



Association of maternal interaction with emotional regulation in 4- and 9-month infants during the Still Face Paradigm

Jean R. Lowe^{a,*}, Peggy C. MacLean^a, Andrea F. Duncan^a, Crystal Aragón^a, Ronald M. Schrader^b, Arvind Caprihan^c, John P. Phillips^d

^a Department of Pediatrics, University of New Mexico, Albuquerque, NM 87131, United States

^b Clinical and Translational Science Center, University of New Mexico, 87131, United States

^c Mind Research Network, Albuquerque, NM 87106, United States

^d Department of Neurology, University of New Mexico, 87131, United States

ARTICLE INFO

Article history:

Received 13 June 2011

Received in revised form 18 October 2011

Accepted 6 December 2011

Keywords:

Maternal interaction

Emotional regulation

Still Face Paradigm

Contingent responding

ABSTRACT

This study used the Still Face Paradigm to investigate the relationship of maternal interaction on infants' emotion regulation responses. Seventy infant–mother dyads were seen at 4 months and 25 of these same dyads were re-evaluated at 9 months. Maternal interactions were coded for attention seeking and contingent responding. Emotional regulation was described by infant stress reaction and overall positive affect. Results indicated that at both 4 and 9 months mothers who used more contingent responding interactions had infants who showed more positive affect. In contrast, mothers who used more attention seeking play had infants who showed less positive affect after the Still Face Paradigm. Patterns of stress reaction were reversed, as mothers who used more attention seeking play had infants with less negative affect. Implications for intervention and emotional regulation patterns over time are discussed.

Published by Elsevier Inc.

1. Introduction

One of an infant's most important developmental tasks is to learn to regulate emotions. Emotional regulation includes the ability to modulate, inhibit, and enhance emotional experiences and expressions (Calkins & Hill, 2007). This regulatory ability has been associated with a number of positive developmental outcomes and has been shown to be predictive of socio-emotional outcomes (Denham et al., 2003; Eisenberg et al., 2003; Schultz, Izard, Ackerman, & Youngstrom, 2001). There is growing evidence that early difficulties in emotional regulation are associated with later behavioral problems and may be the developmental precursors to childhood psychopathology (Calkins & Dedmon, 2000; Calkins & Fox, 2002; Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002; Keenan, 2000; Supplee, Skuban, Shaw, & Prout, 2009).

Studies examining the development of emotional regulation have shown that the ability to regulate emotions begins to develop during the first year of life within the context of the care giving relationship (Calkins & Hill, 2007; Cohn & Tronick, 1988). Between 4 and 9 months of age particularly, infants rapidly develop the skills for emotional responsiveness in face-to-face interactions. These skills are followed by the development of social and emotional skills necessary for triadic interactions (Yato et al., 2008). The quality of mother–infant relationship and the style of maternal interaction are extremely important during this time (Haley & Stansbury, 2003; Little & Carter, 2005). Maternal interaction styles characterized by

* Corresponding author at: University of New Mexico, Department of Pediatrics, Division of Neonatology Albuquerque, NM 87131-5313, United States. Tel.: +1 505 272 3946; fax: +1 505 272 6845/505 925 4089.

E-mail address: jrlowe@unm.edu (J.R. Lowe).

high levels of responsiveness to the child's emotional cues have been identified as particularly important in the development of emotional regulation skills (Erickson & Lowe, 2008; Haley & Stansbury, 2003). Haley and Stansbury (2003) found that children of mothers who showed a higher level of responsiveness to their child's emotional cues, through use of contingent responding interactions, showed greater regulation of negative affect during the Still Face Paradigm compared to children of mothers who were rated as less responsive. In contrast, mothers who were rated as less engaged and responsive during mother–child interactions had infants who displayed more dysregulated affect.

Although the importance of the quality of mother–infant interactions in the development of emotional regulation has been documented, to date there is a paucity of data regarding the longitudinal effects of mother–infant interactions. The objective of the current study was to better understand the association of maternal interaction style with two measures of infant affect associated with emotion regulation (infant positive affect and stress response). More specifically, the current study sought to examine the association of infant affect and maternal responsiveness during mother–infant interactions at 4 and 9 months and to explore the relationship between maternal responsiveness and infant affect at both ages using the Still-Face Paradigm. This Paradigm has become a standard laboratory procedure to evaluate infant affect and mother–child interactions and has been shown to be valid across infant populations and ethnicities (Yato et al., 2008). We hypothesized that mothers who displayed more contingent responding interactions, would have infants who showed better emotional regulation as measured by increased positive affect and decreased stress response, compared to infants of mothers who showed less responsive behaviors (i.e., attention seeking play) at both 4 and 9 months. This study is unique, as it looks at the effect of specific types of parent interaction on emotional regulation in a longitudinal cohort of infants at both 4 and 9 months.

