ARTICLE

THE ROLE OF MATERNAL RESPONSIVENESS IN PREDICTING INFANT AFFECT DURING THE STILL FACE PARADIGM WITH INFANTS BORN VERY LOW BIRTH WEIGHT

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ABSTRACT: There is limited empirical literature addressing infants’ response to a standardized stressor with infants born very low birth weight (VLBW). The purpose of this study was to assess the relative strength of maternal responsiveness in predicting infant affect in response to the Still Face (SF) paradigm in a cross-sectional cohort of ethnically diverse infants born VLBW and their mothers (N = 50; infants 6–8 months old). Infant affect and maternal responsiveness were coded in 1-s intervals while dyads participated in the SF. In addition, perinatal medical status, developmental status, and infant temperament were assessed. Findings revealed that positive infant affect during and after the SF stressor were strongly associated with baseline infant positive affect and maternal responsiveness at the reunion episode, respectively. In contrast, when predicting negative infant affect during and after the SF stressor, prior infant negative affect was strongly and uniquely significant. Infant positive affect, negative affect, and maternal responsiveness were not significantly associated with gender, infant perinatal medical history, developmental status, or temperament. Future research is warranted to determine how these findings relate to infants’ stress reactions in naturalistic settings and if relationship-focused interventions may reverse infant negative emotionality, enhance positive emotionality, and thereby improve self-regulation and longer term social and cognitive developmental outcomes in medically at-risk infants.

RESUMEN: Existe una limitada literatura empírica que se refiera a las respuestas de los infantes a un estímulo estandarizado para causar tensión emocional con infantes nacidos con muy bajo peso (VLBW). El propósito de este estudio fue el de evaluar la relativa fuerza de las respuestas maternales al predecir el afecto del infante como respuesta al paradigma “Still Face (SF)” en un grupo seccional y étnicamente variado de diversos infantes nacidos con un muy bajo peso y sus madres (N = 50; infantes de 6 a 8 meses de edad). Se codificaron tanto el afecto del infante como las reacciones de las madres en intervalos de un segundo mientras las diadas participaban en las actividades relacionadas con el paradigma SF. Adicionalmente, se

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evaluaron la condición médica perinatal, la condición de desarrollo, así como el temperamento del infante. Los hallazgos revelaron que el afecto positivo del infante durante y después de las sesiones con SF estaba fuertemente asociado con las medidas básicas del positivo afecto del infante y las reacciones maternales en el momento de encuentro, respectivamente. En contraste, cuando se trataba de predecir el afecto negativo del infante durante y después de la sesión con SF, el afecto negativo anterior del infante presentó una fuerte y distintiva significación. Ni el afecto positivo del infante, ni el afecto negativo del mismo, ni las reacciones maternales fueron significativamente asociadas con el sexo, la historia médica perinatal del infante, la condición del desarrollo, o el temperamento. Está casi garantizado que la investigación futura determinará cómo estos resultados están relacionados con las reacciones del infante a la tensión emocional en ambientes naturalísticos y si las intervenciones enfocadas en las relaciones pudieran volcar la emocionalidad negativa del infante, mejorar la positiva emocionalidad, y por medio de eso mejorar los resultados de la autorregulación y el desarrollo social y cognitivo a largo plazo en infantes bajo riesgos médicos.

RÉSUMÉ: Il n’existe que des recherches empiriques limitées concernant la réponse des bébés à un stresseur standardisé avec des bébés nés avec un très faible poids (VLBW, l’abréviation en anglais) Le but de cette étude était d’évaluer la force relative du dynamisme maternel à prédire l’affect du bébé en réaction au paradigme de Visage Sans Expression (Still Face en anglais, soit SF) chez un groupe ethniquement divers de bébés dont le poids de naissance était très bas (VLBW) et leurs mères (N = 50; bébés de 6-8 mois). L’affect du bébé et le dynamisme maternel ont été codés en intervalles d’une seconde pendant que les dyades participaient au SF. De plus, le statut médical périnatal, le statut du développement, et le tempérament du bébé ont été évalués. Les résultats ont révélé que l’affect positif du bébé durant et après le stresseur SF étaient fortement liés avec, respectivement, l’affect positif de base du bébé et le dynamisme maternel durant l’épisode. Par contraste, pour ce qui concerne la prédiction d’un affect négatif du bébé durant et après le stresseur SF, l’affect antérieur négatif de l’enfant avait une grande et unique importance. Ni l’affect positif du bébé ni l’affect négatif ni le dynamisme maternel n’était lié de façon importante au sexe de l’enfant, à l’histoire médicale périnatale du bébé, au statut en matière de développement, ou au tempérament. Des recherches à venir sont justifiées, afin de déterminer comment ces résultats sont liés aux réactions de stress des bébés dans des contextes naturels et si les intervention focalisées sur la relation peuvent ou non renverser l’émotionnalité négative du bébé, accroître une émotionnalité positive et donc améliorer l’auto-régulation et les résultats à plus long terme en matière de développement social et cognitif chez les bébés à risque médical.

