during pregnancy may alter the in-utero environment and shape the development of different brain systems. For example, there is evidence that elevated depressive symptoms during pregnancy may program the developing fetal HPA axis to be either over or under aroused in the face of to stress (e.g., Davis et al., 2011; Vedhara et al., 2012). Consistent with this pattern of results, findings from the current study suggest that prenatal MDS were related to dysregulation of arousal as evident in infants' *decreased* negative emotionality when mothers were focused on their own distress, and *increased* negative emotionality when mothers were not self-focused. Second, only postnatal MDS were interactively associated with infants' affective concern. Similar to the majority of developmental processes, individual differences in empathy are theorized to result from the complex interactions between child's biological and genetic disposition and environment (Knafo et al., 2008). Theories of empathic development have emphasized the role of the caregiving environment in this process, suggesting that empathy develops out of experiences in a mutually responsive relationship that are integrated into the child's developing empathetic abilities (Stern & Cassidy, 2018). Thus, it is possible that MDS may be more influential on empathy development in the postnatal period, a time in which actual reciprocal social interactions begin to evolve between infants and their caregivers.

Limitations

This study has several limitations that should be acknowledged. First, our sample was a low-risk community sample with low rates of MDS. Therefore, our findings cannot be generalized to high-risk populations, characterized by low SES or clinical levels of depression. Second, the examination of emotional reactivity was limited to the mother-child dyad and did not consider other contexts. Our measure of negative emotionality was also specific to frustration reactions and did not include other aspects of negative emotionality such as fear or sadness. Additionally, our measurement was restricted to infants at age 3 months, which provides insight into early developmental effects of MDS but does not account for how these tendencies may change as the child matures. Third, our sample size was relatively modest, preventing us from examining more complex questions that require increased statistical power. For example, given previous research suggesting curvilinear rather than linear relationship between MDS and empathy in middle childhood (Zahn-Waxler & Van Hulle 2012), an essential next step would be to examine whether these non-linear effects are evident as early as infancy. Finally, although we controlled for potential confounds, other important factors such as paternal depression and caregiving behaviors, social support, and the infant psychophysiological functioning can also moderate the relationship between MDS and emotional reactivity. Important next steps in future research would be to examine our research questions in samples that are more diverse in terms of MDS, examine trajectories of emotional reactivity over time and beyond the mother-child dyad context.

Implications and conclusions

Despite these limitations, the present study contributes to our understanding of how prenatal and postnatal exposure to MDS may shape early emotional reactivity and highlights the importance of exploring social information processes such as CP cognitions. Our findings suggest that MDS are related to lower negative emotionality and heightened affective concern when mothers held prenatal CP cognitions that were more focused on their own emotions rather than their infants' emotional state and needs. These results have implications for infants' mental health and meaning-making process (Tronick & Beeghly, 2011). Tronick & Beeghly (2011) suggest that from early on, infants make nonverbal "meaning" about themselves in relation to their environment which shapes their ongoing social engagements. Atypical forms of meaning-making may develop in the context of caregiver–child interactions that are characterized by prolonged mismatches and unsuccessful reparations. In these cases, infants may perceive themselves as helpless and hopeless and become depressed or withdrawn or feel threatened by their environment and become hypervigilant and anxious. In the current study, the

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low levels of negative emotionality and high levels of affective concern when exposed to MDS and maladaptive CP cognitions can represent an aberrant process of meaning-making that can ultimately amplify vulnerability to psychopathology. Hence, early interventions aimed at promoting adaptive infant-oriented CP cognitions are important for supporting infants' healthy emotional development. For example, the Nurture and Play (NaP; Salo et al., 2019) is an evidence-based perinatal group intervention that focuses on improving maternal reflective functioning (i.e., the capability of explicitly describing feelings, intentions, and thoughts underlying own own and others' behavior; Fonagy et al., 1991; Slade et al., 2009). During the intervention, expectant mothers learn how their own mental states influence their interactive behavior with their future infants, and how the child's mental states operate and influence the child's behavior, as well as the mother's own mind and behavior (Salo et al., 2019). Enhancing these abilities can promote the ability to focus on the child's needs, desires, and wellbeing in the face of infants' cry and distress and subsequently lead to more sensitive caregiving.

