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Maternal Regulation of Infant Reactivity From 2 to 6 Months

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Previous research has investigated the effect of maternal soothing behaviors on reducing infant reactivity but not the differential effects of specific maternal behaviors on infant stress responses. The present study investigated maternal regulation of 2- and 6-month-olds' responses to an inoculation and found a significant decline with age in both the intensity and duration of infants' crying. Maternal affection and touching decreased from 2 to 6 months, whereas maternal vocalizing and distraction behaviors increased. At both ages, the combination of maternal holding/rocking and vocalizing was associated with decreases in all levels of infant reactivity. Neither strategy alone, however, was found to be effective. Feeding/pacifying behaviors were effective only when initial distress was at a low or moderate level, which suggests that the effectiveness of maternal regulatory behaviors may depend on the intensity of infants' crying.

The dynamic interaction between mother and infant is thought to have important developmental consequences for infants' social and emotional development (e.g., Bowlby, 1969; Brazelton, 1973; Brazelton, Nugent, & Lester, 1987; Stern, 1985). Mothers' soothing of their distressed infants is not only important for the immediate regulation of infant affect but also is thought to be critical to children's development of emotion regulation. Emotion regulation is defined as an extrinsic and intrinsic process that emerges in early infancy and is responsible for the monitoring, evaluating, and modifying of emotional reactions (Thompson, 1994). This ability is present in an immature form in the newborn infant and is thought to evolve as a function of both the infant's own temperamental style and the caregiving style to which the infant is exposed (e.g., Cassidy, 1994; Malatesta & Haviland, 1982; Rothbart & Derryberry, 1981). The influence of the caregiver is particularly salient in early infancy, during which time infants lack the resources to successfully self-regulate, particularly in extremely distressful situations. The body of work emphasizing the role of the mother in facilitating the infant's development of emotion regulation has been largely theoretical (e.g., Kopp, 1989; Thompson, 1994). Thus, there needs to be a better understanding of developmental trends in infants' reactions to highly distressful situations, changes in maternal soothing behaviors used in these situations, and the association between maternal soothing and infant reactivity. Identifying the role of specific maternal behaviors in reducing infant reactivity may be an important step toward achieving an understanding of how infants learn to self-regulate their emotions.

Previous research on developmental trends in both infant reactivity and maternal soothing techniques has revealed an overall decrease in infants' vocal expressions of pain across the 1st year (Craig, McMahon, Morison, & Zaskow, 1984) and faster quieting at 6 months of age than at 2 months of age in response to an inoculation (Ramsay & Lewis, 1994). Overall maternal soothing in the context of an inoculation has also been shown to decrease from 2 to 6 months (Lewis & Ramsay, 1999). However, with the consideration of specific maternal behaviors rather than overall soothing, one might expect different strategies to show different developmental trajectories. This proposition has been set forth by Kopp (1989), who proposed a developmental shift in caregivers' soothing techniques from a reliance on tactile strategies to an emphasis on more expressive vocalizations, as a result of mothers' appreciation of the salience of the near receptors (e.g., touch) for very young infants and of the distance receptors (e.g., vision and audition) for older infants. Few studies have examined changes in maternal soothing behaviors across infant age. Craig et al. (1984) focused on vocal behaviors and found that mothers changed their soothing technique across 2 to 24 months by using vocal soothing more frequently for younger infants and vocal distraction more frequently for older infants. However, changes in a wider range of maternal behaviors have not yet been explored, nor has the association between these behaviors and decreases in infant reactivity, which leaves open the question of whether certain maternal behaviors are more likely than others to precede reductions in negative reactivity.

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The effectiveness of maternal soothing on infant distress has been the focus of a number of studies. Lewis and Ramsay's (1999) investigation of the effectiveness of maternal soothing behavior in an American sample during an inoculation suggested that maternal soothing had no effect on infants' responses to stress at 2 and 6 months. However, a replication with an Italian sample of 3- and 5-month-old infants (Bonichini & Axia, 2002) showed both concurrent and developmental soothing effects on infant's regulation of reactivity. These studies measured the overall degree of maternal soothing in response to inoculation. Such a general measure of maternal soothing, however, fails to capture the wide range of behaviors that mothers use to regulate their infants.

Examining the effectiveness of specific maternal soothing behaviors has received some theoretical and empirical support. For example, Campos (1994) found holding and rocking behaviors to be particularly effective at reducing infant distress to a heel-stick procedure. In a study that tested the efficacy of supplemental carrying on young infants' cry patterns, significant reductions in crying and fussing behavior were found when parents increased their amount of carrying (Hunziker & Barr, 1986). Researchers have argued that holding and rocking may be effective because they provide prolonged contact with the caregiver as well as repetitive, rhythmic movements that create constant stimulation (Campos, 1994; Hunziker & Barr, 1986).