Because infants born very low birth weight (VLBW; <1,250 g) are at increased neurodevelopmental risk, individualized developmental care intervention approaches have been developed to increase maternal responsiveness, diminish infant stress experiences, and enhance infant strengths in this population (Als & Gilkerson, 1997). This transactional intervention approach (Sameroff & Fiese, 2000) has been associated with enhanced infant self-regulation, lowered family stress, and enhanced appreciation of the infant as well as improved medical and other neurodevelopmental outcomes (Als et al., 2004). Importantly, caregiver–infant social interactions among premature infants within the first year of life have been associated with competence at age 2 (Cohen & Beckwith, 1979). More generally, individual differences in interaction histories of mother–infant dyads are the foundation for later interpersonal relationships (Ainsworth, Blehar, Waters, & Wall, 1978; Isabella, Belsky, & von Eye, 1989; Zeanah & Barton, 1989) and specific cognitive abilities (Bornstein & Tamis-LeMonda, 1997). In particular, affective components of early mother–child interactions are conceptualized to provide the foundation for the infant’s later affective repertoire (Tronick, Ricks, & Cohn, 1982).

AFFECTIVE DISPLAYS OF INFANTS BORN VLBW

Infants born VLBW may be at higher risk for displaying affective disturbance (Als et al., 2003; Aylward, 2002; Segal et al., 1995) for many reasons, including neurocognitive impairments.
that have been found to interfere with social and emotional development (Cicchetti & Pogge-Hesse, 1981; Greenspan & Lewis, 1990). Studies comparing emotional responses and affective displays of infants born VLBW versus full-term during face-to-face play interactions with their mothers have found that infants born VLBW display more negative and less positive affect and show higher levels of physiological arousal (Brachfield, Goldberg, & Sloman, 1980; Cnic, Ragozin, Greenberg, Robinson, & Bashman, 1983; Field, 1979a, 1982; Garner & Landry, 1992; Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986; Wolf et al., 2002). In short, these infants are at heightened risk for negativity and emotional dysregulation (Malatesta, Culver, & Tesman, 1989; Segal et al., 1995; Stiefel, Plunkett, & Meisels, 1987). Of particular relevance to our study of infant affective response among infants born VLBW, negative emotionality in infancy has been linked to social and cognitive developmental outcomes in early childhood among children born prematurely (Blair, 2002). More generally, difficulty regulating emotions, including greater negative affect, has been linked with later socioemotional outcomes (Eisenberg, Spinard, & Smith, 2004; Keenan, 2000; Stifter, Spinard, & Braungart-Reiker, 1999).

Furthermore, there is evidence that prematurity may impact the infant’s affective communication as well as the mother’s response to the infant (Muller-Nix et al., 2004; Segal et al., 1995). Malatesta and colleagues (1989) as well as Field (1982) suggested that the increased negative affect and higher physiological arousal levels displayed by infants born VLBW in social interactions may result from both a lower threshold for expressing distress and more general emotion-regulation difficulties. Thus, investigating the nature of infant affective displays during an interpersonal stressor in infants born VLBW is particularly salient.

In addition to studies that have examined the affective displays of infants born VLBW in social interactions, temperament studies have found that mothers of these infants rate their infants as having more negative affect and being less adaptable than do mothers of infants born full-term (Gennaro, Tulman, & Fawcett, 1990; Hughes, Shults, McGrath, & Medoff-Cooper, 2002; Langkamp, Kim, & Pascoe, 1998; Medoff-Cooper, 1986; Thomas, Renaud, & Depaul, 2004). Furthermore, infant temperament in infants born full-term has been associated with maternal sensitivity (Seifer, Sameroff, Dickstein, Keitner, & Miller, 1996), such that heightened infant irritability has been associated with less maternal involvement (Crockenberg, 1986). Seifer and colleagues (1996) suggested that there is both conceptual and operational overlap between infant temperament and maternal sensitivity in that the degree to which an infant is able to be consoled or more broadly, regulate emotions, is both a temperamental individual-differences variable among infants and also a reflection of the effectiveness of maternal efforts.

**MATERNAL CONTRIBUTION TO INFANT AFFECTIVE RESPONSES**

In relation to our study of infant affective response to a standardized stressor (maternal unavailability), full-term infants of more responsive mothers have shown greater regulation of negative affect during the recovery episode of a standardized stressor compared with infants of less responsive mothers (Haley & Stansbury, 2003). The importance of early parental involvement and availability is supported by Field, Vega-Lahr, Scafidi, and Goldstein’s (1986) finding with full-term infants that mothers’ insensitivity and inability to respond to the infant’s signals resulted in infants with dysregulated affect. An intervention study of maternal responsiveness with preterm infants has suggested that greater maternal responsiveness is associated with improved socioemotional mother–infant transactions, including infant affective responses (Heinick et al., 1999). Although it is difficult to determine to what extent infant affect or behavioral...
characteristics influence maternal behavior, and to what extent maternal caregiving influences infant affect and behavior, researchers have documented the bidirectionality within the relationship (Cohn & Tronick, 1988; Feldman, 2003), and specifically with infants born preterm and their mothers (van Beek, Hopkins, Hoeksma, & Samsom, 1994). More generally, support for transactional models of development highlights the dynamic relation between children and their multiple contexts across time (Sameroff & MacKenzie, 2003).

