Maternal Depression and Anxiety Across the Postpartum Year and Infant Social Engagement, Fear Regulation, and Stress Reactivity

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ABSTRACT

Objective: To examine the effects of maternal depression on infant social engagement, fear regulation, and cortisol reactivity as compared with maternal anxiety disorders and controls and to assess the role of maternal sensitivity in moderating the relations between maternal depression and infant outcome. **Method:** Using an extreme-case design, 971 women reported symptoms of anxiety and depression after childbirth and 215 of those at the high and low ends were reevaluated at 6 months. At 9 months, mothers diagnosed with a major depressive disorder ($n = 22$) and anxiety disorders ($n = 19$) and matched controls reporting no symptoms across the postpartum year ($n = 59$) were visited at home. Infant social engagement was observed during mother–infant interaction, emotion regulation was microcoded from a fear paradigm, and mother's and infant's cortisol were sampled at baseline, reactivity, and recovery. **Results:** The infants of depressed mothers scored the poorest on all three outcomes at 9 months—lowest social engagement, less mature regulatory behaviors and more negative emotionality, and highest cortisol reactivity—with anxious dyads scoring less optimally than the controls on maternal sensitivity and infant social engagement. Fear regulation among the children of anxious mothers was similar to that of the controls and their stress reactivity to infants of depressed mothers. Effect of major depressive disorder on social engagement was moderated by maternal sensitivity, whereas two separate effects of maternal disorder and mother sensitivity emerged for stress reactivity. **Conclusions:** Pathways leading from maternal depression to infant outcome are specific to developmental achievement. Better understanding of such task-specific mechanisms may help devise more specifically targeted interventions. *J. Am. Acad. Child Adolesc. Psychiatry,* 2009;48(9):919–927.
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Maternal depression during the postpartum period has long been known to interfere with the mother's capacity to care for her infant.[1,2] Longitudinal studies demonstrate that children of depressed mothers exhibit poor cognitive, neuropsychological, social, and emotional skills across childhood and up to adolescence.[3–7] Maternal depression has similarly been shown to bear long-term negative consequences for the infant's physiological regulation, particularly the consolidation of the stress response.[8] In searching for mechanisms by which maternal depression affects infant development, researchers have suggested that, in addition to genetic vulnerability, depressed mothers are less competent in constructing a growth-promoting environment for their infants, and their relational behavior is characterized by low sensitivity, restricted range of affective expression, and inconsistent support of the infant's budding engagement.[3,6,7,9] Because sensitive mothering is critical for the infant's ability to handle social processes, regulate negative emotions, and manage physiological stress, the diminished sensitivity of depressed mothers may serve as an additional risk factor and disrupt the consolidation of early regulatory capacities that support cognitive,

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physiological, and social-emotional growth.[10,11] Moreover, evidence points to continuity from maternal to child depression and from early-onset to adolescent and adult depression,[6,11–14] underscoring the need to study the effects of maternal depression on child development already in the first year of life.

In this study, we detected cases of maternal depression and anxiety disorders from a large community cohort recruited in the second postbirth day and reevaluated at 6 months using an extreme-case design. Mothers diagnosed with depression and anxiety disorders at 9 months and who reported high symptoms of depression and anxiety across the postpartum year were observed at 9 months with their infants. Cases of maternal depression were compared with those of maternal anxiety as well as with the controls to distinguish outcomes related to maternal mood disorder from those specific to maternal depression. The separate and moderated effects of maternal disorder and mother sensitivity were examined in relation to three child outcomes at 9 months: social engagement, fear regulation, and physiological stress reactivity.