2. Methods

2.1. Participants

Seventy infants born full term and seen between 3½ and 4½ months of age were included in the study. Of these children, twenty-five were seen again at 9 months of age. The children were recruited from the University of New Mexico Health Sciences Center's Pediatric Continuity Clinics as well as local private pediatrician offices and day care centers. Infants were eligible to participate if they were born between 37 and 42 weeks gestation, were appropriate for gestational age, had no medical problems at birth or serious problems after birth, had parents who had no psychiatric history or drug and alcohol problems, and resided with their biological families. Participant demographics are included in Table 1.

Of the 88 mothers who responded to recruitment efforts and agreed to participate, 70 (80%) completed the study at 4 months. Based on demographic information available at 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 non-participants appeared similar to the larger UNMH population.

2.2. Procedures

Informed consent procedures and treatment of participants were in compliance with the University of New Mexico Health Science Center Human Research Review Committee (IRB). Evaluations were performed at the Mind Research Network in a family room. Testing was completed when it was convenient for the families and when infants were well rested, alert and content.

2.2.1. Still-Face Paradigm procedure

The Still-Face Paradigm was used (Tronick, Als, Adamson, Wise, & Brazelton, 1978) to assess maternal interaction styles and infant affect. The Still-Face Paradigm design relies on an A-B-A model, in which A is a baseline/play interaction, B is the still-face episode (SF), and the second A is a reunion/play episode. Mothers sat 18–36 inches from their infants, who were in infant seats. During the play/baseline episode (episode 1) and reunion episode (episode 3), mothers were instructed to play with their child as they normally would. During the still-face episode (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). Each episode lasted for 2 min, and the onset of each episode was prompted vocally by a research assistant that was out of view of the child and parent.

2.3. Behavior rating/coding

2.3.1. Affect rating codes

Mother–child interactions were videotaped during the Still-Face Paradigm and episodes were coded for maternal interaction style and infant affect measures. The maternal interactive style was coded second-by-second for the play/baseline and reunion episode. Infant affect was coded into categories based on a scale used in previous studies (Erickson & Lowe, 2008; Haley & Stansbury, 2003; Lowe, Handmaker, & Aragón, 2006; Maclean, Erickson, & Lowe, 2009) second-by-second during all three episodes. The following coding schema was used: –3 (rhythmic crying for ≥ 3 s), –2 (shorter cry in duration,

Table 1
Demographic characteristics of 4 and 9 month groups.

4 Month <i>n</i> = 70		9 Month <i>n</i> = 25	
Factor	Mean (SD)	Factor	Mean (SD)
Gender		Gender	
Male	53%	Male	52.00%
Female	47%	Female	48.00%
Birth weight (g)	3269.66 (423.91)	Birth weight (g)	3231.38 (417.78)
Child ethnicity	Frequency (%)	Child ethnicity	Frequency (%)
African American	1 (1.43%)	African American	0
White	20 (28.57%)	White	6 (24.00%)
Native American	5 (7.14%)	Native American	1 (4.00%)
Hispanic/Latino	36 (51.43%)	Hispanic/Latino	14 (56.00%)
3+ races not identified	2 (2.86%)	3+ races not identified	2 (8.00%)
Hispanic/White	3 (4.29%)	Hispanic/White	2 (8.00%)
Hispanic/Native American	3 (4.29%)	Hispanic/Native American	0
Maternal age (years)	26.8 (6.31)	Maternal age (years)	27.88 (7.26)
Maternal education	Frequency (%)	Maternal education	Frequency (%)
Less than HS	17 (24.29%)	Less than HS	4 (16.00%)
High school	14 (20.00%)	High school	8 (32.00%)
At least 1 yr college	18 (25.71%)	At least 1 yr college	6 (24.00%)
Assoc. degree	6 (8.57%)	Assoc. degree	1 (4.00%)
Bachelors degree	8 (11.43%)	Bachelors degree	1 (4.00%)
Some grad school	1 (1.43%)	Some grad school	1 (4.00%)
Masters degree or higher	6 (8.57%)	Masters degree or higher	4 (16.00%)
Household income	Frequency (%)	Household income	Frequency (%)
Under \$10 K	9 (12.86%)	Under \$10 K	3 (12.00%)
\$10–\$20 K	21 (30.00%)	\$10–\$20 K	7 (28.00%)
\$20–\$30 K	8 (11.43%)	\$20–\$30 K	4 (16.00%)
\$30–\$40 K	3 (4.29%)	\$30–\$40 K	0
\$40–\$50 K	6 (8.57%)	\$40–\$50 K	2 (8.00%)
\$50–\$60 K	6 (8.57%)	\$50–\$60 K	3 (12.00%)
\$60–\$70 K	6 (8.57%)	\$60–\$70 K	2 (8.00%)
Over \$70 K	9 (12.86%)	Over \$70 K	3 (12.00%)
No data	2 (2.86%)	No data	1 (4.00%)
Age at testing (months)	4.10 (0.46)	Age at testing (months)	9.30 (0.42)
KENT cognitive (%)	96.33 (4.80)	BSID-III cognitive SS	108.2 (7.05)

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).