CONTEXT FOR ASSESSING INFANTS’ AFFECTIVE RESPONSES: STILL-FACE PARADIGM

To assess infant self-regulation in the form of positive and negative affective states, and maternal responsiveness, we employed the Still-Face (SF) procedure (Tronick, Als, Adamson, Wise, & Brazelton, 1978). Maternal responsiveness is controlled in this procedure, resulting in a predictable pattern of decreased social gaze and increased infant negative affect (Tronick et al., 1978). Although it is unclear how infants’ reactions to this paradigm relate to other measures of infant affect regulation, Tronick (1989) proposed that the mechanism for this stressor is that mothers’ unresponsiveness during the SF disrupts infants’ “expectations” of their mother’s behavior during social interactions and their goal of social engagement. Infant responses to this procedure have been explained in part by the quality of the infant–mother relationship (Kogan & Carter, 1996).

The SF episode has been found to be a valid stressor for 6- to 8-month-old infants (Tarabulsy et al., 2003; Toda & Fogel, 1993). Studies examining infants’ response to the paradigm have found that infants respond to the SF episode with increased negative affect, decreased positive affect, and increased autonomic arousal (i.e., drop in vagal tone and increase in heart rate) (Cohn & Tronick, 1983; Tarabulsy et al., 2003; Toda & Fogel, 1993; Weinberg & Tronick, 1994, 1996, 1999). This procedure has been used by numerous studies to examine infants’ emotional responses and emotion regulation strategies (Carter, Mayes, & Pajer, 1990; Braungart-Reiker, Garwood, & Powers, 1998; Kogan & Carter, 1996; Mayes & Carter, 1990; Tarabulsy et al., 2003; Toda & Fogel, 1993; Weinberg & Tronick, 1994, 1996, 1999). Individual differences in maternal interactional style appear to mediate infants’ response to the SF stressor (Haley & Stansbury, 2003; Stoller & Field, 1982; Tronick et al., 1982). In fact, maternal behavior prior to the SF impacts infant affect and behavior during the SF. The only study investigating the SF effect with premature infants found a similar response pattern to the SF and recovery episodes in preterm infants compared with infants born full-term, but displays of positive affect were muted in preterm infants (Segal et al., 1995).

The investigation of affective reactions to the resumption of maternal interaction after the SF stressor has been more limited. Weinberg and Tronick (1996) identified a mixed pattern of both positive and negative infant affect when maternal interaction resumed, with a carryover of negative affect from the SF and a rebound of positive affect. Kogan and Carter (1996) found that maternal behavior prior to the SF episode predicted level of infant affect regulation following the SF episode. Infant affective responses following the SF episode have not yet been investigated with infants born VLBW.

Infant Gender

Although the evidence for gender differences on infant response to the SF is mixed (e.g., Mayes & Carter, 1990; Stoller & Field, 1982; Weinberg & Tronick, 1996; Weinberg, Tronick, Cohn,
infant gender has been found to interact with maternal behavior in predicting infant affective responses to the SF with full-term infants (Carter, Mayes, & Pajer, 1990). In addition, some studies with both full-term and at-risk infants have demonstrated a gender main effect wherein girls expressed greater negative affectivity (Lowe, Handmaker, & Aragon, 2006; Mayes & Carter, 1990).

**Current Study**

The present study extends research on infants’ response to stress in three ways: (a) The relative contributions of prior infant affective state and maternal responsiveness were jointly examined; (b) infant affective states were assessed in relation to characteristics of the infant: infants’ gender, perinatal medical history, developmental status, and temperament; and (c) these relationships were examined in a sample of ethnically diverse infants born VLBW and their mothers. Specifically, we assessed the nature of infants’ affective response to stress as mothers and infants participated in the SF procedure. A preliminary hypothesis included: (1) Gender would evidence a main effect such that female infants would show more negative affect, but equivalent levels of positive affect, at each episode. Primary hypotheses related to infant positive affect included: (2) Mothers who demonstrate more responsiveness at baseline would have infants who manifest greater positive affect during the SF stressor while mothers who exhibit more responsiveness during the subsequent reunion episode would have infants who displayed more positive affect during that reunion episode; (3) infants who exhibit more positive affect during the baseline episode would maintain that positive affect during the SF and subsequent reunion episodes. Primary hypotheses related to infant negative affect included: (4) Mothers who demonstrate more responsiveness at baseline would have infants who manifest less negative affect during the SF stressor while mothers who exhibit more responsiveness during the subsequent reunion episode would have infants who displayed less negative affect during that reunion episode; and (5) infant negative affect would remain relatively stable in these infants such that infants displaying high levels of negative affect at baseline would maintain this negative affect.

**METHOD**

**Participants**

Fifty mother–infant dyads (22 female, 28 male infants) were recruited from the VLBW population at the University of New Mexico’s Newborn Intensive Care Unit. To be eligible for our study, infants had to be between 6 months and 8 months (6 months, 0 days–8 months, 15 days; age adjusted for prematurity) and birth weight had to be less than 1,250 g. Infants were excluded from the study if they had been prenatally exposed to drugs or, if at birth, were visually/hearing impaired, had a known genetic abnormality, were considered small for gestational age, constituted a multiple birth, and/or did not reside with their biological families. Pediatric nurses contacted mothers of eligible infants prior to the infant’s discharge and asked them if they could recontact them when their infants were approximately 6 months of age (age adjusted for prematurity). Participant demographics are included in Table 1.