The mother's sensitive and warm relational style—which carefully adapts to the infant's signals; provides appropriate vocal, tactile, and affective stimulation; and is consistent and predictable—is considered the cornerstone of children's social-emotional growth.[15] Much research has shown that depressed mothers exhibit less consistent interactive behavior, provide minimal warmth and positive affect, display less maternal behavior, touch their infants less frequently, and are unable to construct affective synchrony with the child.[7,9–11,16] Significantly less research has focused on interactions between mothers with anxiety disorders and their infants, and the existing studies report mixed results.[17] Whereas some studies failed to show differences between anxious mothers and controls, others indicate that anxious mothers are overstimulating and override the infant's moment-by-moment signals.[7,10,18,19] Overall, maternal anxiety and depression are expressed in two polarized styles. Anxious mothers exhibit intrusive behavior that is not suited to the infant's state, whereas depressed mothers show flat and withdrawn affect and rarely engage in a true social exchange. Both styles deprive infants of the critical growth-promoting elements in the mother's sensitive style.

Social engagement, emotion regulation, and stress management are three global developmental goals that consolidate during the first year of life into relatively stable trajectories, draw on the mother's sensitive style, and are disrupted in cases of maternal depression. Social engagement involves a set of skills that enables individuals to enter into a social dialogue, form and maintain social ties, and function adaptively within the social milieu.[20] Such abilities depend on brainstem-mediated physiological support systems and form the basis for social adaptation, empathy, and the capacity for intimacy throughout life.[21,22] Infants' social engagement in its rudimentary form begins at birth with the neonate's preference for the human face and selective response to social contingencies[23,24] and undergoes further reorganization in the third month of life with the development of the face-to-face synchronous exchange.[10] Toward the end of the first year, with the emergence of intersubjectivity and intentionality,[25] interactions between parents and infants become more reciprocal, and infants' social engagement increases dramatically.[20] The infant's capacity for social engagement depends on the provision of sensitive parenting.[15] A longitudinal study assessing social engagement repeatedly from birth to 5 years found that social engagement at each time point was predicted by maternal sensitivity at a previous point, and maternal depression altered the trajectory of social engagement, suggesting that mother sensitivity and maternal depression jointly shape the development of social engagement.[26]

Similar to social engagement, infants' emotion regulation undergoes a developmental transition in the second 6 months of life with the emergence of object exploration, mobility, and intentional action, in particular, the capacity to handle stressful situations.[27,28] Toward the end of the first year, infants' regulatory repertoire expands, and tactics, such as turning away from the source of distress, manipulation of objects, or exploration of new events, by which infants actively regulate the distress inherent in novel experiences, replace the more infantile strategies of gaze aversion, fussing, or crying, which attempt to alleviate distress by arousing the caregiver. Infants' regulation of negative emotions, especially the regulation of fear and novelty, is sensitive to the mother's depressed mood.[11] It has been suggested that the mother's inability to regulate her own affect disrupts her capacity to offer a regulatory framework to the infant, limiting the infant's ability to move from the helpless strategies of infancy to tactics that involve more active forms of coping.[29]

Infants' physiological response to stress is similarly susceptible to the mother's negative mood. Animal studies have shown that the hypothalamic-pituitary-adrenal (HPA) stress management system is sensitive to rearing conditions simulating maternal depression, such as maternal deprivation or decrease in tactile contact.[30,31] Similar disruptions to HPA-axis reactivity have been demonstrated in offspring of animals experiencing prenatal stress, pointing to the cross-generation transmission of the stress response and its sensitivity to maternal stress and depression.[32] Studies in human infants have described alterations in diurnal cortisol rhythms, elevated baseline cortisol levels, and heightened cortisol reactivity in children of depressed and anxious mothers across infancy and up to adolescence,[33,34] pointing to the potential for lifelong disruptions to the stress response after early exposure to maternal negative mood. Apart from maternal mood, infants' cortisol reactivity has been associated with the mother's postpartum behavior, particularly with the degree of maternal sensitivity.[35] These findings suggest that maternal negative mood and mother sensitivity may exert two separate effects on the development of the infant's stress response during the first months of life.