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Competing interests. None.

References

Abramson, L., Paz, Y., & Knafo-Noam, A. (2019). From negative reactivity to empathic responding: Infants high in negative reactivity express more empathy later in development, with the help of regulation. *Developmental Science*, *22*(3), e12766.

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage.

Apter-Levy, Y., Feldman, M., Vakart, A., Ebstein, R. P., & Feldman, R. (2013). Impact of maternal depression across the first 6 years of life on the child's mental health, social engagement, and empathy: The moderating role of oxytocin. *American Journal of Psychiatry*, *170*(10), 1161–1168. https://doi.org/10.1176/appi.ajp.2013.12121597

Babineau, V., Green, C. G., Jolicoeur-Martineau, A., Bouvette-Turcot, A. A., Minde, K., Sassi, R., & project, M. A. V. A. N. (2015). Prenatal depression and 5-HTTLPR interact to predict dysregulation from 3 to 36 months-A differential susceptibility model. *Journal of Child Psychology and Psychiatry*, *56*(1), 21–29.

Barker, E. D., Jaffee, S. R., Uher, R., & Maughan, B. (2011). The contribution of prenatal and postnatal maternal anxiety and depression to child maladjustment. *Depression and Anxiety*, *28*(8), 696–702.

Barnes, J., & Theule, J. (2019). Maternal depression and infant attachment security: A meta-analysis. *Infant Mental Health Journal*, *40*(6), 817–834.

Beck, C. T. (2001). Predictors of postpartum depression: An update. *Nursing Research*, *50*(5), 275–285.

Beebe, B., Lachmann, F., Jaffe, J., Markese, S., Buck, K. A., Chen, H., Cohen, P., Feldstein, S., & Andrews, H. (2012). Maternal postpartum depressive symptoms and 4-month mother-infant interaction. *Psychoanalytic Psychology*, *29*(4), 383–407. https://doi.org/10.1037/a0029387

Bell, S. M., & Ainsworth, M. D. S. (1972). *Infant crying and maternal responsiveness* (pp. 1171–1190). Child Development.

Bernard, K., Nissim, G., Vaccaro, S., Harris, J. L., & Lindhiem, O. (2018). Association between maternal depression and maternal sensitivity from birth to 12 months: A meta-analysis. *Attachment & Human Development*, *20*(6), 578–599.

Biringen, Z. (2008). *The emotional availability (E.A.) scales* (4 ed.). Department of Human Development and Family Studies, Colorado State University.

Blandon, A. Y., Calkins, S. D., Keane, S. P., & O'Brien, M. (2010). Contributions of child's physiology and maternal behavior to children's trajectories of temperamental reactivity. *Developmental Psychology*, *46*(5), 1089–1102. https://doi.org/10.1037/a0020678

Braungart-Rieker, J. M., Hill-Soderlund, A. L., & Karrass, J. (2010). Fear and anger reactivity trajectories from 4 to 16 months: The roles of temperament, regulation, and maternal sensitivity. *Developmental Psychology*, *46*(4), 791–804.

Brennan, P. A., Pargas, R., Walker, E. F., Green, P., Jeffrey Newport, D., & Stowe, Z. (2008). Maternal depression and infant cortisol: Influences of timing, comorbidity and treatment. *Journal of Child Psychology and Psychiatry*, *49*(10), 1099–1107.

Bridgett, D. J., Gartstein, M. A., Putnam, S. P., McKay, T., Iddins, E., Robertson, C., Ramsay, K., & Rittmueller, A. (2009). Maternal and contextual influences and the effect of temperament development during infancy and parenting in toddlerhood. *Infant Behavior and Development*, *32*(1), 103–116. https://doi.org/10.1016/j.infbeh.2008.10.007

Buss, A. H., & Plomin, R. (1984). *Temperament: Early developing personality traits*. Freeman.

Chan, J. C., Nugent, B. M., & Bale, T. L. (2018). Parental advisory: Maternal and paternal stress can impact offspring neurodevelopment. *Biological Psychiatry*, *83*(10), 886–894.

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression: Development of the 10-item edinburgh postnatal depression scale. *The British Journal of Psychiatry*, *150*(6), 782–786.