Of the 87 eligible mothers of VLBW preterm infants who could be reached, 51 (59%) agreed to participate and completed the study, 32 (37%) refused to participate, and 4 (5%) failed to keep their scheduled appointment. One VLBW preterm infant was eliminated from data analysis due to videorecording difficulties. Based on demographic information available at...
TABLE 1. Descriptives of Maternal Demographics and Infant Perinatal Variables

<table>
<thead>
<tr>
<th>Maternal ethnicity</th>
<th>42% Hispanic (n = 21)</th>
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<tbody>
<tr>
<td></td>
<td>30% Caucasian (n = 15)</td>
</tr>
<tr>
<td></td>
<td>24% Native American (n = 12)</td>
</tr>
<tr>
<td></td>
<td>4% African American (n = 2)</td>
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</table>

<table>
<thead>
<tr>
<th>Insurance</th>
<th>48% Medicaid (n = 24)</th>
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<tr>
<td></td>
<td>52% Private Insurance (n = 26)</td>
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</table>

<table>
<thead>
<tr>
<th>Prenatal care</th>
<th>80% Yes (n = 40)</th>
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<tbody>
<tr>
<td></td>
<td>20% No (n = 10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mother’s marital status</th>
<th>44% Single (n = 22)</th>
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<tbody>
<tr>
<td></td>
<td>52% Married (n = 26)</td>
</tr>
<tr>
<td></td>
<td>4% Unspecified (n = 2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perinatal Variable</th>
<th>M</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>Infant test age (months)</td>
<td>7.15</td>
<td>0.70</td>
<td>6.10</td>
<td>8.60</td>
</tr>
<tr>
<td>(adjusted for prematurity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother age (years)</td>
<td>26.72</td>
<td>7.10</td>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td>Gestation (weeks)</td>
<td>27.66</td>
<td>2.00</td>
<td>23.00</td>
<td>31.00</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>1001.24</td>
<td>197.23</td>
<td>600.00</td>
<td>1250.00</td>
</tr>
<tr>
<td>Days on ventilator</td>
<td>18.04</td>
<td>21.92</td>
<td>0</td>
<td>89.0</td>
</tr>
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</table>

Bayley Standard Scores

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<thead>
<tr>
<th>Mental Development Index</th>
<th>99.67</th>
<th>7.52</th>
<th>80.00</th>
<th>116.00</th>
</tr>
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<tr>
<td>Psychomotor Dev. Index</td>
<td>88.18</td>
<td>17.10</td>
<td>50.00</td>
<td>123.00</td>
</tr>
<tr>
<td>Orientation/Engagement</td>
<td>55.55</td>
<td>21.91</td>
<td>9.00</td>
<td>98.00</td>
</tr>
<tr>
<td>Emotion Regulation</td>
<td>61.67</td>
<td>27.31</td>
<td>5.00</td>
<td>99.00</td>
</tr>
</tbody>
</table>

Note. n = 50.

Infant Behavior Questionnaire Mean Scores

<table>
<thead>
<tr>
<th>Activity</th>
<th>4.71</th>
<th>0.73</th>
<th>3.18</th>
<th>6.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distress to limitations</td>
<td>3.71</td>
<td>0.83</td>
<td>1.70</td>
<td>5.65</td>
</tr>
<tr>
<td>Distress to novelty</td>
<td>2.82</td>
<td>0.84</td>
<td>1.00</td>
<td>5.55</td>
</tr>
<tr>
<td>Orientation</td>
<td>4.57</td>
<td>1.05</td>
<td>2.27</td>
<td>7.00</td>
</tr>
<tr>
<td>Smiling</td>
<td>5.56</td>
<td>0.88</td>
<td>3.13</td>
<td>7.00</td>
</tr>
<tr>
<td>Soothability</td>
<td>5.58</td>
<td>0.89</td>
<td>3.50</td>
<td>7.00</td>
</tr>
</tbody>
</table>

Note. n = 50.

recruitment, mothers who refused to participate or failed to keep their scheduled appointments were comparable to those who completed the study, and both participants and nonparticipants appeared similar to the larger UNMH population.

Procedures

Informed consent procedures and treatment of participants were in compliance with the sponsoring institution’s human subjects review board. Evaluations were conducted either in the hospital or during home visits with participating mother–infant dyads. Because the university hospital
has a Level 3 tertiary care neonatal intensive care unit, the majority of participating dyads were from outside the metropolitan area, and therefore hospital-based assessments were conducted while families were in town for medical appointments. For in-town families, mothers were provided the option of a hospital- or a home-based evaluation, with 12 (24%) selecting home-based evaluations. During the evaluation, all three scales of the Bayley Scales of Infant Development-II (BSID-II; Bayley, 1993) were administered to the infant by a developmental psychologist, and mothers completed a questionnaire about their child’s temperament.

**SF Protocol**

Tronick et al.’s (1978) SF protocol was used to assess infant positive and negative affect and their mothers’ interaction behaviors. The SF design relies on an A-B-A model, in which A is a normal play interaction, B is the SF episode, and the second A is a reunion/play episode. Mothers sat approximately 18 to 36 in. from their infants, who were in infant seats, car seats, or high chairs with seat belts. During Episodes 1 and 3, mothers were instructed to play with their child as they normally would. During the SF episode (i.e., Episode 2), mothers were instructed to express a neutral facial expression, remain still, and look slightly above the infants’ head, thereby avoiding eye contact, touch, and any interaction with their infant (Haley & Stansbury, 2003). Each episode lasted for 2 min, and the onset of each episode was prompted by an experimenter.