The role of feeding and pacifying behaviors in regulating distress has also been examined. In a series of studies, Campos demonstrated that pacifying reduced young infants' distress (i.e., reduced crying and heart rate) in response to a painful heel-stick procedure when combined with swaddling (Campos, 1989) and rocking (Campos, 1994). Also, Gunnar, Fisch, and Malone (1984) found that infants who sucked a pacifier cried significantly less during circumcision than control infants without a pacifier. In addition, nutrient behaviors have been shown to interact with holding to effectively reduce newborn infants' crying in response to a painful stimulus (Gormally et al., 2001). Sucking either a pacifier or nutrients may be an effective soothing behavior because, according to Campos (1994), it provides a salient source of perceptual information, which may "mute" the consequences of pain. Or, as Blass and Ciaramitaro (1994) suggested, sucking may stimulate neural pathways associated with behavioral calming.

Other soothing behaviors have been associated not only with child regulation of pain but with modulation of reactivity to a variety of stimuli as well as modulation of the general expression of negative affect. For example, maternal touch has been shown to lower negative affect and to increase smiling during the still-face procedure (Stack & Muir, 1992) and to add to the positive reinforcement value of other forms of reinforcing stimuli (Pelaez-Nogueras et al., 1996). In an experimental study assessing the efficacy of a massage intervention, parents reported less infant crying when massage was combined with supplemental carrying (Elliott, Reilly, Drummond, & Letourneau, 2002). The effectiveness of various forms of touch in reducing infant distress may be because touching conveys a message of safety (Tronick, 1995). Indeed, on the basis of work with nonhuman primates, attachment theory has proposed that the comfort infants derive from contact with their mothers may be an important factor in providing a secure base from which infants may explore their surroundings (Bowlby, 1969).

Finally, there exists a limited amount of work on the efficacy of distraction for reducing infants' perceived pain. Specifically, Cohen (2002) found nurse-directed distraction (i.e., directing the infants' attention to a movie or to age-appropriate toys) to reduce 2- to 36-month-old infants' immunization distress. Distraction may be effective because it diverts the infants' attention from the painful stimulus and reinforces nondistress behavior (Cohen, 2002) or because it alters nociceptive responses and triggers an internal pain-suppressing system (McGrath, 1991).

Many of the above-mentioned studies involved experimental interventions of soothing behaviors (e.g., Elliott et al., 2002; Gunnar et al., 1984) and soothing of infants by an experimenter (e.g., Campos, 1994; Cohen, 2002). Naturalistic observations of mother–infant regulatory interactions would extend this work. The inoculation situation provides an excellent opportunity to observe the effect of maternal behaviors on infant crying. This ecologically valid context provides a salient stimulus to which all healthy infants consistently respond negatively, thereby allowing the systematic observation of both infant reactivity and maternal regulatory behaviors. In addition, the gradual decrease in reactivity postinoculation provides ample opportunity to observe the wide range of behaviors in which mothers engage. Indeed, one might expect that different maternal behaviors would be used as the nature of infant distress changes to reflect differential levels of infants' perceived pain in response to the inoculation.

Although parental soothing of infants during inoculations is generally felt to be important, Lewis and Ramsay (1999) did not find soothing to be effective. This may have been because these authors did not look either at specific features of maternal soothing behavior that could vary in their developmental significance across infant age or at specific sequential relations of soothing behavior to infant distress resolution. The present study extends Lewis and Ramsay's study of the influence of maternal regulation on infant reactivity by examining several parental behaviors used to soothe infant distress. Consistent with the work of Lewis and Ramsay, we examined infant reactivity and maternal behaviors in response to an inoculation when infants were 2 and 6 months of age. Whereas Lewis and Ramsay measured only the occurrence and intensity of any maternal soothing, we parsed maternal behaviors into eight possible categories to explore the effectiveness of these specific behaviors in reducing infant distress. Furthermore, Lewis and Ramsay coded maternal regulation and infant reactivity for a maximum of 45 s following the inoculation. This period may not have been long enough to adequately capture variability in infants' responses (i.e., moments when an infant is at the highest level of intensity of crying and moments when the same infant is at the lowest level of crying intensity), precluding the examination of maternal regulation of low levels of infant distress. In the present study, we videotaped infant and maternal behaviors for up to 4 min following an inoculation in order to capture and track all changes in infant reactivity as well as the range of maternal regulatory behaviors used to bring about these changes. Finally, Lewis and Ramsay examined the effectiveness of maternal soothing by computing correlations between their measure of maternal soothing and the infants' average stress response. This method may not have been an appropriate measure of effectiveness for two reasons. First, a great deal of information may have been lost by averaging these variables across the entire postinoculation period in order to calculate bivariate correlations. Second, because the presence of

infant reactivity necessitates the occurrence of maternal behavior, one would expect that these variables would be confounded at the outset, such that more crying would be associated with more maternal soothing. This makes it difficult to interpret the direction of influence between crying and maternal behaviors. In the present study, we examined the contingency between maternal behavior and infant reactivity at each precise moment that infants displayed a decrease in reactivity, thereby more fully explaining the processes by which mothers regulate their infants' distress.