In light of the above, the present study examined the effects of maternal depression and anxiety on three infant outcomes at 9 months: social engagement, fear regulation, and cortisol reactivity. To specify the mechanisms linking maternal depression to infant development, we recruited a large community cohort, assessed the chronicity of the mother's mood from birth, and compared the effects of maternal depression with those of maternal anxiety disorders. Furthermore, to tease apart the effects of maternal depression from those of typically co-occurring risk conditions, such as single parenthood, teenage pregnancy, or premature birth, we recruited women who were physically healthy, educated, and in a stable relationship and those who delivered a healthy term infant. The separate and moderated effects of maternal depression and anxiety disorders and mother sensitivity were examined for each outcome. In light of research showing that the trajectory of social engagement was altered in cases of maternal depression,[26] we expected that maternal sensitivity would moderate the relations between maternal depression and child social engagement. As to fear regulation and cortisol reactivity, we expected that maternal disorder and mother sensitivity would exert two separate risks. Finally, it was hypothesized that the mother's sensitive, intrusive, and withdrawn styles would each be associated in a specific way with social engagement, fear regulation, and cortisol reactivity at 9 months.

METHOD

Participants

The initial sample included 971 mothers who completed measures of anxiety and depressive symptoms on the 2nd post-birth day. Assistants visited the maternity wards of two tertiary care hospitals in a large metropolitan area and invited women who were physically healthy by their own account, delivered a healthy term singleton infant (excluding genetic disorders and infants requiring specialized medical care or NICU hospitalization), completed at least 12 years of education, and were cohabitating with the infant's father to participate in a study on maternal postpartum mood. Recruitments were conducted twice a week in each ward between February 2001 and September 2002 and approximately 40% of the women approached refused participation. Hospital records showed no systematic differences on demographic variables between participating and declining women or between women in the two hospitals.

At six months postpartum, we mailed questionnaires of anxiety, depression, and parenting to 360 women (180 at the top and 180 at the bottom of the depressive symptoms continuum at birth) and 215 questionnaires were returned (59.7%) with no significant differences between groups. Among the non-returned questionnaires, 55 returned for wrong address and 90 mothers (25%) declined further participation and the information collected at birth showed no differences in demographic, medical, or mood variables from the participating families. Of those reporting at 6 months, we contacted 150 mothers in the upper and lower ends of the depressive symptoms continuum when infants were 9 months. The final sample at 9 months included 100 dyads. Of the 41 mothers composing the clinical group, 22 had a major depressive disorder (MDD), and 19 had an anxiety disorder (generalized anxiety disorder, social phobia, specific phobias, or panic disorder). These mothers also scored high on depressive and anxiety symptoms, respectively (State-Trait Anxiety Inventory[36] > 43; Beck Depression Inventory [BDI][37] > 9) at all 3 assessments. Mothers with schizophrenia, schizoaffective disorders, bipolar disorder, and subclinical levels of anxiety or depression were not included as well as one mother with two Axis I diagnoses of MDD and anxiety disorder. Seven mothers in the MDD group and three in the anxiety group were treated by medications, and these did not differ on any maternal or infant measure from the members of their respective groups. Fifty-nine mothers, matched to the clinical group in age, education, parenting experience (prima/multipara), and infant birth weight and sex, were included as controls. These mothers reported low anxiety and depressive symptoms on all three assessments. The mothers in the final sample (53 boys) were, on average, 30.7 years (SD 3.4) and completed 15.8 years (SD 2.6) of education, and 45% were first-time mothers.

Procedure

The 9-month assessment included two home visits. In the first, the mothers were diagnosed with the Structured Clinical Interview

for *DSM-IV* Axis-I Disorders[38] by a trained clinical psychologist and completed self-report measures. In the second, mother–infant interaction was videotaped, infants' emotion regulation was tested, and cortisol was sampled from mother and child.

Mother–Infant Free Play. Mothers and infants engaged in free play for 6 minutes. Instructions were "play with your child as you normally do."

Fear Regulation. In this procedure, adapted from the Laboratory Temperament Assessment Battery,[39] infants sat in an infant seat, and the experimenter put on four masks of increasing fearfulness while the infant was looking: clown, pet animal, scary animal, and ghost. The experimenter put on the mask, called the infant's name, and left it on for 10 seconds.