Mother–child interactions were videotaped during the SF paradigm. SF episodes were coded for both positive and negative infant affect (all episodes), and maternal responsiveness (available for Episodes 1 and 3). Coding for mothers and infants were completed by one coder using 1-s time intervals. The coder was trained by reaching reliability (85%) with a master coder on pilot videotapes.

Infant affect was coded into categories based on a scale adapted from the Infant Regulatory Scoring System (Tronick & Weinberg, 1990). The following coding schema was used: −3 (rhythmic crying for ≥3 s), −2 (shorter cry in duration, a protest or yell), −1 (mild fuss/frown), 0 (baby is neutral), +1 (corners of the mouth straight, soft coo), +2 (corners of the mouth go up, cheeks raised, chuckle or small giggle), +3 (laugh, must be ≥2 s). Similar scales have been used in numerous studies to code infant affect (e.g., Braungart-Reiker, Garwood, Powers, & Notaro, 1998; Calkins, Dedmon, Gill, Lomax, & Johnson, 2002; Crockenberg & Leerkes, 2004; Haley & Stansbury, 2003; Kogan & Carter, 1996; Mayes & Carter, 1990).

Percent positive (+1 to +3 codes) for each episode were calculated for analyses (percent positive affect = “infant positive affect”). Percent negative (−1 to −3 codes) for each episode also were calculated (percent negative affect = “infant negative affect”) (Lowe et al., 2006). We averaged 120 observations per episode for positive and negative affect variables to achieve data reduction while representing fluctuations in affect during this period.

The mother’s interactive style was analyzed according to the coding system developed by Haley and Stansbury (2003). Their coding of maternal responsiveness consisted of an ordinal scale of variables including: (a) watching (i.e., mother neutral as she watches the infant’s behavior), (b) attention seeking (i.e., mother is attempting to gain infant’s attention by using various strategies such as calling infant’s name, or clapping her hands), (c) Mirror A (i.e., mother mimics infant’s behavior in an exaggerated fashion), and (d) Mirror B (i.e., mother mimics infant’s behavior; in return, infant responds to mother’s response in a positive manner). Categories 3 and 4 included contingent responding: unilateral (Category 3), wherein mothers used vocal inflection or facial imitation as a contingent response to infant-initiated vocalization or
facial expression (e.g., mother exaggerating infant facial expression); and bilateral (Category 4), wherein both infant and mother took turns initiating behavioral acts which were responded to by the other (e.g., peek-a-boo), respectively (Haley & Stansbury, 2003). Categories 2 to 4 included soothing behaviors at different levels: Category 2 included efforts to entertain or reengage that were unassociated with child cues, and Categories 3 and 4 included efforts to entertain or reengage through mimicking vocal and facial responses based on child cues. Because bilateral responsiveness (Category 4) includes unilateral responsiveness (Category 3), we combined these two “responsive” categories in our analyses (proportion of Categories 3 and 4 responses = “maternal responsiveness”). To evaluate interrater reliability, 10% of episodes were randomly selected, independently recoded, and reliability was based on agreement between coders for each second. Reliability coefficients averaged 88% for infant positive affect, infant negative affect, and parent responsiveness.

**Measures**

*BSID-II* (Bayley, 1993). The BSID-II scales are the most widely used infant development scales. An overall developmental age can be obtained from this test specifically related to mental or cognitive ability (MDI), and performance or motor ability (PDI). The Behavior Record provides standardized scores for measures of orientation/engagement, emotional regulation, and motor quality. The Orientation/Engagement factor (OE) and Emotion Regulation factors (ER) were used for this study. Motor Quality was not used, as we used the PDI as a measure of motor skills.

*Infant Behavior Questionnaire* (*IBQ*: Rothbart, 1981). The IBQ has been widely used as a measure of infant temperament and self-regulation from 0 to 14 months. The questionnaire was completed by the primary caregiver and was scored using procedures provided by the author (Rothbart, 1986). The measure includes six subscales of infant temperament: Activity Level, Distress to Novelty, Distress to Limitations, Orientation, Smiling, and Soothability. Reliability and validity are adequate (Rothbart, 1981), and this measure has been used with preterm infants (e.g., Plunkett & Cross, 1989).

*Perinatal Medical Variables.* Gestational age, as measured using obstetrical dates, was used to approximate level of prematurity (Laptook, O’Shea, Shankaran, & Bhaskar, 2005). Birth weight was also obtained. Days on ventilator was used as a measure of illness severity impacting developmental status, as days on ventilator has been associated with increased mortality and impaired neurodevelopmental outcomes among infants born extremely low birth weight (i.e., 501–1,000 g) (Walsh et al., 2005). Furthermore, infant illness has been shown to be associated with mother–infant interactive behaviors wherein illness predicted less infant interactive behavior (i.e., more crying and irritability) and less maternal affective responsiveness (Greene, Fox, & Lewis, 1983).

