SECTION 4. EMOTIONAL CARE OF THE AT-RISK INFANT

Early Interventions for Infants of Depressed Mothers

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ABSTRACT. Infants of mothers who remain depressed for 1 year after birth have a distinct profile of behavioral, physiologic, and biochemical dysregulation. Their mothers also have a distinct profile that can be used to target those in need of intervention. These interventions may include mood induction, massage therapy, interaction coaching, and natural buffers such as nondepressed fathers and caregivers. Pediatrics 1998;102:1305–1310; mothers, infants, depression, intervention, mood induction, EEG, massage therapy, cortisol, vagal tone.

ABBREVIATION. EEG, electroencephalography.

Infants of mothers who remain depressed for 1 year after birth show a distinct profile of behavioral, physiologic, and biochemical dysregulation. Their mothers also have a profile that can be used to identify those mothers who are likely to remain depressed and to target high-risk mother–infant dyads in need of intervention. This article of New Perspectives in Early Emotional Development reviews data on identifying mothers who remain depressed; dysregulation in infants of depressed mothers; and interventions, both brief and intensive.

Recent research suggests the following:

• Maternal depression can negatively affect infants as early as the neonatal period, implicating prenatal effects of maternal depression.
• Infants show a profile of dysregulation in their behavior, physiology, and biochemistry that may be attributable to prenatal exposure to a maternal biochemical imbalance.
• These effects are compounded by the disorganizing influence of the mother’s interaction behavior.
• Depressed mothers have two predominant interaction styles, withdrawn or intrusive, that seem to have differential, negative effects on their infants because of inadequate stimulation and arousal modulation.
• Nondepressed caregivers such as fathers may buffer these effects because they provide more optimal stimulation and arousal modulation.
• Interventions that are mood-altering for the mothers and arousal-reducing for the infants (eg, music and massage therapy) make them more responsive to interaction coaching and improve their interactions.

The interventions we have been studying may be effective because 1) they induce a better mood state in the mothers (and alter right frontal electroencephalography [EEG], a marker of depression) and lower stress hormone (norepinephrine and cortisol) levels; 2) they reduce sympathetic arousal in the infants; and 3) reduced sympathetic arousal leads to improved responsiveness, greater availability to interaction coaching, and improved interactions.

DEPRESSED MOTHERS

Of the depressed mothers we studied, 70% had chronic depression that persisted during their infant’s first 6 months of life. These infants showed delays in growth and development at 12 months. Physiologic/biochemical markers for the mothers’ chronic depression included relative right frontal EEG activation; low vagal tone and serotonin; and elevated norepinephrine and cortisol levels. Measurement of these variables at 3 months accounted for 51% of the mothers’ continuing depression at 6 months (with mothers’ right frontal EEG activation alone explaining 31% of the variance).

Because infants whose mothers remained depressed at 6 months had growth and developmental delays at 1 year, it is important to identify those mothers for intervention purposes. In our sample, simple electrocardiography, EEG, and urine analysis (for cortisol, norepinephrine, and serotonin) could explain more than half the variance in the mothers’ continuing depression. These measures also could be used to identify those mother–infant dyads needing early intervention.

NEWBORNS OF DEPRESSED MOTHERS

Infants of depressed mothers appeared to have profiles of dysregulation as early as the neonatal period. These profiles are characterized by:

• limited responsivity on the Brazelton scale, excessive indeterminate sleep, and elevated stress hormone (norepinephrine and cortisol) levels in the neonatal period;
• right frontal EEG activation at 1 week, 1 month, and 3 months; stability in these patterns from 3 months to 3 years;
• limited responsivity to facial expressions, lower
vagal tone, and signs of neurologic delays at 6 months;
• less social referencing at 9 months; and
• limited play and exploratory behavior, inferior
Bayley scores, and delayed growth at 12 months.

Evidence for physiologic dysregulation in infants
of depressed mothers has been noted as early as 1
week of age and is characterized by relative right
frontal EEG activation, lower vagal tone, and less
mature sleep patterns.

**Disturbed Sleep–Wake Behavior**

In our studies at the Touch Research Institute,
newborns of depressed mothers showed inferior per-
formance on the Brazelton scale for orientation (par-
ticularly on inanimate items), depression, and ro-
botuness, and they demonstrated more stressed
behavior (Table 1). They also showed excessive
indeterminate sleep (sleep that is difficult to code),
which is disconcerting given the findings of Sigman
and Parmelee suggesting an inverse relationship be-
tween the amount of indeterminate sleep during the
neonatal period and IQ scores at 12 years. Finally,
they were less attentive and less expressive when
exaggerated faces were modeled for them and their
looking behavior and mimicry were recorded.