In order to assess emotional regulation, three measures of infant affect were obtained. First, the percent of positive affect displayed over the duration of each episode of the Still-Face Paradigm was coded, as in previous emotional regulation studies (Erickson & Lowe, 2008; Lowe et al., 2006). Second, a Stress Response score was created to assess an infant's stress response during the still-face episode. Since stress reactions can occur at different times during the still-face episode, the 120-s still-face episode was divided into four 30-s quartiles. The mean of the affect scores for each quartile was then calculated and the lowest quartile score, indicating when the infant had the greatest negative reaction, was identified. This quartile score was then subtracted from the mean affect score for the play/baseline episode. Infants who had greater negative Stress Response scores, thus, showed greater negative affect change from play/baseline to the still-face episode were considered to show more distress during the Still Face Paradigm.

2.3.1.1. Maternal interaction codes. Maternal interactive styles were analyzed according to the coding system developed by Haley and Stansbury (2003) that has been used as a measure of maternal responsiveness in previous studies (Erickson & Lowe, 2008; Haley, Handmaker, & Lowe, 2006; Lowe et al., 2006). As previously noted, maternal responsiveness was coded during the play/baseline and reunion/play episodes using the following ordinal scale: (1) Maternal Watching (mother is neutral as she watches the infant's behavior); (2) Maternal Attention Seeking (mother is attempting to gain infant's attention by using various strategies such as calling infant's name, or clapping her hands); (3) Maternal Contingent Responding (mothers mimics infants behaviors in an exaggerated fashion as infants respond to mothers; mothers and infants then take turns initiating behaviors and responding to each one's behavior). This coding system measures different levels of maternal responsiveness with contingent responding being the highest level.

2.3.2. Coding reliability

A research assistant was trained by the master coder and coded all mother–infant tapes for infant affect and maternal interaction. Inter-rater reliability between the coder and the master coder was determined for infant affect and maternal interaction coding by randomly selecting 10% of tapes and comparing the independent coding done by the coder and master coder. For infant affect coding, reliability over the 120-s baseline/play, still-face, and reunion/play episodes was calculated and Cronbach alphas (Cronbach, 1951) were .881, .929, and .867, respectively. For maternal interaction coding, reliability for the baseline/play and reunion/play episodes were calculated and Cronbach alphas were .952 and .889, respectively.

2.4. Cognitive measures

The Kent Developmental Questionnaire (Reuter & Wozniak, 1996) was administered at 4 months of age and the Bayley Scales of Infant Development, 3rd edition (Bayley, 2006) was administered at 9 months of age to assess development (see Table 1 for more information).

3. Results

3.1. Statistical analysis

Paired *t*-tests were used to assess the difference between infant affect scores (Percent Positive Affect and Stress Response scores) and maternal interaction style on the Still-Face Paradigm at 4 and 9 months. Pearson correlation was used to assess the relationship between infant affect scores and maternal interaction styles within and across age levels.

3.2. Infant cognitive scores

The Kent Infant Developmental Scale was administered at 4 months to ensure normal physical and cognitive development. Scores on these measures were within the average range as indicated in Table 1. In addition, the Bayley Scales of Infant Development, 3rd edition cognitive scale was administered at 9 months to ensure typical development. Scores on this measure were within the average to above average range (see Table 1). Additional demographic information is also presented in Table 1.

3.3. Still Face Paradigm results

3.3.1. Maternal responsiveness and infant affect at four months

When examining the maternal interaction styles used during the Still-Face Paradigm, Maternal Watching only occurred 3% of the time compared with Maternal Attention Seeking and Maternal Contingent Responding, which occurred 70% and 27% of the time, respectively. Therefore, the Maternal Watching code was not included in further analysis. Maternal Attention Seeking was negatively correlated with Percent Positive Affect during the play/baseline episode ($r = -0.75, p < .0001$) and reunion/play episode ($r = -0.70, p < .0001$), indicating that the infants had less positive affect the more attention seeking play their mothers used. In contrast, significant positive correlations were found between Maternal Attention Seeking and Stress Response score during play/baseline episode ($r = 0.50, p < .0001$) and reunion/play episode ($r = 0.38, p = .001$) indicating that the infants had less stress responses when their mothers used more attention seeking play.