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological Bulletin*, *115*(1), 74–101.

Cutrona, C., & Troutman, B. (1986). Social support, infant temperament, and parenting self-efficacy: A mediational model of postpartum depression. *Child Development*, *57*(6), 1507–1518. https://doi.org/10.2307/1130428

Davidov, M., Paz, Y., Roth-Hanania, R., Uzefovsky, F., Orlitsky, T., Mankuta, D., & Zahn-Waxler, C. (2021). Caring babies: Concern for others in distress during infancy. *Developmental Science*, *24*(2), e13016.

Davidov, M., Zahn-Waxler, C., Roth-Hanania, R., & Knafo, A. (2013). Concern for others in the first year of life: Theory, evidence, and avenues for research. *Child Development Perspectives*, *7*(2), 126–131.

Davis, E. P., Glynn, L. M., Waffarn, F., & Sandman, C. A. (2011). Prenatal maternal stress programs infant stress regulation. *Journal of Child Psychology and Psychiatry*, *52*(2), 119–129.

Deave, T., Heron, J., Evans, J., & Emond, A. (2008). The impact of maternal depression in pregnancy on early child development. *BJOG: An International Journal of Obstetrics & Gynaecology*, *115*(8), 1043–1051.

Eisenberg, N., Shea, C. L., Carlo, G., & Knight, G. P. (2014). Empathy-related responding and cognition: A, chicken and the egg, dilemma. In *Handbook of moral behavior and development* (pp. 85–110). Psychology Press.

Ertel, K. A., Koenen, K. C., Rich-Edwards, J. W., & Gillman, M. W. (2010). Antenatal and postpartum depressive symptoms are differentially associated with early childhood weight and adiposity. *Paediatric and Perinatal Epidemiology*, *24*(2), 179–189.

Evans, J., Melotti, R., Heron, J., Ramchandani, P., Wiles, N., Murray, L., & Stein, A. (2012). The timing of maternal depressive symptoms and child cognitive development: A longitudinal study. *Journal of Child Psychology and Psychiatry*, *53*(6), 632–640.

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. *Infant Behavior and Development*, *33*(1), 1–6.

Field, T., Diego, M., & Hernandez-Reif, M. (2009). Depressed mothers' infants are less responsive to faces and voices. *Infant Behavior and Development*, *32*(3), 239–244.

Fonagy, P., Steele, M., Steele, H., Moran, G. S., & Higgitt, A. C. (1991). The capacity for understanding mental states: The reflective self in parent and child and its significance for security of attachment. *Infant Mental Health Journal*, *12*, 201–218.

Forman, D. R., O'Hara, M. W., Stuart, S., Gorman, L. L., Larsen, K. E., & Coy, K. C. (2007). Effective treatment for postpartum depression is not sufficient to improve the developing mother-child relationship. *Development and Psychopathology*, *19*(2), 585–602.

Glover, V. (2011). Annual Research Review: Prenatal stress and the origins of psychopathology: An evolutionary perspective. *Journal of Child Psychology and Psychiatry*, *52*(4), 356–367.

Gluckman, P. D., Hanson, M. A., & Buklijas, T. (2010). A conceptual framework for the developmental origins of health and disease. *Journal of Developmental Origins of Health and Disease*, *1*(1), 6–18.

Goldsmith, H. H., & Rothbart, M. K. (1999). *The laboratory temperament assessment battery (prelocomotor version, edition 3.1)*. University of Wisconsin-Madison.

Goodman, S. H., & Gotlib, I. H. (1999). Risk for psychopathology in the children of depressed mothers: A developmental model for understanding mechanisms of transmission. *Psychological Review*, *106*(3), 458–490. https://doi.org/10.1037/0033-295X.106.3.458

Goodman, S. H., Rouse, M. H., Connell, A. M., Broth, M. R., Hall, C. M., & Heyward, D. (2011). Maternal depression and child psychopathology: A meta-analytic review. *Clinical Child and Family Psychology Review*, *14*(1), 1–27.

Grace, S. L., Evindar, A., & Stewart, D. E. (2003). The effect of postpartum depression on child cognitive development and behavior: A review and critical analysis of the literature. *Archives of Women's Mental Health*, *6*(4), 263–274.