**Data Analysis**

This study included a cross-sectional single cohort of infants born VLBW and their mothers. Percent infant positive affect and percent infant negative affect were included in our primary analyses at three episodes: baseline, SF, and reunion. Maternal responsiveness in Episodes 1 and 3, averaged across 1-s intervals per episode, was also included in our analyses. Preliminary
analyses included determining whether the experimental manipulation resulted in expected changes in infant affect. In addition, preliminary to the main analyses, we conducted Pearson correlations to assess bivariate associations between both positive and negative infant affect and maternal responsiveness at Episodes 1 and 3.

We then evaluated the main and interaction effects of gender on infant affect (Hypothesis 1). To identify static and more distal variables for potential inclusion in path analysis models, we conducted bivariate Pearson correlational analyses between infant positive affect, infant negative affect, and maternal responsiveness during the SF and reunion episodes; and perinatal medical history variables (gestational age, birth weight, and number of days on a ventilator), the four Bayley scores (MDI, PDI, OE, and ER), and the six IBQ subscale scores.

Next, to address our primary hypotheses (2–5) regarding the relative explanatory power of prior infant affect (Episodes 1 and 2) compared with concurrent maternal responsiveness (Episodes 1 and 3) in determining infants’ affect during the SF stressor and subsequent play episode (Episodes 2 and 3), we conducted two path analyses (AMOS 4.0; Arbuckle & Wothke, 1999). Procedures recommended by Byrne (1994) to test path coefficients were used to interpret the path models.

RESULTS

Preliminary Analyses

To determine if our experimental manipulation resulted in infant affect responses similar to previous SF studies (Haley & Stansbury, 2003; Tronick et al., 1978), a repeated measures analysis of variance (ANOVA) was conducted with episode as the repeated factor. Infant affect differed by episode ($p < .001$), and follow-up contrasts revealed that infant affect at Episodes 1 and 3 was greater than infant affect at Episode 2 ($p < .05$).

As an additional preliminary analysis, we conducted Pearson correlations between both positive and negative infant affect and maternal responsiveness at Episodes 1 and 3. Positive affect was highly correlated with mothers’ responsiveness during Episodes 1 and 3 ($r = .70$, $p < .001$; $r = .64$, $p < .001$, respectively). In contrast, negative affect was not significantly correlated with maternal responsiveness during Episode 1 or 3.

Descriptives of other study variables (including perinatal variables, Bayley scores, and IBQ subscale scores) are included in Table 1. There were no infant gender differences on birth weight, gestation, days on ventilator, Bayley summary scores, or IBQ subscale scores. More importantly, using a series of analysis of covariance (ANCOVA), we found no infant gender main effects on negative and positive affect at baseline, SF, or reunion episodes controlling for the previous episode (i.e., baseline negative affect, baseline positive affect, SF negative affect controlling for baseline negative affect, SF positive affect controlling for baseline positive affect, recovery episode negative affect controlling for SF negative affect, and recovery episode positive affect controlling for SF positive affect). Furthermore, maternal responsiveness did not differ by infant gender and the Maternal Responsiveness × Gender Interactions were nonsignificant across infant affect outcome variables. Because infant gender had no main effect or interaction on outcome measures, gender was not included in subsequent analyses.

To identify potential variables for path analyses, we conducted correlational analyses between infant positive affect, infant negative affect, and maternal responsiveness during the SF and reunion episodes; and gestation, birth weight, and days on ventilator; Bayley MDI, PDI,
TABLE 2. Bivariate Correlation Matrix Between Infant Positive Affect, Infant Negative Affect, and Maternal Responsiveness During the Still Face and Reunion Episodes; and Perinatal Medical History, Bayley Scores, and IBQ Subscale Scores

<table>
<thead>
<tr>
<th>Perinatal Variables</th>
<th>Episode 2 (Still Face)</th>
<th>Episode 3 (Reunion)</th>
<th>Maternal Responsiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Infant Positive Affect</td>
<td>Infant Negative Affect</td>
<td>Infant Positive Affect</td>
</tr>
<tr>
<td>Gestation</td>
<td>−0.05</td>
<td>−0.19</td>
<td>0.04</td>
</tr>
<tr>
<td>Birth weight</td>
<td>0.02</td>
<td>−0.16</td>
<td>−0.01</td>
</tr>
<tr>
<td>Illness</td>
<td>0.01</td>
<td>−0.02</td>
<td>−0.04</td>
</tr>
<tr>
<td>Bayley Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDI</td>
<td>0.20</td>
<td>−0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>PDI</td>
<td>0.00</td>
<td>−0.08</td>
<td>−0.02</td>
</tr>
<tr>
<td>OE</td>
<td>−0.09</td>
<td>−0.16</td>
<td>0.03</td>
</tr>
<tr>
<td>ER</td>
<td>−0.03</td>
<td>−0.22</td>
<td>0.07</td>
</tr>
<tr>
<td>IBQ Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>0.06</td>
<td>−0.22</td>
<td>−0.06</td>
</tr>
<tr>
<td>Distress to Limits</td>
<td>0.20</td>
<td>−0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Distress to Novelty</td>
<td>−0.19</td>
<td>−0.18</td>
<td>−0.22</td>
</tr>
<tr>
<td>Orientation</td>
<td>0.01</td>
<td>−0.01</td>
<td>−0.15</td>
</tr>
<tr>
<td>Smiling</td>
<td>0.15</td>
<td>0.10</td>
<td>−0.03</td>
</tr>
<tr>
<td>Soothability</td>
<td>0.19</td>
<td>−0.11</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*p < .05.