**Sympathetic Activation**

During the neonatal period, stress hormones (nor-
epinephrine and cortisol) were significantly elevated
in both depressed mothers and their infants. Differ-
ences continued across the first several months.

**FETUSES OF DEPRESSED MOTHERS**

The need to identify chronically depressed moth-
ers during pregnancy and evaluate the behavior of
their fetuses was highlighted in a report by Field
and colleagues. In this study, biochemical profiles in
newborns matched their mothers’ prenatal biochem-
ical profile.2 During the third trimester of pregnancy,
the depressed mothers’ norepinephrine and cortisol
levels were elevated and their dopamine levels were
lower than those in nondepressed mothers. Assays of
their newborns’ catecholamine and cortisol levels
suggested that they also had elevated norepineph-
rine and cortisol and depleted dopamine levels.

In a subsequent study, we identified chronically
depressed mothers during the third trimester of
pregnancy. Again, catecholamine and cortisol levels
were assayed, and a similar pattern was noted. Fetal
sonograms were evaluated for activity levels and
responses to vibrotactile stimuli. Fetuses of the de-
pressed mothers were less active; they had weaker
responses to vibration, and their weight was esti-
icated to be significantly lower.

**INFANTS OF DEPRESSED MOTHERS**

**Right Frontal EEG Activation**

Assessments of EEG asymmetry in mothers and
infants revealed a pattern that is noted in chronically
depressed adults, namely, more right frontal EEG
activation and less left frontal activation (in both the
mothers and their infants) when the infants were 3
months old, 1 month old, and even as young as 1
week old.9 Right frontal EEG at 1 month also was
related to indeterminate sleep patterns and negative
affect in the neonatal period10 (Fig 1). That the de-
pressed mothers showed relative right frontal EEG
activation is not surprising, but the appearance of
this pattern in their infants as early as 1 week was
very unexpected, given the supposed plasticity of
brain development during the first several months of
life. In addition, this pattern appeared to be stable
in infants of depressed mothers, at least from 3 months
to 3 years of age.

**Depressed Vagal Tone**

Lower vagal tone has been reported for 6-month-
old infants of depressed mothers.15 Specifically,
developmental increase in vagal tone that occurred
between 3 and 6 months in infants of nondepressed
mothers did not occur in the infants of depressed
mothers. Lower vagal tone at 6 months also corre-
lated with fewer vocalizations during interactions
and less optimal neurologic ratings, suggesting di-
minished autonomic development and control in
infants of depressed mothers. Lower vagal tone also
has been noted in 3-month-old infants of depressed
mothers during their interactions with their mothers
or nondepressed strangers.17

Vagal tone could be responsive to contextual fac-
tors such as stress and changes in attention during
interactions, and these factors could be different for
infants of depressed and nondepressed mothers. For
example, depressed mothers are notably less expres-
sive, and their infants may become agitated in their
attempts to elicit more expression. Whether the dif-
ferences are neuroregulatory or reflect different de-
mands in the interaction situation is unclear. The
absence of a developmental increase in vagal tone in
infants of depressed mothers could relate to cumu-
lative effects of maternal depression, including the
continuing elevated norepinephrine levels noted in
these infants.

Another complex finding emerged in a study in
which both facial expressions and vagal tone were
recorded.18 Here, interest and joy expressions were
significantly correlated with vagal tone in infants of
nondepressed mothers; however, infants of de-
pressed mothers had more negative behaviors (in-
cluding gaze aversion and sad or angry expressions)
and also were positively correlated with vagal tone.

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**TABLE 1. Means For Newborn Variables**

<table>
<thead>
<tr>
<th></th>
<th>Newborns of Depressed Mothers</th>
<th>Newborns of Nondepressed Mothers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 47)</td>
<td>(n = 36)</td>
</tr>
<tr>
<td>Orientation</td>
<td>4.8</td>
<td>5.6*</td>
</tr>
<tr>
<td>Inanimate auditory</td>
<td>5.5</td>
<td>6.9**</td>
</tr>
<tr>
<td>Inanimate auditory and visual</td>
<td>4.4</td>
<td>5.4*</td>
</tr>
<tr>
<td>Depression</td>
<td>3.3</td>
<td>2.3*</td>
</tr>
<tr>
<td>Robustness</td>
<td>5.0</td>
<td>5.8*</td>
</tr>
<tr>
<td>Indeterminate sleep</td>
<td>19.3</td>
<td>2.7***</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>141.2</td>
<td>58.4***</td>
</tr>
</tbody>
</table>

* P < .05; ** P < .01; *** P < .001.
At 6 months, vagal tone was significantly lower and behavioral responses to facial expressions were slower in the infants of depressed mothers. Although the significance of lower vagal tone is not entirely understood, higher vagal tone typically is associated with better performance on attention and learning tasks.