Gustafsson, H. C., Sullivan, E. L., Nousen, E. K., Sullivan, C. A., Huang, E., Rincon, M., Nigg, J. T., & Loftis, J. M. (2018). Maternal prenatal depression predicts infant negative affect via maternal inflammatory cytokine levels. *Brain, Behavior, and Immunity*, *73*, 470–481.

Guyon-Harris, K., Huth-Bocks, A., Lauterbach, D., & Janisse, H. (2016). Trajectories of maternal depressive symptoms across the birth of a child: Associations with toddler emotional development. *Archives of Women's Mental Health*, *19*(1), 153–165.

Haltigan, J. D., Leerkes, E. M., Burney, R. V., O'Brien, M., Supple, A. J., & Calkins, S. D. (2012). The infant crying questionnaire: Initial factor structure and validation. *Infant Behavior and Development*, *35*(4), 876–883.

Hay, D. F., Asten, P., Mills, A., Kumar, R., Pawlby, S., & Sharp, D. (2001). Intellectual problems shown by 11-year-old children whose mothers had postnatal depression. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(7), 871–889.

Hechler, C., Beijers, R., Riksen-Walraven, M., & De Weerth, C. (2019). Prenatal predictors of postnatal quality of caregiving behavior in mothers and fathers. *Parenting*, *19*(1-2), 101–119. https://doi.org/10.1080/15295192.2019.1556010

Hentges, R. F., Graham, S. A., Fearon, P., Tough, S., & Madigan, S. (2020). The chronicity and timing of prenatal and antenatal maternal depression and anxiety on child outcomes at age 5. *Depression and Anxiety*, *37*(6), 576–586.

Hoffman, C., Crnic, K. A., & Baker, J. K. (2006). Maternal depression and parenting: Implications for children's emergent emotion regulation and behavioral functioning. *Parenting: Science and Practice*, *6*(4), 271–295.

Hoffman, M. L. (1975). Developmental synthesis of affect and cognition and its implications for altruistic motivation. *Developmental Psychology*, *11*(5), 607–622.

Hoffman, M. L. (2001). *Empathy and moral development: Implications for caring and justice*. Cambridge University Press.

Horwitz, S. M., Briggs-Gowan, M. J., Storfer-Isser, A., & Carter, A. S. (2009). Persistence of maternal depressive symptoms throughout the early years of childhood. *Journal of Women's Health*, *18*(5), 637–645.

Johnson, P. O., & Neyman, J. (1936). *Tests of certain linear hypotheses and their application to some educational problems*. Statistical research memoirs.

Jones, N. A., Field, T., & Davalos, M. (2000). Right frontal EEG asymmetry and lack of empathy in preschool children of depressed mothers. *Child Psychiatry and Human Development*, *30*(3), 189–204.

Knafo, A., Zahn-Waxler, C., Van Hulle, C., Robinson, J. L., & Rhee, S. H. (2008). The developmental origins of a disposition toward empathy: Genetic and environmental contributions. *Emotion*, *8*(6), 737–752.

Lai, K. (2018). Estimating standardized SEM parameters given nonnormal data and incorrect model: Methods and comparison. *Structural Equation Modeling: A Multidisciplinary Journal*, *25*(4), 600–620.

Leerkes, E., & Qu, J. (2017). The maternal (Non) responsiveness questionnaire: Initial factor structure and validation. *Infant and Child Development*, *26*(3), 1–14.

Leerkes, E., Sommers, S., & Bailes, L. (2022). The validity of prenatal assessments of mothers' emotional, cognitive, and physiological reactions to infant cry. *Parenting*, *22*(4), 286–314.

Leerkes, E. M. (2010). Predictors of maternal sensitivity to infant distress. *Parenting: Science and Practice*, *10*(3), 219–239.

Leerkes, E. M., & Augustine, M. E. (2019). Parenting and emotions. In *Handbook of parenting* (pp. 620–653). Routledge.