In contrast, significant positive correlations were found between Maternal Contingent Responding and Percent Positive Affect during the play/baseline ($r = 0.76, p < .0001$) and reunion/play ($r = 0.74, p < .0001$) episodes, indicating infants were more positive in their affect when their mother's used more contingent play (see Fig. 1). In addition, significant negative correlations were found between infant Stress Response scores and Maternal Contingent Responding during the play/baseline ($r = -0.45, p < .0001$) and reunion/play ($r = -0.38, p = .001$) episodes, indicating infants had a more negative change in affect (from the play/baseline episode to the still face episode) when their mother used more Maternal Contingent Responding.

3.3.2. Maternal responsiveness and infant affect at nine months

Among the subset of infants also seen at 9 months ($n = 25$), results were similar to those found at four months between the infant affect measures and maternal interaction styles. A significant negative association between Maternal Attention Seeking and Percent Positive Affect during the play/baseline ($r = -0.89, p < .0001$) and the reunion/play episode 3 ($r = -0.80, p < .0001$) was found, indicating that the more attention seeking play the mothers used, the less positive affect the infants showed. Maternal Attention Seeking during the play/baseline episode was significantly positively correlated with infants' Stress Response ($r = -0.45, p < .05$), indicating infants had less stress during the still-face episode if their mother usually engaged in more attention seeking play.

As previously found with 4 month olds, Maternal Contingent Responding was significantly correlated with Percent Positive Affect during the play/baseline ($r = 0.92, p < .0001$) and reunion/play ($r = 0.83, p < .0001$) episodes, indicating the more mothers used contingent play, the more positive affect the infants showed (see Fig. 2).

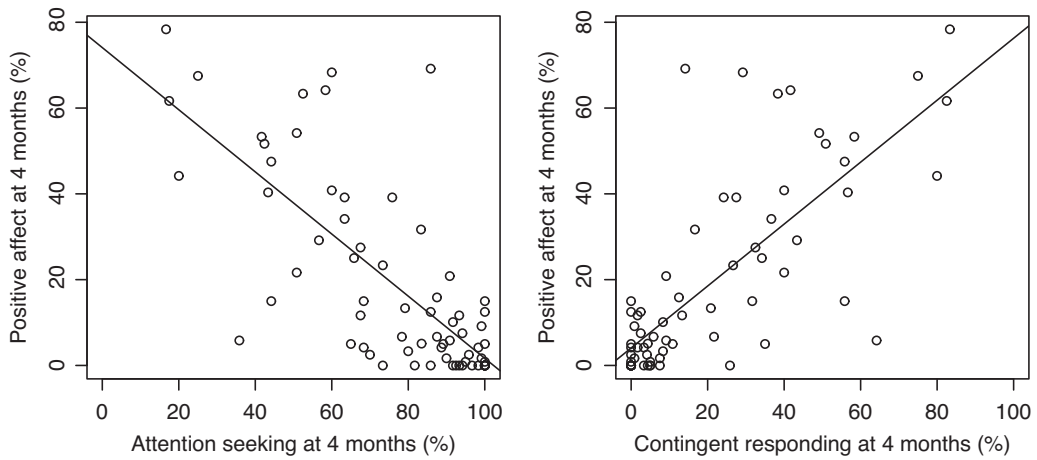


Fig. 1. Four month percent positive affect decreases with more Maternal Attention Seeking play and increases with more Contingent Interactive play.

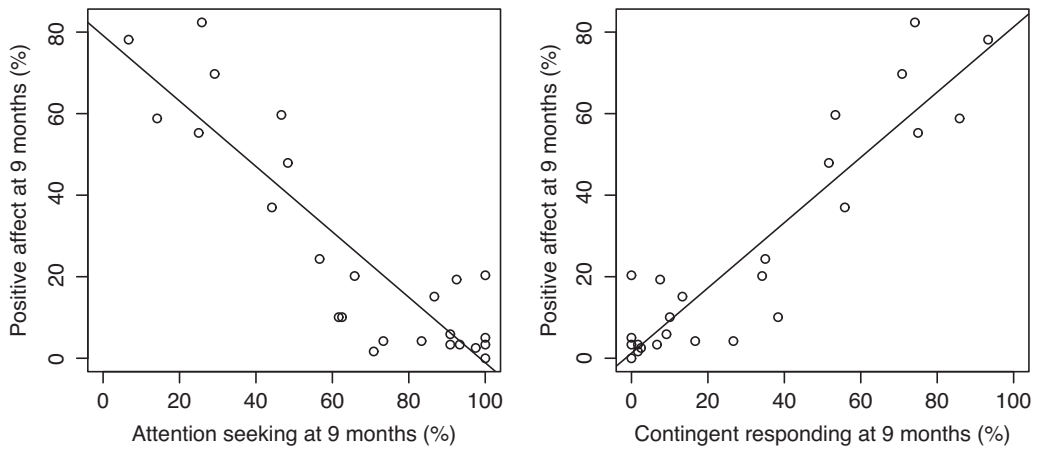


Fig. 2. Nine-month infant percent positive affect decreases with more Maternal Attention Seeking play and increases with more Contingent Interactive play. This is a similar pattern to 4-month response.