OE, ER scores; and the six IBQ subscales. Pearson correlations between variables were all non-significant and ranged from .00 to ±.27 (Table 2). Variables in these correlations were related in predictable ways, given convergent and divergent validity considerations. Because none of the correlations were of a large magnitude, no additional variables were included in the subsequent path analyses.

Path Analyses

Results of the path analyses are included in Figures 1 and 2. Path models were tested with standardized path coefficients listed by each corresponding path. First, in the path model predicting infant positive affect at Episodes 2 and 3 (SF and reunion) with infant positive affect at Episodes 1 and 2 (baseline and SF) and maternal responsiveness at Episodes 1 and 3, the two most significant paths were from maternal behavior at Episode 3 to infant positive affect at Episode 3 (β = .78, p < .01) and infant baseline positive affect to infant positive affect at Episode 2 (β = .66, p < .01) (Figure 1). Furthermore, both direct and indirect paths from baseline positive affect to positive affect at Episode 3 were significant (β = .39, p < .05; β = .43, .05.

Although infant smile was included in both infant positive affect and the IBQ, because the frequency of infant smile was very low in our positive affect variable, overlap between these variables was minimal.
To investigate this unexpected finding, follow-up bivariate correlations revealed that the association between infant positive affect at Episodes 2 and 3 was statistically nonsignificant ($r = .08$, n.s.) whereas both variables were significantly correlated with baseline positive affect ($r = .41$, $p < .01$; $r = .40$, $p < .01$, respectively). Therefore, when positive affect at Episode 2 is controlled for, error variance may be removed from baseline positive affect that is unrelated to positive affect at Episode 3. These findings provide partial support for Hypothesis 2 (i.e., mothers’ responsiveness during the Reunion Episode 3 predicted infant positive affect.
during that episode, but mothers’ responsiveness at baseline did not predict infant positive affect during the SF stressor and partial support for Hypothesis 3 (i.e., infant positive affect stability from baseline to Episode 2, but not Episode 2 to Episode 3).

Second, in the parallel path model predicting infant negative affect at Episodes 2 and 3, significant paths were from infant negative affect at Episode 1 to infant negative affect at Episode 2 (β = .71, p < .01) and infant negative affect at Episode 2 to infant negative affect at Episode 3 (β = .60, p < .01) (Figure 2). Furthermore, both direct and indirect paths from baseline negative affect to negative affect at Episode 3 were significant (β = .61, p < .01; β = .33, p < .05, respectively). Thus, negative affect during Episode 2 mediated the relationship between baseline negative affect and Episode 3 negative affect, leading to a significant decrement in variance accounted for by the direct effect of baseline negative affect. The findings of this path model are congruent with Hypothesis 5 (i.e., stability of infant negative affect), but not with Hypothesis 4.

**DISCUSSION**

The primary finding of this study is the relative explanatory power of maternal responsiveness in predicting positive infant affect, but not negative infant affect, in response to a standardized interpersonal stressor. Specifically, we found that infant positive affect and maternal responsiveness were strongly associated at both baseline and reunion episodes, and concurrent maternal responsiveness predicted infant positive affect during the reunion episode above and beyond prior infant positive affect. We also found some stability of positive affect wherein positive affect during the SF and reunion episodes were both significantly associated with baseline positive affect, although they were unrelated to each other. Of particular interest, positive affect during the SF stressor was predicted by baseline positive affect above and beyond baseline maternal responsiveness. Overall, our results are congruent with Feldman’s (2003) findings of strong infant–mother synchrony in the coregulation of positive affect. In addition, these associations would be predicted by more general literature addressing the mutual impact of interaction partners early in life (Sameroff & Fiese, 2000; Sameroff & MacKenzie, 2003).

In contrast, infant negative affect during the SF and recovery episodes was largely determined by prior negative affect: Infants who were more strongly distressed at baseline remained distressed during the SF stressor and recovery episodes, and infants who were more strongly distressed during the SF stressor remained distressed during recovery regardless of how responsive mothers were to infant affect. Furthermore, negative affect during the SF episode provided additional information (i.e., served as a mediator) regarding the stability of negative affect from baseline to reunion: Infants who were more strongly distressed during the SF evidenced relatively less stability of negative affect. Weinberg and Tronick (1996) found that 6-month-old full-term infants responded to the reunion episode (resumption of maternal interaction) with a mixed pattern of positive and negative affect. In their study, during the reunion episode, negative affect demonstrated considerable carryover from the SF stressor, with an increase in fussiness and crying, as well as increased positive affect. Our finding with infants born VLBW is particularly important in that these infants are at heightened risk for negativity and emotional dysregulation (Malatesta et al., 1989; Segal et al., 1995; Stiefel et al., 1987), and our results suggest that once they are distressed, they remain distressed regardless of maternal responsiveness. Importantly, negative emotionality in premature infants has been associated with social and cognitive developmental outcomes in early childhood (Blair, 2002). There also is empirical evidence that
compared to infants born full-term, infants born VLBW are less capable of generating readable cues concerning their psychological and physiological state and thus have more difficulties recruiting the assistance of their caregiver(s) in the regulation process (Field, 1979b; Malatesta et al., 1989; Segal et al., 1995; Singer et al., 1996).