**Laboratory Studies of Affect Perception/Production**

In affect perception/production studies at the Touch Research Institute, we have learned that:

- Depressed mothers exhibit fewer positive faces and fewer animated faces and voices. 18
- Infants of depressed mothers produced more sad and angry faces and showed fewer expressions of interest. 19 They also showed a preference for sad faces/voices (greater looking time at videotaped models looking and sounding sad), 20 which might relate to sad expressions being more familiar to them. They also displayed less accurate matching of happy facial expressions with happy vocal expressions. 12
- The absence of a relationship between infant facial expressions and vagal tone in infants of depressed mothers suggests biobehavioral uncoupling that might derive from the infants’ excessive vigilance in emotional situations. 19

Later at 1 year, during a “mother holding doll” situation, infants of depressed mothers showed less protest behavior. 21

**Developmental Delays**

By 12 months, more infants of depressed mothers had neurologic soft signs and showed less exploratory behavior, lower Bayley Mental and Motor scale scores, and lower weight percentiles. 1

**Chronic Depression Markers Used To Identify Highest Risk**

In our 6-month longitudinal study (138 depressed dyads, 84 nondepressed dyads), regression analyses yielded several reliable markers of the mothers’ chronic depression at 6 months’ postpartum. 14 These included right frontal EEG activation at 3 months, lower vagal tone and serotonin, and elevated norepinephrine and cortisol levels during the neonatal period.

Longitudinal Follow-up

In our longitudinal follow-up sample at 3 years, 75% of the mothers with high scores on the Beck during the neonatal period still had elevated Beck scores. Their preschool children continued to show interaction problems, and on the Children’s Behavior Checklist, they scored in the clinical range for externalizing and internalizing factors. 22 They also had elevated cortisol levels and were considered vulnerable by their mothers. Early infancy predictors that may contribute to this perceived vulnerability included the ratings of the infants’ interactions with strangers and their heart rate variability at 3 months. 23 In a follow-up study on stability of relative right frontal EEG activation, 3-month-old infants with right frontal EEG continued to have the same pattern at 3 years. 3 The 3-year-olds with relative right frontal activation also were more inhibited in strange object/strange person situations, and they showed nonempathetic behavior during their mothers’ display of distress (crying).

**EFFECTIVE INTERVENTIONS**

**Natural Buffers of the Depressed Mothers’ Negative Effects (Fathers and Nursery School Caregivers)**

Natural buffers in the environment for infants of depressed mothers included putative fathers/boyfriends 24 and nursery school teachers. 25 Infants of depressed mothers received better interaction ratings with their nondepressed fathers (Table 2) and their nursery school teachers than with their mothers. Fathers also can help overcome the negative effects of depression, as improvement is noted when infants of depressed mothers interact with their fathers. 24 The fathers showed more positive facial expressions and vocalizations than did mothers and, in turn, the infants showed more positive facial expressions and vocalizations when interacting with their fathers. These data suggest that nondepressed fathers and nondepressed nursery teachers can compensate for the negative effects of depressed mothering.

The Touch Research Institute study on switching mothers, which asked whether depressed infants improved when interacting with nondepressed mothers and whether depressed mothers showed more responsive behavior with infants of nondepressed mothers, yielded very few group differences. 26 The infants’ “depressed” behavior generalized to the

Fig 1. Frontal asymmetry of 1-month-old infants of depressed and nondepressed mothers.
nondepressed mother, possibly because interacting with strangers was stressful for the infant. Interestingly, depressed mothers did not negatively affect the infants of nondepressed mothers, suggesting that normal infants might be less vulnerable to unresponsive interaction behavior than are infants of depressed mothers.