3.3.3. Comparing the four and nine month olds

When comparing the 4- and 9-month infants, we found significant differences between maternal interaction styles during the play/baseline episode. Mothers used significantly more Contingent Responding ($t = -2.373, p < .026$) and less Attention Seeking ($t = 2.106, p < .046$) at 9 months compared to at 4 months, although only during the play/baseline episode.

Table 2
Comparison of 4 months and 9 months Still Face Paradigm affect and maternal interaction scores.

	4 months Mean (SD)	9 months Mean (SD)	t-Test	Correlations between 4 and 9 months
Play/baseline episode-Maternal Attention Seeking	.81 (.21)	.67 (.30)	$t = 2.106, p = .046$	$r = .180, p = .389$
Play/baseline episode-maternal contingent responding	.15 (.20)	.31 (.31)	$t = -2.373, p = .026$	$r = 0.275, p = .183$
Play/baseline episode-percent positive affect	.15 (.20)	.26 (.27)	$t = -1.862, p = .075$	$r = 0.243, p = .241$
Reunion/play episode-Maternal Attention Seeking	.69 (.26)	.61 (.31)	$t = 1.107, p = .279$	$r = 0.192, p = .359$
Reunion/play episode-maternal contingent responding	.26 (.26)	.35 (.31)	$t = -1.302, p = .205$	$r = 0.198, p = .343$
Reunion/play episode-percent positive affect	.18 (.23)	.25 (.27)	$t = -1.862, p = .075$	$r = 0.356, p = .081$
Stress response	-.56 (.48)	-.89 (.75)	$t = 1.989, p = .058$	$r = 0.137, p = .514$

N = 25 children per group.

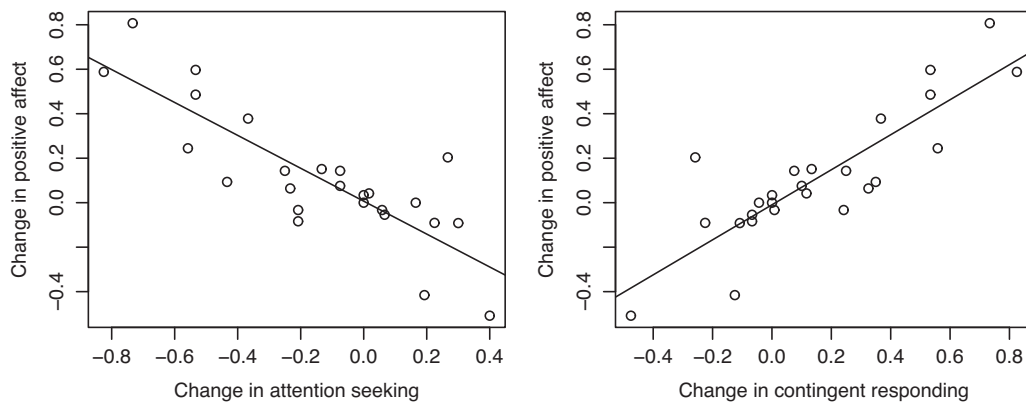


Fig. 3. Change in percent positive affect was significantly negatively related to change in Maternal Attention Seeking play between 4 and 9 months and positively related to change in Contingent Interactive play between 4 and 9 months.

No significant difference in maternal interaction styles was found for the reunion episode (see Table 2). We did not find any significant difference in any of the affect scores between 4 and 9 months for any of the episodes (see Table 2).

To better understand longitudinal effects in affect and maternal interaction style, we created change scores by subtracting each child's percent positive affect at 4 months from percent positive affect at 9 months. We also created corresponding 4–9 month change scores for maternal interaction style for both attention seeking play and contingent responding play. We found a significant negative correlation for change in percent of positive child affect and change in Maternal Attention Seeking play between 4 and 9 months ($r = -0.83$, $p < .001$). Our findings for change in percent of positive child affect and contingent responding play were also significant (see Fig. 3) though in the positive direction ($r = 0.85$, $p < .001$).