Our first goal in the present study was to examine the developmental trend in infants' reactivity in response to an inoculation. Consistent with prior research (e.g., Lewis & Ramsay, 1999), we hypothesized a developmental decline over age in infant reactivity. Our second goal was to examine the specific maternal behaviors used in response to infants' stress reactions. In line with this goal, we also sought to identify developmental changes in the use of these maternal behaviors. Although little research has compared the use of various regulatory behaviors in response to infant distress (e.g., Craig et al., 1984), we hypothesized that mothers would use a range of behaviors and, because of the infants' development of motor, cognitive, and communication skills, that these maternal soothing behaviors would show differential developmental changes such that some would decrease whereas others would increase in frequency across time. Driven by theoretical and empirical work concerning maternal soothing strategies, we observed maternal behaviors of affection, touching, holding/rocking, vocalizing, caretaking, distracting, presenting face, and feeding/pacifying. Finally, we sought to examine the relation between specific maternal behaviors and reductions in infant reactivity. Because there is currently no research on the effectiveness of specific maternal behaviors during the inoculation context, this aspect of our investigation was exploratory in nature. However, we expected that certain maternal behaviors would be contingently associated with reductions in infant reactivity and that different behaviors would be more effective at varying levels of distress.

Method

Participants

The original sample consisted of 150 healthy term infants who were recruited at birth from a local community hospital in the central Pennsylvania area. As part of a longitudinal study that began when the infants were 2 weeks of age, 141 subjects (75 girls and 66 boys) were observed with their mothers during an inoculation when the infants were 2 months old, and 133 subjects (66 girls and 67 boys) were observed at 6 months. At the 2-month observation, infants had a mean age of 2.1 months (range = 1.5 to 3.5 months), and at the 6-month observation, the mean age was 6.3 months (range = 4.9 to 8.8 months). Families were predominantly White (5 African American, 4 Asian, and 1 Hispanic) and were recruited from a local community hospital. Eighty-four percent of the mothers were married, and 97% were living with the infants' fathers. At the time of recruitment, mothers had a mean age of 29.7 years (range =16 to 43 years) and an average of 15.6 years of education (range = 10 to 26 years).

Procedure

Infants and their mothers were observed during a routine inoculation visit. Fifteen different pediatric offices were visited by the research team. Prior to the inoculation, the experimenter completed a rating of the infant's general state of irritability during the period of time when the infant and mother were in the waiting area through the time in the examination room just prior to the administration of the injection.

First, either a doctor or a nurse administered the injections, and infants received between one to four injections during the visit. After the injections, the infant was given to the mother, who was free to soothe her infant. Each mother–infant dyad was videotaped until the baby was calm and had stopped crying. Although these procedures were relatively consistent across doctor's offices, the doctor's office and the number of injections were noted by the experimenter and examined in the analyses.[1]

Measures

Infants and their mothers were videotaped for at least 1 min prior to the administration of the shot and until the subject was calm for a period of 20 consecutive seconds following the inoculation. An effort was made to keep the infant's body in full view during the entirety of the procedure. The videotapes were subsequently coded independently for infant variables and maternal variables. Coding of infant reactivity began once the last needle was retracted and continued for a period of up to 4 min after the start of the inoculation. Coding of maternal soothing behavior occurred for the same period of time. Infant reactivity and maternal behaviors were coded in 5-s intervals, for a total of up to 48 intervals.

Infant Variables

The infant's state of general irritability was measured with a 9-point Likert-type scale ranging from *no irritability* (1) to *irritable in response to all degrees of stimulation* (9), reflecting the infant's disposition while in the waiting room and up to 1 min prior to the inoculation. This scale was adapted from the Irritability behavioral item of the Brazelton Neonatal Behavioral Assessment Scale (Brazelton, 1973), which has been shown to provide reliable information regarding young infants' responsiveness and is valid for the study of infants from divergent populations. The original scale was set so that the midpoint was the norm (Brazelton, 1973).