Massage Therapy for Infants

Massage therapy was an effective intervention for the infants of depressed mothers. In contrast to rocking, massage therapy contributed to more organized sleep patterns, more positive interaction behaviors, and greater weight gain. Forty full-term 1- to 3-month-old infants born to depressed adolescent mothers were given 15 minutes of either massage or rocking on 2 days per week for 6 weeks. Compared with rocked infants, massaged infants spent more time in active alert and active awake states, cried less, and had lower salivary cortisol levels, suggesting lower stress. Immediately after the massage, the infants spent less time in an active awake state, suggesting that massage therapy may be more effective than rocking for inducing sleep. During the 6-week period, the massage therapy infants gained more weight; showed greater improvement on emotional-

![Fig 2. Attenuation of right frontal EEG activity during and following music mood induction.](image-url)
right frontal EEG activation. These results were surprising, because EEG had been considered unalterable in adults and frontal EEG is a marker of chronic depression. However, more recent positron emission tomography data on blood flow suggest that frontal cortex activity might reflect a difference in mood state, whereas differences in the amygdala might reflect chronicity.

### Interaction Coaching

Studies have shown that imitation and attention-getting instructions are effective in improving mothers' interaction behaviors. Mothers became more animated when trying to get their infants' attention and more sensitive to their infants' signals when imitating them. The infants, in turn, became more responsive. In a subsequent study, we noted that interventions were differentially effective with different (withdrawn/intrusive) depressed mothers. Interventions were most effective when tailored to the mother's style; for example, using imitation with an intrusive mother was effective in "slowing her down."

### Lifestyle Intervention Study

Mothers and infants were followed for their first 6 months to assess the infant's development and identify potential markers in the first 3 months that predicted chronic depression in the mother. The markers then were used to identify a second sample of chronically depressed mothers who received an intervention composed of social/educational/vocational rehabilitation, mood induction (including relaxation therapy, music mood induction, massage therapy, and interaction coaching), and infant day care.

Although the intervention mothers continued to have higher depression scores than the non-depressed mothers, their interaction behavior became significantly more positive and their biochemical values and vagal tone normalized (or approximated the values of the nondepressed control group) (Table 4). The infants in the intervention group also showed more positive interaction behavior, better growth, fewer pediatric complications, and normalized biochemical values; by 1 year, they had superior Bayley Mental and Motor scores. Thus, chronically depressed mothers could be identified and were offered a relatively cost-effective intervention that attenuated the typical delays in growth and development. Finally, although there was limited success in modifying depressed mothers' relatively flat facial and vocal expressions, we were able to increase their touching behavior. This in turn improved the mother's mood state and interaction behavior, as well as their infant's interaction behavior.

### ACKNOWLEDGMENTS

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### REFERENCES

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### TABLE 4. Six-Month Outcome Variables After Intervention

<table>
<thead>
<tr>
<th>Groups</th>
<th>Depressed Control (n = 40)</th>
<th>Depressed Intervention (n = 40)</th>
<th>Nondepressed Intervention (n = 40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal interview</td>
<td>Beck Depression Inventory</td>
<td>13.0</td>
<td>10.9b</td>
<td>6.5</td>
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<tr>
<td>DISC dysthymia (%)</td>
<td>22.7a</td>
<td>14.3a</td>
<td>0.0</td>
<td>.05</td>
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<tr>
<td>Background stress ratings</td>
<td>Mother</td>
<td>20.5a</td>
<td>21.3a</td>
<td>22.3a</td>
</tr>
<tr>
<td></td>
<td>Infant</td>
<td>2.0</td>
<td>2.3a</td>
<td>2.5a</td>
</tr>
<tr>
<td></td>
<td>Infant % time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mother negative</td>
<td>14.8a</td>
<td>6.8a</td>
<td>10.3a</td>
</tr>
<tr>
<td></td>
<td>Mother neutral</td>
<td>43.2a</td>
<td>27.2a</td>
<td>33.9a</td>
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<tr>
<td></td>
<td>Mother positive</td>
<td>41.9a</td>
<td>66.1a</td>
<td>55.6a</td>
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<tr>
<td></td>
<td>Infant negative</td>
<td>5.9a</td>
<td>3.6b</td>
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<tr>
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<td>64.9a</td>
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<tr>
<td></td>
<td>Infant positive</td>
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<td>34.5b</td>
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<tr>
<td>Infant physical measures</td>
<td>Vagal tone</td>
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<tr>
<td></td>
<td>Weight</td>
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<td></td>
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<td>68.3a</td>
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<tr>
<td></td>
<td>Pediatric complications</td>
<td>101.5a</td>
<td>109.4b</td>
<td>119.1b</td>
</tr>
</tbody>
</table>

Note: Different letter subscripts denote significant differences between means.
behave more positively with their infants after completing the BDI. *Infant Ment Health J.* 1997;18:161–172


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