4. Discussion

The focus of this study was to better understand how maternal interaction styles are associated with infants' emotional regulation during the first year of life. Understanding the relationship between maternal interaction styles and infant emotional regulation is particularly important given that emotion regulation in early childhood has been directly associated with a host of positive social outcomes, including overall social competence (Denham et al., 2003; Eisenberg et al., 2003), conscience (Kochanska, Murray, & Coy, 1997), resiliency in early to middle childhood (Eisenberg, Guthrie, Fabes, Reiser, Murphy, & Holmgren, 1997), and development of secure attachments (Vondra, Shaw, Swearingen, Cohen, & Owens, 2001). In contrast, emotional regulation deficits in early childhood have been associated with later behavioral problems and are considered developmental precursors to childhood psychopathology (Calkins & Dedmon, 2000; Calkins & Fox, 2002; Keenan, 2000). Stifter, Spinrad, and Braungart-Rieker (1999), for instance, found that emotional reactivity and poor regulation at 5, 10, and 18 months of age predicted noncompliant behaviors, such as defiance and avoidance, at 30 months.

In our study, we found that mothers who had higher responsiveness (i.e., used more contingent responding behaviors) during the Still-Face Paradigm had infants who showed better emotional regulation evidenced by more positive affect during the baseline/play and reunion/play episode. In contrast, mothers who used attention seeking behaviors (behaviors considered to demonstrate less maternal responsiveness) had infants who displayed less optimal emotional regulation; these infants showed less positive affect during the baseline/play and reunion/play episodes at both 4 and 9 months of age.

Our finding linking maternal responsiveness and infant emotional regulation is consistent with the findings of previous studies examining the relationship between maternal responsiveness and infant affect during the Still-Face Paradigm. Haley and Stansbury (2003), for example, found that mothers who showed a higher level of responsiveness to their child's emotional cues had 5–6 month old infants who showed greater regulation of negative affect during the Still-Face Paradigm compared to infants of mothers who were rated as less responsive. In contrast, mothers who were rated as less engaged and less responsive during mother–child interactions had infants who displayed more dysregulated affect. Similarly, Erickson and Lowe (2008) found that in six-month old infants born preterm, increased maternal responsiveness during the Still Face Paradigm was associated with an increase in infant positive affect.

Similarly, studies examining the relationship between infant affect and maternal sensitivity, a component of maternal responsiveness, also found that mothers who were more sensitive to their infants' cues during play had infants who showed better emotional regulation during the Still-Face Paradigm (Braungart-Rieker, Garwood, Powers, & Wang, 2001; Lowe et al., 2006; Rosenblum, McDonough, Muzik, Miller, & Sameroff, 2002; Tarabulsy, Provost, Deslandes, St-Laurent, Moss, & Lemelin, 2003). In a recent meta-analysis by Mesman, Van IJzendoorn, and Bakermans-Kranenburg (2009), higher maternal sensitivity was found to predict positive infant affect during the Still-Face Paradigm and, in turn, positive infant affect during the Still-Face Paradigm was found to predict more secure infant attachments at a later date, highlighting the importance of early maternal interaction styles in children's social-emotional outcomes.

No significant differences were found between infant positive affect at 4 and 9 months in this study. These findings are consistent with other studies that have not found the results of the Still Face to be stable over time. Yato et al. (2008) who did a longitudinal design in 4 and 9 month olds, found 4 month olds showed more negative affect during the still face and 9 month olds showed more negative affect in the reunion stage. Toda and Fogel (1993) did not find significant correlations between 3 and 6 month olds on measures of negative affect, smiling and gazing during the Still Face. No significant associations were found between emotional expression at 2½ and 5 months for any of the Still Face in a study by Cossette, Pomerleau, Malcuit, and Kaczorowski (1996).

In our study we found that mothers used significantly more contingent responding at 9 months of age compared to at 4 months. In contrast, mothers used more attention seeking play at 4 months compared to 9 months, but only during the play/baseline episode. It is possible that mothers of 9 month olds found their infant more interactive and therefore used more contingent responding during their play. There are also more infant games such as pat-a-cake and peek-a-boo that would potentially inspire mothers to use more contingent responding at 9 months. Yato et al. (2008) proposed that differences in affect found at 4 and 9 months could be due to developmental changes in social cognition and social expectations of maternal intervention that is used to help regulate affect. Specific reasons for this difference should be studied, especially since contingent responding play appears to be beneficial for eliciting more adaptive emotional regulation skills after a stressful situation.

Interestingly, when examining correlations within the group of mothers who were seen both at 4 and 9 months, maternal interaction styles were not significantly correlated across age. There was a trend for mothers at 9 months to use more Contingent Responding Behavior and less Maternal Attention Seeking than at 4 months. This suggests that mothers may change the type of interaction they use with their infants across ages. More importantly, the relationship between maternal interaction styles and emotional regulation was similar at both 4 and 9 months, indicating that the types of interactions used by mothers was similarly related to emotional regulation across both ages. Our longitudinal analysis also showed that mothers using more contingent responding at 4 and 9 months were much more likely to have infants displaying more positive affect at that same age.