Cortisol. Cortisol was sampled between 4 P.M. and 6 P.M. The mothers placed a roll of cotton in their own and the infant's mouth, and both chewed on it for 1 minute until it became saturated and was placed in a Salivette (Sarstedt, Rommelsdorft, Germany). Assays were collected on arrival (baseline), 20 minutes after the negative emotion procedures, and 15 minutes thereafter. Salivettes were kept frozen at −20°C until assayed. Before measurement, the samples were thawed and centrifuged at 1,000*g* for 15 minutes. Cortisol levels were assayed using a commercial RIA kit (Cout-a-Count Cortisol; Siemens Medical Solutions Diagnostics, Los Angeles, CA). Measurements were performed by a modification of the assay, diluting the provided calibrators 1:10 in distilled water, increasing the analyte volume (from 25 to 200 μL), increasing the incubation time from 45 to 180 minutes, and decreasing the incubation temperature from 37°C to room temperature. The intra-assay and interassay coefficient were 10.5% and 15%, respectively. Two variables were used here for mother and child: baseline cortisol (first assessment) and cortisol reactivity, computed as the difference between cortisol after stress (second assessment) and baseline cortisol. At each assessment, two to three samples were insufficient for analysis. Cortisol values were log transformed before data analysis.

Measures

Structured Clinical Interview for DSM-IV Axis-I Disorders.[38] This is a semistructured, clinician-administered diagnostic interview that includes modules corresponding to major *DSM* psychiatric classifications.

Beck Depression Inventory.[37] This widely used 21-item self-report inventory is designed to measure the severity of depressive symptoms. Scores of above 9 indicate elevated depressive symptoms and a risk for MDD.[40]

State-Trait Anxiety Inventory.[36] This widely-used instrument examines transitory anxiety states and stable propensity for anxiety. The trait anxiety score was used. Scores of 43 or above are considered a risk indicator for anxiety disorders.[41]

Maternal Adjustment and Maternal Attitudes. This 60-item instrument assesses maternal attitudes during pregnancy and after childbirth. The Attitudes toward Pregnancy and Infant scale was used, which showed good test-retest reliability.[42]

Parenting Stress. The Parenting Stress Index is a 36-item questionnaire measuring the magnitude of stress in the parent–child system and has been widely used, with good reliability.[43]

Parental Competence. The Parental Competence and Satisfaction Scale is a 17-item instrument assessing competence, frustration, and problem solving in the parenting role with good reliability and validity.[44]

Social Support. The Social Support Scale[45] is a 12-item instrument assessing the parent's perception of support availability in different domains (e.g., attachment, guidance, reassurance of worth), with good reliability and validity.

Coding

Mother–Infant Interactions. Interactions were coded using the Coding Interactive Behavior Manual.[46] The Coding Interactive Behavior Manual is a global coding system for adult–child interactions consisting of 45 codes that aggregate into several composites. The system has been applied to a wide range of normative and high-risk samples from birth to adolescence and has shown sensitivity to infant age, culture, interacting partner, biological and social-emotional risk conditions, and effects of intervention, and has good psychometric properties[9,19,24,26] Two coders, trained to 90% reliability and unaware of maternal psychiatric status, coded the interactions. Reliability was conducted for 20 interactions, and reliability κ's were averaged .86 (range .78 – .95). The following constructs were used, each including the following averaged scales.

Maternal Sensitivity (α = .92). This includes mother acknowledgement of child communications, warm vocal quality, continuous gaze, appropriate range of affect, resourcefulness, consistency of style, adaptation to infant signals, and supportive presence.

Mother Intrusiveness (α = .85). Mother overriding behavior, physical manipulation, maternal anxiety, mother hostility, and interactions are judged to be mother led.

Mother Withdrawal (α = .91). This includes maternal depressed mood and mother positive affect (reversed).

Child Social Engagement (α = .86). This includes infant alertness, fussiness (reversed), social initiation, vocalizations, gaze maintenance, and positive affect.

Fear regulation. The fear episode was microcoded in 0.01-second frames using a computerized system for four categories of behavior, each including a set of codes: gaze, affect, vocalization, and regulatory behavior. Two factors were used: infant negative emotionality was the standardized sum of fuss and cry codes from the vocalization category, and infant regulatory behavior was the standardized sum of infant self-regulatory behavior (e.g., sucking thumb), manipulating objects (e.g., strap of chair), and goal-directed behavior (e.g., trying to reach the mask). Two coders coded the fear episode and reliability, measured on 15 interactions, averaged κ = 0.82 (range 0.73–0.91). A list of all study measures according to age of assessment is shown in Table 1.