Infant reactivity was coded according to the following 4-point scale, representing an increasing intensity of negative affect: 0 (no audible vocalization), 1 (fussing, whining, or whimpering but not crying), 2 (low-intensity crying which may have occurred at a rapid frequency but without shrieking cries), 3 (very intense, loud, piercing crying, usually with a quavering out-of-control quality and typically with a red face, squinted eyes, and an open mouth). If more than one level of intensity of crying was observed during a 5-s interval, the predominant (> 2.5 s) intensity level during that interval was coded. Scores were averaged across the number of intervals observed to produce the measure of *overall cry intensity*. The number of intervals during which the infant was coded as distressed (i.e., rating > 0) was added and multiplied by 5. This resulted in a measure of *overall cry duration*. Two independent coders trained until acceptable agreement (Cohen's kappa $> .75$) was achieved. Ten percent of all infant reactivity observations were coded to assess coder drift reliability. The mean interrater reliability for infant reactivity was .92 (Cohen's kappa) across the 2- and 6-month observations.

Maternal Variables

The presence or absence of the following eight maternal soothing behaviors was coded in 5-s intervals: affection, touching, holding/rocking, vocalizing, caretaking, distracting, presenting face, and feeding/pacifying. See Table 1 for descriptions and interrater reliabilities for each of these

[1] It is possible that there were differences in needle diameter, the nature of the inoculation, and the time the injection actually took place that could have affected the infants' level of discomfort, but this information was not available to the experimenters.

Table 1
Descriptions of Maternal Soothing Behavior Categories

Behavior	κ	Definition
Affection	.83	When the mother engages in any behavior that denotes affection, such as kissing, hugging, face-to-face contact, holding the infant's head next to the mother's cheek, or tucking the infant under the mother's chin
Touching	.78	When the mother touches the infant with her hand in a soothing (i.e., moving) manner, such as patting or stroking the infant's back or stroking the cheek with a finger
Holding/rocking	.93	When the mother is picking up the infant, with or without any movement, including jiggling/bouncing and playful "flying"
Vocalizing	.85	When the mother makes any vocalizations directed at the child, including talking, singing, "shushing," and even unrecognizable vocal noises
Caretaking	.89	When the mother dresses the infant, changes his or her diaper, wipes his or her nose, or otherwise gets the infant ready to leave the doctor's office
Distracting	.80	When the mother makes an overt attempt to direct the infant's attention away from the continued discomfort of the shot
Presenting face	.90	When the mother makes an overt attempt to look directly into the infant's face while the infant is pulled away from the mother and held out in front of her
Feeding/pacifying	.98	When the mother gives the infant a bottle or pacifier, begins breast feeding, or attempts to feed the infant or give him or her a pacifier, whether or not the infant accepts the feeding or pacifier

behaviors. As these variables were not mutually exclusive, more than one behavior could be coded as present during each interval. The variables used for noncontingency analysis represent the proportion of time that the mother engaged in the given behavior (i.e., the total number of intervals that the specific maternal behavior was present divided by the total number of intervals during which the infant cried). Two independent coders trained until acceptable agreement (Cohen's kappa $> .75$) was achieved. Ten percent of all maternal behavior observations were recoded to assess coder drift reliability.

Results

Results are presented in the following order: (a) preliminary analyses to examine the effect of possible covariates on the study variables; (b) changes in the duration and intensity of infant reactivity across age; (c) changes in maternal behaviors used across age; and (d) associations between infant reactivity and maternal behaviors.

Preliminary Analyses

Several variables (i.e., general irritability, number of shots, and doctor's office) were thought to be possible covariates to the study variables. Prior to describing infant reactivity and maternal behaviors, and to exploring developmental change in these variables, we thought it was important to consider whether these independent variables should be accounted for in the analyses.

The mean general irritability scores at 2 and 6 months were 5.78 ($SD = 1.48$) and 5.37 ($SD = 1.53$), respectively. Infants' general irritability at 2 months was related to concurrent mean intensity of crying, $r_s(140) = .34$, $p < .01$, and duration of crying, $r_s(140) = .30$, $p < .01$. Likewise, at 6 months, infants' general irritability was related to concurrent mean intensity of crying, $r_s(130) = .57$, $p < .01$, and duration of crying, $r_s(130) = .45$, $p < .01$. Infants who were rated as high in irritability prior to receiving their injection cried longer and more intensely at both 2 and 6 months of age. As such, general irritability was included as a covariate in all analyses concerning intensity and duration of crying.

The mean numbers of shots administered at 2 and 6 months were 2.6 ($SD = 0.88$) and 2.4 ($SD = 0.66$), respectively. The number of shots administered was not associated with mean cry intensity or duration of crying at 2 months. At 6 months, the number of shots administered was significantly associated with mean cry intensity, $r(132) = .19$, $p < .05$, but not with duration of crying. As such, number of shots was included as a covariate in all analyses concerning intensity of crying at 6 months. Finally, no significant differences were found in any of the study variables with respect to which doctor's office administered the inoculation.