We did not expect to find significant negative correlations between infants' Stress Response scores and Maternal Contingent Responding during both the play/baseline and reunion/play episodes, which indicated that infants had more negative change in affect the more their mothers used Maternal Contingent Responding. Mothers who were anxious were found to have infants who were less interactive and less likely to show negative affect during the Still Face Paradigm (Kaitz, Maytal, Devor, Bergman, & Mankuta, 2010). Field et al. (2007) found infants of depressed high-risk mothers to be less upset and less interactive when their mothers were inattentive to them. In addition, Field et al. (2007) hypothesized that this could reflect flattened affect, inhibition or avoidance on the part of infants who had affectively disordered mothers. It is possible that infants of mothers who use more contingent responding are accustomed to this style, and when mothers do not respond to their cues and playful gestures, they become more stressed and upset. However it is important to note that infants of mothers who used Maternal Contingent Responding had greater positive affect once their mother re-engaged in play. This may indicate a resilience that can be beneficial in daily situations that can be stressful to an infant.

Although our study is strengthened by the large number of mother–infant dyads we seen at 4 months ($n = 70$) and the inclusion of both mother and infant coding schemas, it is limited by the fact that only 25 of these dyads were seen again at 9 months. The addition of fathers in the study and a comparative sample of at-risk infants would have provided additional information regarding the importance of parental behaviors among fathers and other at-risk groups. Another potential limitation is that the calculated 'stress' score that was used in this study and has not been used before.

Overall, our findings supported our hypothesis that maternal responsiveness is associated with emotion regulation at both 4 and 9 month, and contingent responding was associated with increased infant's positive affect. We did not expect to find that Maternal Attention Seeking play is associated with decreased positive affect in infants after the still face. This study highlights the importance of implementing early intervention programs that focus on increasing maternal responsiveness to infant cues and helping mothers respond contingently to their infant. Studies examining the effectiveness of early childhood intervention programs that focus on maternal responsiveness in at-risk children such as infants born preterm have found improvements on later cognitive development outcomes (Nordhov et al., 2010) and regulation skills (Spittle et al., 2010). Given these findings, interventions focusing on maternal responsiveness could easily be incorporated into parenting programs, which could in turn positively impact infants' emotional regulation skills and ability to cope with stressors. These skills have been positively linked with improved behavioral outcomes.

Acknowledgements

This research was supported by University of New Mexico Clinical and Translational Science Center, #1UL1RR031977-01 and the Delle Foundation. We would like to thank Susanne Duvall, Erica Montague, Russ Hall and Joy VanMeter for their time evaluating the children, conducting the Still Face Paradigm, coding tapes and entering data. We would like to acknowledge all the families that participated in our study.

References

Bayley, N. (2006). *Bayley scales of infant and toddler development* (third ed.). San Antonio, TX: The Psychological Corporation.