RESULTS

Postpartum Anxiety and Depressive Symptoms in a Large Community Cohort

Overall, in this large community cohort on the second postbirth day, 25.2% of the women reported subclinical depressive symptoms (BDI > 9), and 3.6% reported severe depressive symptoms (BDI > 15). High symptoms of anxiety (State-Trait Anxiety Inventory > 43) were reported by 12.2% of parturient women.

At 6 months, maternal depressive and anxiety symptoms were related to less optimal measures of parenting, in terms of higher stress, lower sense of competence, and less social support (Table 2). Lower maternal

TABLE 1
Study Measures at the Three Assessment Points

Time 1: Second day postpartum in maternity ward (N = 971)
Depressive symptoms (BDI—Beck, 1978)[37]
Anxiety symptoms (STAI—Spielberger et al., 1970)[36]
Maternal adjustment and maternal attitudes (MAMA—Kumar et al., 1984)[42]
Time 2: Six months postpartum by mail (N = 215)
Depressive symptoms (BDI)[37]
Anxiety symptoms (STAI)[36]
Parenting stress (PSI—Abidin, 1983)[43]
Parenting competence (PCSC—Johnston and Mash, 1989)[44]
Social support (Cutrona, 1984)[45]
Time 3: Nine months postpartum—home visit (N = 100)
Depressive symptoms (BDI)[37]
Anxiety symptoms (STAI)[36]
Structured clinical interview (SCID—First et al., 1995)[38]
Mother–infant interaction—mother sensitivity, mother intrusiveness, mother withdrawal, child social engagement (CIB—Feldman, 1998)[46]
Fear paradigm—fear regulation, negative emotionality (LAB-TAB—Goldsmith and Rothbart, 1996)[39]
Cortisol—baseline and reactivity from mother and infant

Note: BDI = Beck Depression Inventory; CIB = Coding Interactive Behavior Manual; LAB-TAB = Laboratory Temperament Assessment Battery; MAMA = Maternal Adjustment and Maternal Attitudes; PCSC = Parental Confidence and Satisfaction Scale; PSI = Parenting Stress Index; SCID = Structured Clinical Interview for *DSM-IV* Axis I Disorders; STAI = State-Trait Anxiety Inventory.

adjustment at birth correlated with higher symptoms at 6 months. No differences between anxious and depressed mothers emerged for the four measures of parenting, and both groups scored less optimally than the controls. Maternal anxiety and depressive symptoms were interrelated at each time point (r = 0.43–0.57, $p < .001$).

Group Differences in Maternal Relational Behavior and Child Outcomes

Mother–Infant Relational Behavior. Multivariate analysis of variance with group (maternal depression, anxiety, and controls) and child sex as the between-subject factors conducted for the four relational factors yielded significant effect for group (Wilks $F_{8,182}$ = 3.02, $p < .01$, effect size [ES] = .11). Analyses of variance with Duncan's post hoc tests (Table 3) showed that mother sensitivity was highest among the controls, lower among the mothers with anxiety disorders, and lowest among the mothers with MDD. Mother intrusiveness was highest among the mothers with anxiety disorders, with no differences between those with MDD and the controls. Mother withdrawal was highest in the mothers with MDD compared with those with anxiety disorders and the controls. Child social engagement was lowest among the children of the mothers with MDD, higher in the children of the mothers with anxiety disorders, and highest in the children of the controls.

Infant Fear Regulation. Multivariate analysis of variance for the two regulatory factors—negative emotionality and regulatory behavior—showed significant group effect (Wilks $F_{4,186}$ = 3.11, $p < .01$, ES = .07). Post hoc analyses of variance (Table 3) showed that the infants of the mothers with MDD cried and fussed more during the paradigm and scored the lowest on regulatory behavior. Main effect for sex was (Wilks $F_{4,186}$ = 2.85, $p < .05$, ES = .04) related to higher negative emotionality among the boys.