Leerkes, E. M., Parade, S. H., & Gudmundson, J. A. (2011). Mothers' emotional reactions to crying pose risk for subsequent attachment insecurity. *Journal of Family Psychology*, *25*(5), 635–643. https://doi.org/10.1037/a0023654

Leerkes, E. M., Supple, A. J., O'Brien, M., Calkins, S. D., Haltigan, J. D., Wong, M. S., & Fortuna, K. (2015). Antecedents of maternal sensitivity during distressing tasks: Integrating attachment, social information processing, and psychobiological perspectives. *Child Development*, *86*(1), 94–111.

Leerkes, E. M., Weaver, J. M., & O'Brien, M. (2012). Differentiating maternal sensitivity to infant distress and non-distress. *Parenting*, *12*(2-3), 175–184.

Lemerise, E. A., & Arsenio, W. F. (2000). An integrated model of emotion processes and cognition in social information processing. *Child Development*, *71*(1), 107–118.

Liddle, M. J. E., Bradley, B. S., & Mcgrath, A. (2015). Baby empathy: Infant distress and peer prosocial responses. *Infant Mental Health Journal*, *36*(4), 446–458.

Lins, T., Alvarenga, P., Havighurst, S., & Silva, A. C. S. D. (2023). Maternal depressive symptoms and child internalizing problems: The mediation of emotion socialization. *Family Relations*, *72*(4), 2123–2136.

Lipscomb, S. T., Leve, L. D., Harold, G. T., Neiderhiser, J. M., Shaw, D. S., Ge, X., & Reiss, D. (2011). Trajectories of parenting and child negative emotionality during infancy and toddlerhood: A longitudinal analysis. *Child Development*, *82*(5), 1661–1675. https://doi.org/10.1111/j.1467-8624.2011.01639

Little, R. J. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association*, *83*(404), 1198–1202.

Liu, X., Wang, S., & Wang, G. (2022). Prevalence and risk factors of postpartum depression in women: A systematic review and meta-analysis. *Journal of Clinical Nursing*, *31*(19-20), 2665–2677.

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review*, *20*(5), 561–592.

Luoma, I., Tamminen, T., Kaukonen, P., Laippala, P., Puura, K., Salmelin, R., & Almqvist, F. (2001). Longitudinal study of maternal depressive symptoms and child well-being. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(12), 1367–1374.

Madigan, S., Oatley, H., Racine, N., Fearon, R. M. P., Schumacher, L., Akbari, E., Cooke, J. E., & Tarabulsy, G. M. (2018). A meta-analysis of maternal prenatal depression and anxiety on child socioemotional development. *Journal of the American Academy of Child & Adolescent Psychiatry*, *57*(9), 645–657.

Martins, C., & Gaffan, E. A. (2000). Effects of early maternal depression on patterns of infant-mother attachment: A meta-analytic investigation. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *41*(6), 737–746.

Maughan, A., Cicchetti, D., Toth, S. L., & Rogosch, F. A. (2007). Early-occurring maternal depression and maternal negativity in predicting young children's emotion regulation and socioemotional difficulties. *Journal of Abnormal Child Psychology*, *35*(5), 685–703.

Murray, L., Arteche, A., Fearon, P., Halligan, S., Goodyer, I., & Cooper, P. (2011). Maternal postnatal depression and the development of depression in offspring up to 16 years of age. *Journal of the American Academy of Child & Adolescent Psychiatry*, *50*(5), 460–470.

Muthén, L. K., & Muthén, B. O. (2021). *Mplus: Statistical analysis with latent variables*.

Nolvi, S., Bridgett, D. J., Korja, R., Kataja, E., Junttila, N., Karlsson, H., & Karlsson, L. (2019). Trajectories of maternal pre- and postnatal anxiety and depressive symptoms and infant fear: Moderation by infant sex. *Journal of Affective Disorders*, *257*, 589–597. https://doi.org/10.1016/j.jad.2019.07.055

Partridge, T., & Lerner, L. V. (2007). A latent growth-cure approach to infant temperament. *Infant and Child Development*, *16*(3), 255–265.

Paz, Y., Orlitsky, T., Roth-Hanania, R., Zahn-Waxler, C., & Davidov, M. (2021). Predicting externalizing behavior in toddlerhood from early

individual differences in empathy. *Journal of Child Psychology and Psychiatry*, *62*(1), 66–74.