Infant Reactivity

To examine developmental and sex differences in infant reactivity to inoculation, we conducted repeated measures analyses of covariance with one between-subjects factor (sex), one within-subject factor (2- or 6-month inoculation), and two covariates (general irritability and number of shots) on the dependent variables of cry intensity and cry duration. No significant main or interaction effects were found with respect to sex. Cry intensity was significantly higher at 2 months than at 6 months, $F(1, 108) = 14.03$, $p < .01$. Cry duration at 2 months was also significantly longer than at 6 months, $F(1, 108) = 4.93$, $p < .05$ (see Table 2).

Maternal Behaviors

Interrelations among the maternal behaviors at 2 and 6 months were assessed using Pearson's correlations, which are presented in Table 3. Affection behaviors were positively associated with touching, vocalizing, and holding/rocking behaviors at 2 months and with vocalizing and holding/rocking behaviors at 6 months. Caretaking behaviors were negatively associated with affection, touching, and holding/rocking behaviors at 2 months and with touching, presenting face, and holding/rocking behaviors at 6 months. Presenting face behaviors were positively associated with vocalizing and feeding/pacifying behaviors at 2 months and with vocalizing at 6 months. Finally, touching behaviors were positively associated with vocalizing behaviors at 2 months but neg-

Table 2
Means, Standard Deviations, and Ranges for Infant and Maternal Variables

Variable	2 months			6 months		
	M	*SD*	Range	*M*	*SD*	Range
Infant variables						
Overall cry intensity[a]	1.64	.46	.66–2.92	1.32	.50	.17–2.90
Overall cry duration[b]	28.03	12.63	7.0–48.0	21.98	12.32	5.0–48.0
Maternal variables						
Affection[c]	.26	.25	0–.97	.19	.19	0–.82
Touching	.39	.25	0–1.0	.34	.24	0–.93
Holding/rocking	.81	.24	0–1.0	.85	.24	0–1.0
Vocalizing	.66	.22	.09–1.0	.73	.25	0–1.0
Caretaking	.07	.13	0–.57	.07	.15	0–.82
Distracting	.01	.04	0–.42	.07	.12	0–.60
Presenting face	.34	.27	0–1.0	.40	.30	0–1.0
Feeding/pacifying	.20	.29	0–1.0	.17	.28	1–1.0

[a] Overall cry intensity was measured on a scale ranging from 0 to 3. [b] Overall cry duration reflects number of 5-s intervals. [c] Maternal behaviors reflect the proportion of time that the mother engaged in a specific behavior.

atively associated with presenting face behaviors at 2 months and with distracting behaviors at 6 months.

To examine differences in the mean proportion of time mothers engaged in each of the specific behaviors at 2 and 6 months, we conducted repeated measures analyses of variance (ANOVAs). These tests revealed a significant difference among the maternal behaviors at 2 months, $F(7, 978) = 212.98$, $p < .01$, and at 6 months, $F(7, 917) = 222.41$, $p < .01$. Tukey's honestly significant difference tests were used to test all pairwise comparisons of maternal behaviors. These tests revealed that all behavioral pairs occurred for significantly different proportions of time ($p < .05$) with the exception of affection and feeding/pacifying, touching and presenting face, and caretaking and distracting at both 2 and 6 months. The mean proportions of time that mothers engaged in each behavior at 2 and 6 months are graphically depicted in Figure 1.

To examine developmental and sex differences in maternal behaviors, we conducted a repeated measures ANOVA with one between-subjects factor (sex) and one within-subject factor (2- or 6-month inoculation) on each of the maternal behaviors. No significant main or interaction effects were found with respect to sex. These analyses revealed that there was a significant decrease in the proportion of time that mothers spent engaging in affection from 2 months to 6 months, $F(1, 126) = 13.09$, $p < .01$, and in the proportion of time mothers used touching behaviors from 2 months to 6 months, $F(1, 126) = 5.78$, $p < .05$. On the other hand, mothers increased their time using vocalizations, $F(1, 126) = 7.47$, $p < .01$, and distraction, $F(1, 126) = 28.43$, $p < .01$, from 2 months to 6 months.

Behavior Combinations

We expected that several of the soothing behaviors mothers exhibited would co-occur. Indeed, the graphic representation (see Figure 1) of the proportion of time mothers used these strategies suggests such an overlap. To further investigate the degree to which mothers used behaviors in tandem, we created a table of the mean proportions of time that each strategy co-occurred with each of the other strategies. As can be seen in Table 4, holding/rocking and vocalization co-occurred more often in real time than they occurred independently. Specifically, the mean proportion of time that these behaviors co-occurred within the same interval was .55