Cortisol Reactivity. Analyses of variance conducted for infant cortisol baseline and reactivity showed significant differences between the children of the mothers with MDD and anxiety disorders and the controls, with no differences between clinical groups (Table 3). The findings are presented in Figure 1.

Mothers' and infants' baseline cortisol were interrelated (r = 0.71, $p < .001$), as well as their cortisol reactivity (r = 0.42, $p < .001$), pointing to mechanisms of cross-generation transmission.

Social engagement correlated with higher maternal sensitivity (r = 0.38, $p < .001$), lower maternal intrusiveness (r = −0.25, $p < .05$), and lower maternal withdrawal (r = −0.27, $p < .01$). Fear regulation correlated with lower maternal withdrawal (r = 0.33, $p < .01$), and negative emotionality correlated with higher maternal withdrawal (r = 0.28, $p < .01$). Infant baseline cortisol and cortisol reactivity correlated with lower maternal sensitivity (r = −0.32, −0.33; $p < .01$).

TABLE 2
Correlations Between Depressive and Anxiety Symptoms at 6 Months and Measures of Parenting

	Depressive Symptoms	Anxiety Symptoms
Maternal adjustment	−0.32***	−0.25*
Parenting stress	0.50***	0.50***
Parental competence	−0.52***	−0.49***
Social support	−0.40***	−0.45***

*$p < .05$; ***$p < .001$.

TABLE 3
Developmental Outcomes at 9 Months in Cases of Maternal Depression, Maternal Anxiety, and Controls

	A		B		C		
	Maternal Depression		Maternal Anxiety		Control		
	Mean	SD	Mean	SD	Mean	SD	*F*
Relational behavior							
Mother sensitivity[a]	3.16	0.83	3.87	0.92	4.08	0.95	4.33* c > b > a
Mother intrusiveness[a]	1.92	0.67	2.71	0.89	1.64	0.77	4.61** b > a,c
Mother withdrawal[a]	2.05	0.87	1.08	0.68	1.19	0.72	4.97** a > b,c
Child social engagement[a]	2.14	0.94	2.86	0.87	3.44	0.92	4.31* c > b > a
Fear regulation							
Negative emotionality[b]	0.09	0.06	0.05	0.03	0.02	0.01	3.99* a > b > c
Regulatory behavior[b]	0.15	0.11	0.20	0.14	0.27	0.19	4.02* c > a
Cortisol (μg/dL)							
Baseline	0.57	0.43	0.62	0.58	0.31	0.25	3.97* a,b > c
Reactivity	0.92	0.75	0.87	0.65	0.54	0.45	4.15* a,b > c
Recovery	0.72	0.62	0.63	0.48	0.37	0.22	4.04* a >c

[a] Numbers represent codes on a scale of 1 to 5.
[b] Numbers represent proportions of time out of the entire episode.
*$p < .05$; **$p < .01$.

Mother baseline cortisol and cortisol reactivity correlated with mother intrusiveness ($r = 0.23, 0.25$; $p < .05$).

Effects of Maternal Disorder on Child Outcome

In a series of hierarchical multiple regressions, we examined the separate and moderated effects of maternal disorder and mother sensitivity on child outcome. In each regression predicting social engagement, fear regulation, and cortisol reactivity, three predictors were entered. In the first block, maternal disorder was entered as a binary variable (depression and anxiety); in the second, mother sensitivity was entered, and in the third, the interaction of mother sensitivity and maternal disorder was entered. After obtaining significant findings for maternal disorder, we recomputed the same regressions once with maternal depression versus nondepression and again with maternal anxiety versus nonanxiety to assess the source of findings (Table 4).

Child Social Engagement. Child social engagement was uniquely predicted by maternal disorder, mother sensitivity, and their interaction, indicating a moderator model.[47] The separate models showed significant moderation only for MDD, not maternal anxiety. Assessment of the means with sensitivity divided into high/low using the median split showed that, in the high-sensitivity group, social engagement was unrelated to MDD. However, in the low-sensitivity group, social engagement was lower among the children of the mothers with MDD compared with the controls ($F_{1,47} = 4.42$, $p < .05$).