Pearson, R. M., Evans, J., Kounali, D., Lewis, G., Heron, J., Ramchandani, P. G., O'Connor, T. G., & Stein, A. (2013). Maternal depression during pregnancy and the postnatal period: Risks and possible mechanisms for offspring depression at age 18 years. *JAMA Psychiatry*, *70*(12), 1312–1319.

Pratt, M., Goldstein, A., Levy, J., & Feldman, R. (2017). Maternal depression across the first years of life impacts the neural basis of empathy in preadolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *56*(1), 20–29.

Premo, J. E., & Kiel, E. J. (2016). Maternal depressive symptoms, toddler emotion regulation, and subsequent emotion socialization. *Journal of Family Psychology*, *30*(2), 276–285.

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development: An International Journal of Research and Practice*, *17*(4), 387–405.

Radke-Yarrow, M., Zahn-Waxler, C., Richardson, D. T., Susman, A., & Martinez, P. (1994). Caring behavior in children of clinically depressed and well mothers. *Child Development*, *65*(5), 1405–1414.

Roth-Hanania, R., Davidov, M., & Zahn-Waxler, C. (2011). Empathy development from 8 to 16 months: Early signs of concern for others. *Infant Behavior and Development*, *34*(3), 447–458.

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon, & N. Eisenberg (Ed.), *Handbook of child psychology: Vol. 3. social, emotional and personality development*. (5th ed. pp. 105–176). Wiley.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In N. Eisenberg, W. Damon, & R. M. Lerner (Ed.), *Handbook of child psychology: Social, emotional, and personality development* (pp. 99–166). John Wiley & Sons, Inc.

Salo, S. J., Flykt, M., Mäkelä, J., Biringen, Z., Kalland, M., Pajulo, M., & Punamäki, R. L. (2019). The effectiveness of nurture and play: A mentalisation-based parenting group intervention for prenatally depressed mothers. *Primary Health Care Research & Development*, *20*, e157.

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, *81*(1), 6–22.

Savory, K., Garay, S. M., Sumption, L. A., Kelleher, J. S., Daughters, K., Janssen, A. B., Van Goozen, S., & John, R. M. (2020). Prenatal symptoms of anxiety and depression associated with sex differences in both maternal perceptions of one year old infant temperament and researcher observed infant characteristics. *Journal of Affective Disorders*, *264*, 383–392.

Shapiro, A. F., Jolley, S. N., Hildebrandt, U., & Spieker, S. J. (2018). The effects of early postpartum depression on infant temperament. *Early Child Development and Care*, *90*(12), 1918–1930.

Shaw, D. S., Schonberg, M., Sherrill, J., Huffman, D., Lukon, J., Obrosky, D., & Kovacs, M. (2006). Responsivity to offspring's expression of emotion among childhood-onset depressed mothers. *Journal of Clinical Child and Adolescent Psychology*, *35*(4), 540–552.

Slade, A., Cohen, L. J., Sadler, L. S., & Miller, M. (2009). The psychology and psychopathology of pregnancy. *Handbook of Infant Mental Health*, *3*, 22–39.

Sohr-Preston, S. L., & Scaramella, L. V. (2006). Implications of timing of maternal depressive symptoms for early cognitive and language development. *Clinical Child and Family Psychology Review*, *9*(1), 65–83.

Spinrad, T. L., Eisenberg, N., & Morris, A. S. (2022). Empathy-related responding in children. In *Handbook of moral development* (pp. 255–271). Routledge.

Spinrad, T. L., & Stifter, C. A. (2002). Maternal sensitivity and infant emotional reactivity: Concurrent and longitudinal relations. *Marriage & Family Review*, *34*(3-4), 243–263.

Spry, E., Moreno-Betancur, M., Becker, D., Romaniuk, H., Carlin, J. B., Molyneaux, E., Howard, L. M., Ryan, J., Letcher, P., McIntosh, J., Macdonald, J. A., Greenwood, C. J., Thomson, K. C., McAnally, H., Hancox, R., Hutchinson, D. M., Youssef, G. J., Olsson, C. A., & Patton, G. C. (2020). Maternal mental health and infant emotional reactivity: A 20-year two-cohort study of preconception and perinatal exposures. *Psychological Medicine*, *50*(5), 827–837. https://doi.org/10.1017/S0033291719000709

Stern, J. A., & Cassidy, J. (2018). Empathy from infancy to adolescence: An attachment perspective on the development of individual differences. *Developmental Review*, *47*, 1–22.