- Braungart-Rieker, J. M., Garwood, M. M., Powers, B. P., & Wang, X. Y. (2001). Parental sensitivity, infant affect and affect regulation: Predictors of later attachment. *Child Development*, 72., 252–270.
- Calkins, S. D., & Dedmon, S. A. (2000). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology*, 28., 103–118.
- Calkins, S. D., & Fox, N. A. (2002). Self-regulatory processes in early personality development: A multilevel approach to the study of childhood social withdrawal and aggression. *Development & Psychopathology*, 14., 477–498.
- Calkins, S. D., & Hill, A. (2007). Caregiver influences on emerging emotion regulation: Biological and environmental transactions in early development. In J. Gross, & R. Thompson (Eds.), *The Handbook of Emotion Regulation* (pp. 229–248). New York, NY: Guilford Publication, Inc.
- Cohn, J. F., & Tronick, E. Z. (1988). Mother–infant interaction: The influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology*, 24., 386–392.
- Cossette, L., Pomerleau, A., Malcuit, G., & Kaczorowski, J. (1996). Emotional expressions of female and male infants in a social and a nonsocial context. *Sex Roles*, 35., 693–709.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16., (3), 297–334.
- Denham, S. A., Blair, K. A., DeMulder, E., Levitas, J., Sawyer, K. S., Auerbach-Major, S. T., et al. (2003). Preschoolers' emotional competence: Pathway to mental health? *Child Development*, 74., 238–256.
- Eisenberg, N., Guthrie, I. K., Fabes, R. A., Reiser, M., Murphy, B. C., Holmgren, R., et al. (1997). The relations of regulation and emotionality to resiliency and competent social functioning in elementary school children. *Child Development*, 68., 295–311.
- Eisenberg, N., Zhou, Q., Losoya, S., Fabes, R. A., Shepard, S. A., & Murphy, B. C. (2003). The relations of parenting, effortful control, and ego control to children's unregulated expression of emotion. *Child Development*, 74., 875–895.
- Erickson, S. J., & Lowe, J. R. (2008). The role of maternal responsiveness in predicting infant affect during the still face paradigm with infants born very low birth weight. *Infant Mental Health Journal*, 29., (2), 1–19.
- Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Yanexy, V., Gil, K., et al. (2007). Still-face and separation effects nondepressed mother–infant interactions. *Infant Mental Health Journal*, 28., 314–323.
- Gilliom, M., Shaw, D. S., Beck, J. E., Schonberg, M. A., & Lukon, J. L. (2002). Anger regulation in disadvantaged preschool boys: Strategies, antecedents, and the development of self-control. *Developmental Psychology*, 38., 222–235.
- Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and reunion. *Child Development*, 74., 1534–1546.
- Haley, D. W., Handmaker, N. S., & Lowe, J. (2006). Infant stress reactivity and prenatal alcohol exposure. *Alcoholism: Clinical and Experimental Research*, 30., 2055–2064.
- Kaitz, M., Maytal, H. R., Devor, N., Bergman, L., & Mankuta, D. (2010). Maternal anxiety, mother–infant interactions, and infants' response to challenge. *Infant Behavior and Development*, 33., 136–148.
- Keenan, K. (2000). Emotion dysregulation as a risk factor for child psychopathology. *Clinical Psychology: Science and Practice*, 7., 418–434.
- Kochanska, G., Murray, K., & Coy, K. C. (1997). Inhibitory control as a contributor to conscience in childhood: From toddler to early school age. *Child Development*, 68., 263–277.
- Little, C., & Carter, A. (2005). Negative emotional reactivity and regulation in 12-month-olds following emotional challenge: Contributions of maternal–infant emotional availability in a low-income sample. *Infant Mental Health Journal*, 26., 354–368.
- Lowe, J., Handmaker, N., & Aragón, C. (2006). Impact of mother interactive style on infant affect among babies exposed to alcohol in-utero. *Infant Mental Health Journal*, 27., 371–382.
- Maclean, P., Erickson, S. J., & Lowe, J. R. (2009). Comparing emotional reactivity and regulation in infants born ELGA and VLGA. *Infant Behavior and Development*, 32., 336–339.
- Mesman, J., Van Ijzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-face Paradigm: A review. *Developmental Review*, 29., 120–162.
- Nordhov, S. M., Rønning, J. A., Dahl, L. B., Ulvund, S. E., Tunby, J., & Kaarensen, P. I. (2010). Early intervention improves cognitive outcomes for preterm infants: Randomized controlled trial. *Pediatrics*, 126., (5), 1088–1094.
- Reuter, J. M., & Wozniak, J. R. (1996). *The Kent Infant Development (KID) scale* (3rd ed.). Kent, OH: Kent Developmental Metrics, Inc.
- Rosenblum, K. L., McDonough, S., Muzik, M., Miller, A., & Sameroff, A. (2002). Maternal representations of the infant: Associations with infant response to the Still Face. *Child Development*, 73., 999–1015.
- Schultz, D., Izard, C. E., Ackerman, B. P., & Youngstrom, E. A. (2001). Emotion knowledge in economically disadvantaged children: Self-regulatory antecedents and relations to social difficulties and withdrawal. *Development and Psychopathology*, 13., 53–68.
- Spittle, A. J., Anderson, P. J., Lee, K. J., Ferretti, C., Eeles, A., Orton, J., et al. (2010). Preventive care at home for very preterm infants improves infant and caregiver outcomes at 2 years. *Pediatrics*, 126., 171–178.
- Stifter, C. A., Spinrad, T. L., & Braungart-Rieker, J. M. (1999). Toward a developmental model of child compliance: The role of emotion regulation in infancy. *Child Development*, 70., 21–32.
- Supplee, L. H., Skuban, E. M., Shaw, D. S., & Prout, J. (2009). Emotion regulation strategies and later externalizing behavior among European American and African American children. *Development and Psychopathology*, 21., 393–415.
- Tarabulsky, G. M., Provost, M. A., Deslandes, J., St-Laurent, D., Moss, E., Lemelin, J., et al. (2003). Individual differences in infant still-face response at 6 months. *Infant Behavior and Development*, 26., 421–438.
- Toda, S., & Fogel, A. (1993). Infant response to the still face situation at 3 and 6 months. *Developmental Psychology*, 29., 532–538.
- Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry*, 17., 1–13.
- Vondra, J. I., Shaw, D. S., Swearingen, L., Cohen, M., & Owens, E. B. (2001). Attachment stability and emotional and behavioral regulation from infancy to preschool age. *Development and Psychopathology*, 13., 13–33.
- Yato, Y., Masatoshi, K., Negayama, K., Sogon, S., Tomiwa, K., & Yamamoto, H. (2008). Infant responses to maternal still-face at 4 and 9 months. *Infant Behavior & Development*, 31., 570–577.