Table 3
Intercorrelations Among Maternal Behaviors Used at 2 and 6 Months

Maternal behavior	1	2	3	4	5	6	7	8
1. Affection	—	.17**[a]	.22*[a]	−.22**[a]	−.04[a]	−.33**[b]	.27**[a]	−.35**[a]
2. Touching	.03	—	.17*[a]	−.23**[a]	.04[a]	−.03[b]	−.02[a]	−.19*[a]
3. Vocalizing	.27**	−.04	—	−.11[a]	.15[a]	.29**[b]	.04[a]	−.08[a]
4. Caretaking	−.15	−.29**	.01	—	−.07[a]	−.03[b]	−.44**[a]	.03[a]
5. Distracting	−.07	−.23**	.14	.11	—	−.03[b]	.02[a]	−.09[a]
6. Presenting face	.12	.17	.31**	−.18*	.09	—	−.05[b]	.34**[b]
7. Holding/rocking	.22*	.08	.14	−.37**	−.14	.12	—	.02
8. Feeding/pacifying	−.14	−.13	−.03	−.03	−.09	−.15	.05	—

Note. Values represent the intercorrelations of the mean proportions of time spent engaging in those types of maternal behavior. Correlations above the diagonal are for the 2-month maternal regulation variables; correlations below the diagonal are for the 6-month maternal regulation variables ($n = 132$).
[a] $n = 141$. [b] $n = 139$.
* $p < .05$. ** $p < .01$.

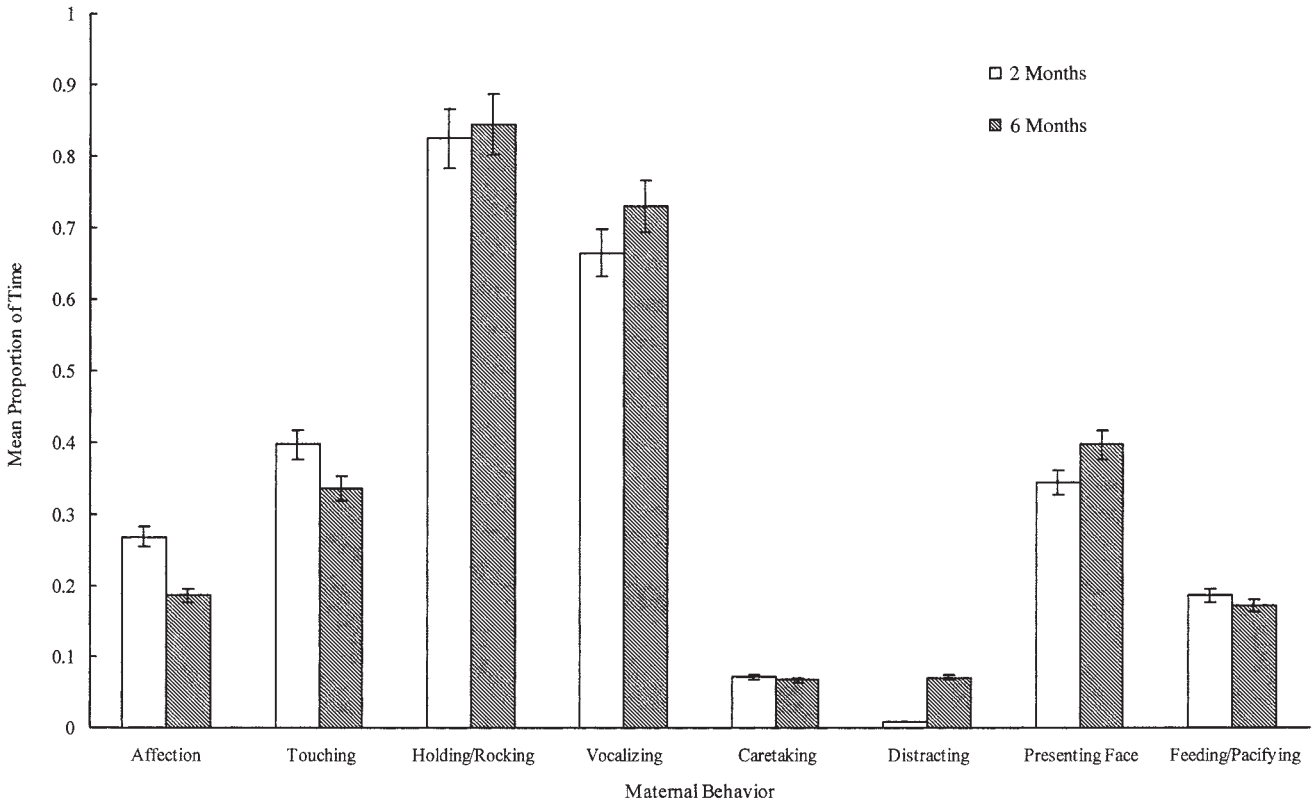

Figure 1. Mean proportion of time that each maternal behavior was used at 2 and 6 months (vertical lines indicate ± 1 *SE*).

at 2 months and .63 at 6 months. Furthermore, the proportion of time during which holding/rocking occurred independently of vocalization was .26 at 2 months and .22 at 6 months, and the proportion of time in which vocalization occurred independently of holding/rocking was .10 at both 2 and 6 months. However, overlap among the other strategies used at both 2 and 6 months was never greater than 36% of the time.[2] Given the overlap in the occurrence of holding/rocking and vocalization, we created three new behavioral categories and used them in all further analyses: (a) holding/rocking with vocalization, (b) holding/rocking with no vocalization, and (c) vocalization with no holding/rocking.