Fear Regulation. Maternal disorder, but not maternal sensitivity or their interaction, predicted fear regulation. In the separate models, only MDD emerged as a significant predictor of fear regulation.

Cortisol Reactivity. Maternal disorder and mother sensitivity, but not their interaction, each predicted cortisol reactivity, indicating two separate effects on

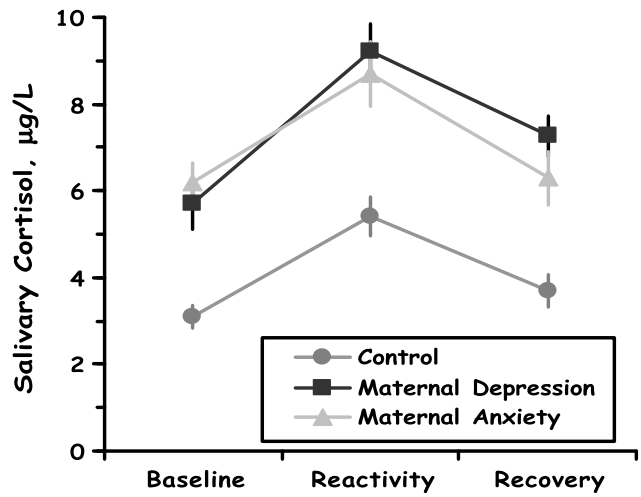

Fig. 1 Cortisol baseline, reactivity, and recovery in infants of the mothers with depression and anxiety and the controls.

TABLE 4
Direct and Mediated Effects of Maternal Affective Disorder on Infant Outcome at 9 Months

Criterion	Social Engagement			Fear Regulation			Cortisol Reactivity		
Predictors	β	R^2 Change	*F* Change	β	R^2 Change	*F* Change	β	R^2 Change	*F* Change
Maternal disorder	−.24*	0.07	6.86**	−.31*	0.11	10.96**	.29*	0.08	7.65**
Mother sensitivity	.32*	0.08	7.31**	.08	0.01	0.88	−.19*	0.06	5.11**
Maternal disorder × sensitivity	.40*	0.06	6.49**	−.02	0.00	0.65	.13	0.02	1.65
R^2 total	0.21, $F_{3,95} = 7.17$, $p < .001$.			0.12, $F_{3,95} = 3.98$, $p < .01$			0.16, $F_{5,95} = 5.84$, $p < .01$		

*$p < .05$; **$p < .01$.

stress reactivity. The separate models for MDD and maternal anxiety did not yield significant results, suggesting that maternal mood disorder, in general, is the component associated with disruptions to the infant's stress response.

DISCUSSION

Results of this study are the first to examine the effects of maternal depression in the postpartum year on three infant outcomes central for social-emotional growth—social engagement, fear regulation, and physiological stress reactivity—in comparison with both maternal anxiety disorders and controls. By recruiting a large community sample, separating maternal depression from typically occurring conditions, comparing cases of MDD with those of postpartum anxiety disorders, and assessing the chronicity of the mother's mood from birth, the findings may illuminate specific pathways leading from maternal depression to child outcomes across the first year of life. Furthermore, the unique associations found between maternal depression and each outcome underscore the need to consider maternal depression in the context of the child's global rearing environment and in relation to the attainment of specific developmental goals.