Sutherland, S., Nestor, B. A., Pine, A. E., & Garber, J. (2022). Characteristics of maternal depression and children's functioning: A meta-analytic review. *Journal of Family Psychology*, *36*(5), 671–680.

Tone, E. B., & Tully, E. C. (2014). Empathy as a "risky strength": A multilevel examination of empathy and risk for internalizing disorders. *Development and Psychopathology*, *26*(4pt2), 1547–1565.

Tronick, E., & Beeghly, M. (2011). Infants' meaning-making and the development of mental health problems. *American Psychologist*, *66*(2), 107–119. https://doi.org/10.1037/a0021631

Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, *17*(2), 147–156.

Tully, E. C., & Donohue, M. R. (2017). Empathic responses to mother's emotions predict internalizing problems in children of depressed mothers. *Child Psychiatry & Human Development*, *48*(1), 94–106.

Vaish, A., & Grossmann, T. (2022). Caring for others: The early emergence of sympathy and guilt. In L. Sybil & D. F. B. Hart (Eds.). *Evolutionary perspectives on infancy* (pp. 349–369). Springer.

Van den Bergh, B. R. H., van den Heuvel, M. I., Lahti, M., Braeken, M., de Rooij, S. R., Entringer, S., Hoyer, D., Roseboom, T., Räikkönen, K., King, S., & Schwab, M. (2020). Prenatal developmental origins of behavior and mental health: The influence of maternal stress in pregnancy. *Neuroscience & Biobehavioral Reviews*, *117*, 26–64.

Vedhara, K., Metcalfe, C., Brant, H., Crown, A., Northstone, K., Dawe, K., Lightman, S., & Smith, G. D. (2012). Maternal mood and neuroendocrine programming: Effects of time of exposure and sex. *Journal of Neuroendocrinology*, *24*(7), 999–1011.

Wang, Z., Liu, J., Shuai, H., Cai, Z., Fu, X., Liu, Y., Xiao, X., Zhang, W., Krabbendam, E., Liu, S., Liu, Z., Li, Z., & Yang, B. X. (2021). Mapping global prevalence of depression among postpartum women. *Translational Psychiatry*, *11*(1), 543.

Wu, Y., Zhang, H., Wang, C., Broekman, B. F. P., Chong, Y.-S., Shek, L. P., Gluckman, P. D., Meaney, M. J., Fortier, M. V., & Qiu, A. (2021). Inflammatory modulation of the associations between prenatal maternal depression and neonatal brain. *Neuropsychopharmacology*, *46*(2), 470–477.

Zahn-Waxler, C., Radke-Yarrow, M., Wagner, E., & Chapman, M. (1992). Development of concern for others. *Developmental Psychology*, *28*(1), 126–136. https://doi.org/10.1037/0012-1649.28.1.126

Zahn-Waxler, C., Robinson, J. A. L., & Emde, R. N. (1992). The development of empathy in twins. *Developmental Psychology*, *28*(6), 1038–1047. https://doi.org/10.1037/0012-1649.28.6.1038

Zahn-Waxler, C., Schoen, A., & Decety, J. (2018). An interdisciplinary perspective on the origins of concern for others: Contributions from psychology, neuroscience philosophy and sociobiology. In N. Roughley, & T. Schramme (Eds.), *Forms of fellow feeling: Empathy, sympathy, concern and moral agency* (pp. 184–215). Cambridge University Press.

Zahn-Waxler, C., & Van Hulle, C. (2012). Empathy, guilt, and depression: When caring for others becomes costly to children. In B. Oakley, A. Knafo, G. Madhavan, & D. Wilson (Eds.), *Pathological altruism* (pp. 321–344). Oxford University Press.

Zenter, M., & Bates, J. E. (2008). Child temperament: An integrative review of concepts. *Research Programs, and Measures. European Journal of Developmental Science*, *2*, 7–37.