Relation Between Overall Infant Reactivity and Specific Maternal Behaviors

As in previous research (e.g., Lewis & Ramsay, 1999), we first used correlation analyses to assess the overall relation between infant reactivity (i.e., cry intensity and cry duration) and the proportion of time the mothers engaged in each of the specific maternal behaviors. At both ages, 3 of the 16 possible bivariate correlations were significant. Specifically, at 2 months, cry intensity was negatively related to touching behavior, $r_s(141) = -.19$, $p < .05$, and cry duration was positively related to both caretaking, $r_s(141) = .18$, $p < .05$, and distracting behaviors, $r_s(141) = .24$, $p < .01$. At 6 months, cry intensity was positively related with caretaking behavior, $r_s(131) = .20$, $p < .05$, and cry duration was positively related with both caretaking, $r_s(131) = .36$, $p < .01$, and distracting behaviors, $r_s(131) = .21$, $p < .05$.

Contingency Between Infant Reactivity and Specific Maternal Behaviors

For descriptive purposes, the contingencies between specific maternal behaviors (at Lag 0) and all changes in infant reactivity (at Lag 1) were calculated (see Table 5). Each co-occurrence reflects whether the specific maternal behavior was followed in the next 5-s interval by any of the three possible changes in infant reactivity: decrease, increase, or no change (i.e., maintenance). The proportion of each dyad's interactions consisting of each type of co-occurrence was first calculated, and these values were then averaged to provide information concerning the entire sample. As might be expected within the context of an aversive procedure, the majority of maternal behaviors were followed by no change in infant distress. And, with one exception (affection at 2 months), decreases in infant crying were more likely to occur in response to maternal soothing strategies than were increases in crying.

[2] Analyses were conducted on all strategies paired separately with both holding/rocking and vocalization. None of the behavioral combinations was revealed to be effective in reducing infant distress overall or at any level.

Table 4
Mean Proportions of Time in Which Specific Behaviors Co-Occurred in the Same Interval

Maternal behavior	1	2	3	4	5	6	7	8
1. Affection	—	.12	.25	.20	.00	.00	.04	.01
2. Touching	.07	—	.32	.28	.01	.00	.13	.06
3. Holding/rocking	.18	.29	—	.55	.03	.01	.29	.17
4. Vocalization	.15	.22	.63	—	.04	.01	.28	.12
5. Caretaking	.00	.00	.03	.06	—	.00	.01	.01
6. Distracting	.01	.01	.05	.06	.01	—	.00	.00
7. Presenting face	.09	.14	.36	.32	.01	.03	—	.15
8. Feeding/pacifying	.02	.04	.10	.10	.01	.01	.04	—

Note. Values represent the mean proportion of time each maternal behavior co-occurred with another behavior. Proportions above the diagonal are for the 2-month maternal regulation behaviors; proportions below the diagonal are for the 6-month maternal regulation behaviors.

In an effort to better understand the association between specific maternal behaviors and decreases in infant reactivity levels, we performed a contingency analysis for every instance of a Lag 1 co-occurrence between each maternal behavior and a decrease in reactivity. That is, the analysis assessed whether a specific maternal behavior was followed in the next 5-s interval by a decrease in infant reactivity more often than would be expected by chance for each dyad. The number of co-occurrences expected by chance reflected the total number of decreases displayed by the infant multiplied by the total number of times the mother used the strategy and divided by the total number of 5-s intervals that the infant cried. Dyads who did not exhibit one or both of the behaviors examined were excluded from the analyses. Sign tests were then conducted to determine whether, across all dyads, mothers' use of each specific behavior and decreases in infants' reactivity co-occurred more often than would be expected by chance (Putnam, Spritz, & Stifter, 2002).

Our approach was to first examine the co-occurrences of maternal behavior with infant reactivity for decreases in all levels of distress. We then examined each level of distress separately to address whether the effectiveness of maternal regulatory behaviors varied as a function of the infants' level of distress.

Decreases in all levels of distress. We first explored whether maternal behaviors were contingently associated with any decrease in infant reactivity regardless of level of distress (i.e., a decrease in intensity of crying from Level 3 to Level 2, from Level 2 to Level 1, from Level 3 to Level 1, from Level 2 to Level 0, or from Level 1 to Level 0). Table 3 shows the results of an examination of whether particular maternal behaviors were associated with decreases in reactivity more often than expected by chance in a significant proportion of dyads. The results of these analyses at 2 months revealed that the holding/rocking and vocalization behaviors combined and the feeding/pacifying behavior contingently occurred more often with a decrease in reactivity. Vocalization with no holding/rocking behaviors contingently occurred less often with a decrease in reactivity. At 6 months, the holding/rocking and vocalization behaviors combined and the feeding/pacifying behavior contingently occurred more often with a decrease in reactivity (see Table 6).