Maternal sensitivity was meaningfully related to infant social engagement and cortisol reactivity but not to fear regulation. In the prediction of social engagement, maternal sensitivity moderated the effects of MDD on social behavior, whereas two separate effects emerged for stress reactivity. These findings point to the importance of maternal sensitivity for the development of social competence. It is possible that maternal depression has an impact on the infant's social skills by diminishing the mother's sensitivity and limiting the infant's exposure to the growth-promoting elements in the maternal sensitive style. As seen, maternal anxiety and depression had a linear-decline effect on social engagement, with the children of the mothers with anxiety disorders scoring lower than the controls and those of the mothers with MDD scoring the poorest, parallel to the linear-decline pattern of maternal sensitivity. The mother's sensitive style is theorized as containing two parameters—the positive relational elements in the gaze, affect, vocal, and tactile modalities and the online coordination of these elements with the infant's social signals. Whereas the withdrawal associated with maternal depression disrupts both parameters, the mothers with anxiety disorders typically express adequate amounts of social behavior, but these are not adapted to the infant's cues. Thus, although the mother's negative mood is generally associated with lower sensitivity, the moderating effect of sensitivity was observed only in the more extreme case of MDD. These findings highlight the importance of interventions that provide training for maternal sensitivity to attenuate the effects of maternal depression on infant social development.

In contrast to the moderator model, mother sensitivity had an independent effect on infant stress reactivity, and the effect was not specific to MDD but appeared globally for maternal mood disorders. Research in animal and human infants demonstrates that prenatal stress shapes the fetus' stress response through structural changes to glucocorticoid receptors.[30,32] After birth, maternal postpartum sensitivity, similar to the licking and grooming of mammalian mothers, may have functioned to ameliorate some of the intrauterine effects on the child's physiological reactivity,[31] but the diminished sensitivity associated with MDD and anxiety disorders was not sufficient in buffering the prenatal effects. Animal studies on the cross-generation transmission of HPA reactivity discuss the combination of physiological effects and effects related to deficits in postpartum

maternal behavior in shaping the pup's compromised stress response,[30–34] and the present findings point to similar mechanisms in human infants.

Infants of depressed mothers displayed less mature regulatory strategies and higher negative emotionality, and their ability to use proactive and goal-directed tactics were limited. However, unlike social engagement and stress reactivity, maternal sensitivity was unrelated to fear regulation, and the maternal factor associated with emotion regulation and negative affect was maternal withdrawal. These findings echo animal research on the effects of maternal deprivation on the pup's diminished capacities to regulate negative arousal and on the centrality of the maternal presence and active engagement for the formation of biobehavioral regulators.[48]

The last quarter of the first year is a point of reorganization in the infant's environment-dependent capacities. During these months, infants begin to use symbols, intersubjectivity emerges with the infant's first signs of concern, and the infant's emotion regulation repertoire increases substantially. Individual differences in these abilities observed between 9 and 12 months serve as a basis of children's cognitive, neurobiological, social, and emotional growth across childhood and up to adolescence.[3,6,7,10,12] The detrimental effects of the mother's chronic negative mood on the infant's regulatory skills during this sensitive period have not been studied in detail, yet such research is central for addressing the long-term impact of maternal depression on infant development. Because children born to depressed mothers are more likely to experience depression at some point in their life,[3,6,11,12] specifying the source of the effect and its developmental course may enable the detection of risk at an earlier time point and may lead to the formation of more specific interventions.

Several limitations of the study are important to consider in the interpretation of the findings. First, although all infants grew in two-parent families, we did not collect information on fathers. The finding that fathering did not attenuate the effects of MDD may relate to the fact that these mothers reported high depressive symptoms across the postpartum year and the chronicity of maternal mood may have exacerbated the infant's difficulties, but the effects of fathering in the context of maternal depression requires much further research. Similarly, our sample was limited to women with high-school education, partner support, and healthy infants, and generalizability of the results to other groups needs further study. The fact that maternal sensitivity and infant social engagement were coded by the same coder may have influenced the associations between the two variables. In addition, there was a significant attrition between birth and 6 months, and although no differences were detected between mothers who did or did not respond and response rates fell within the typical range for survey studies, responding mothers may have differed from nonresponders on dimensions unrelated to the assessed mood, demographic, or medical factors. Finally, several potential confounders were not assessed, including maternal smoking and breast-feeding, and exploration of other relevant physiological systems and genetic markers could have contributed to a fuller understanding. Further research may follow the children of the mothers with depression across childhood, compare the effects of MDD with those of other birth conditions, and assess a range of physiological support systems that may be compromised by the infant's prenatal and postpartum exposure to the mother's chronic negative mood.

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