Our finding of no gender difference on infant positive and negative affect, maternal responsiveness, and Maternal Responsiveness × Infant Gender interactions suggests that female and male infants born VLBW behave similarly to this standardized stressor, their mothers respond to them similarly, and their affect is not differentially related to maternal responsiveness. The empirical literature regarding sex differences in response to the SF in full-term infants is mixed (Carter et al., 1990; Cohn & Tronick, 1983; Weinberg et al., 1999). Most relevant to our study, using the same definition of negative affect as used in our current study, Lowe and colleagues (2006) found that with another vulnerable population, in utero alcohol-exposed 6-month-old infants, girls showed greater negative affect than did boys during the SF paradigm. In summarizing the SF sex differences literature more generally, Carter and colleagues (1990) suggested that sex differences in affective response to the SF paradigm should be placed in the context of individual patterns of mother–infant interaction.

We found that variables that were more distal to the mother–infant interaction (i.e., infant perinatal medical history, developmental status, or temperament) were not significantly associated with infant affect during and subsequent to the SF stressor nor with maternal responsiveness. Gestational age, as a marker of prematurity, is considered an important predictor of cognitive, motor, and social development (Hediger, Overpeck, Ruan, & Troendle, 2002), but there is limited literature addressing the role of gestational age in infant emotionality and maternal responsiveness, and especially with infants born VLBW. In addition, although infant illness has been associated with subsequent mother–infant interactive behaviors among high-risk infants (Greene et al., 1983), we did not find this relationship in our experimental paradigm. Of particular interest, the Bayley scores, including MDI, PDI, OR, and ER, employed almost exclusively in the infant literature as outcome variables, were not associated with infant affective responses or maternal responsiveness to the SF paradigm. This suggests that infants’ affective response and mothers’ responsiveness to the dyadic interaction are not a function of more broadly defined cognitive development and behavior. In addition, it is important to consider that Bayley scores of infants born VLBW are quite unstable, with considerable discontinuity in scores over time (Lowe, Woodward, & Papile, 2005).

Finally, regarding the modest associations between temperament and infant affect, this appears surprising in that negative affect is often conceptualized as a temperament dimension (e.g., Rothbart, 1986); however, negative affect employed in the present study includes a state-like variable compared to a trait-like construct. In addition, because mothers’ ratings of their infants’ temperaments have been found to be only minimally associated with observer ratings (Seifer, Sameroff, Dickstein, Schiller, & Hayden, 2004), it is possible that observational methods of temperament evaluation would yield a stronger association between temperament and infant affect.

We incorporated a novel approach to characterizing mother–infant interactions, a method involving coding infant affect and maternal responsiveness, including soothing efforts, in 1-s intervals. Although in its current form this coding method would be too cumbersome for use in a pediatric clinic setting, this method may be adapted for such settings. For example, a less intensive coding system could be employed that includes an overall impressionistic rating of infant affect and maternal responsiveness after an encounter with a mother–infant dyad.
health care professional could then comment on the nature of the observed interaction and offer suggestions toward increasing maternal responsiveness.

Even within this narrowly defined sample of infants born VLBW, there may be substantial variation in medical history (e.g., intraventricular hemorrhages) that may moderate relationships of interest. In addition, it is unknown whether our results replicate to fathers. Additional limitations of this study include combining data from both home and clinic evaluations, and employing a relatively new coding system. Furthermore, path analysis model misspecification is always a concern. Here, our path models are limited by the variables we included: There may be variables not included in our study that would explain significant infant affect variance during and subsequent to a stressor. In addition, future research is warranted to determine how our findings relate to the stress reactions of infants born VLBW in naturalistic settings.

In conclusion, the results of this study provide support for the importance of both concurrent maternal responsiveness and prior infant affect in differentially predicting positive and negative infant affect, respectively, in response to a standardized stressor. Of greatest interest, mothers’ responsiveness did not influence infant negative affect, suggesting the relative chronicity or maintenance of negative affect in this population. In contrast, stress appears to have a more acute role for positive affect, with positive affect being highly associated with concurrent maternal responsiveness pre- and poststressor. Additional research is warranted to investigate the longitudinal nature of these dyadic interaction associations, and to investigate the nature of these associations in less experimentally controlled paradigms.

Clinical Implications

There is increasing evidence that relationship-focused early intervention can increase parental responsiveness to their infants born VLBW, with associated benefits to the infants/toddlers (Als et al., 2004; Mahoney & Perales, 2005; Trivette, 2003). In fact, one early intervention study with low birth weight, preterm infants found that educational and interaction-focused intervention effects were largest among children characterized by high negative emotionality in infancy (Blair, 2002). Therefore, intervention efforts with infants born VLBW may include anticipating distress and intervening accordingly to avoid the maintenance of negative affect. Further research is warranted to explore the possibility of enhancing infants’ affective responses through parental educational efforts aimed at increasing mothers’ interactive sensitivity. In this way, it can be determined if such relationship-focused interventions may soothe infant negative emotionality and enhance positive emotionality, and thereby improve self-regulation and longer term social and cognitive developmental outcomes in medically at-risk children.

REFERENCES