Decreases by level of distress. Next we explored whether contingencies between decreases in infant reactivity and specific maternal behaviors were dependent on level of infant reactivity. The results of these analyses, indicating differential effectiveness of maternal behavior according to infant distress level, are summarized in Table 7.

We first conducted analyses of decreases in infant reactivity from Level 3 (i.e., decreases from Level 3 to Level 2, from Level 3 to Level 1, or from Level 3 to Level 0). At 2 months, the behavior that occurred contingently with a decrease from Level 3 reactivity significantly more often than expected by chance was

Table 5
Contingency Between Maternal Behavior (at Lag 0) and Infant Reactivity Level Change (at Lag 1)

	2 months			6 months		
Maternal behavior	Infant reactivity level decreases	Infant reactivity level is maintained	Infant reactivity level increases	Infant reactivity level decreases	Infant reactivity level is maintained	Infant reactivity level increases
Affection	.21	.52	.27	.32	.57	.11
Touching	.23	.67	.10	.29	.59	.12
Holding/rocking with vocalization	.26	.60	.13	.35	.51	.14
Holding/rocking with no vocalization	.29	.59	.12	.30	.55	.15
Vocalization with no holding/rocking	.13	.79	.08	.25	.71	.04
Caretaking	.22	.68	.10	.23	.60	.17
Distracting	.14	.76	.10	.31	.48	.21
Presenting face	.24	.64	.12	.30	.57	.13
Feeding/pacifying	.44	.43	.13	.60	.30	.10

Note. Values represent the mean percentage of a given co-occurrence across dyads.

Table 6
Contingency Between Maternal Behavior and Decrease in Crying

Maternal behavior	2 months			6 months		
	No. of dyads with contingency < chance	No. of dyads with contingency > chance	*p* for sign test	No. of dyads with contingency < chance	No. of dyads with contingency > chance	*p* for sign test
Affection	55	65	.41	54	70	.18
Touching	72	68	.80	68	65	.86
Holding/rocking and vocalization	51	**89**	<.01	41	**90**	<.01
Holding/rocking with no vocalization	62	69	.60	68	51	.14
Vocalization with no holding/rocking	**109**	41	<.01	31	38	.47
Caretaking	38	33	.64	27	31	.69
Distracting	10	12	.83	33	38	.64
Presenting face	57	66	.47	62	60	.93
Feeding/pacifying	22	**48**	<.01	11	**48**	<.01

Note. $n = 141$ at 2 months; $n = 133$ at 6 months. Only dyads for which the observed frequency of a given contingency was unequal to the expected frequency are included in this table. Boldface values highlight the higher number of dyads in each comparison.

holding/rocking and vocalization combined. At 2 months, the behaviors that occurred contingently with a decrease from Level 3 reactivity significantly less often than expected by chance were holding/rocking with no vocalization, vocalization with no holding/rocking, touching, and caretaking. At 6 months, the behavior that occurred contingently with a Level 3 decrease in reactivity significantly more often than expected by chance was holding/rocking and vocalization combined, whereas holding/rocking with no vocalization and distracting occurred contingently with a decrease from Level 3 reactivity significantly less often than expected by chance. That is, holding/rocking and vocalization combined was effective in reducing Level 3 distress, whereas each of these behaviors independently (at 2 and 6 months), touching (at 2 months), caretaking (at 2 months), and distracting (at 6 months) were ineffective.

Analyses with respect to decreases in infant reactivity that started at Level 2 (i.e., decreases from Level 2 to Level 1 and from Level 2 to Level 0) revealed that at 2 months, the behaviors that occurred contingently with a Level 2 decrease in reactivity significantly more often than expected by chance were holding/rocking

Table 7
Contingency Between Maternal Behavior and Decrease in Varying Levels of Crying

Maternal behavior	2 months			6 months		
	No. of dyads with contingency < chance	No. of dyads with contingency > chance	*p* for sign test	No. of dyads with contingency < chance	No. of dyads with contingency > chance	*p* for sign test
			Level 3			
Holding/rocking and vocalization	53	**86**	<.01	43	**81**	<.01
Holding/rocking with no vocalization	**79**	52	<.05	**70**	40	<.01
Vocalization with no holding/rocking	**117**	33	<.01			
Touching	**84**	57	<.05			
Caretaking	**51**	20	<.01			
Distracting				**47**	22	<.01
			Level 2			
Holding/rocking and vocalization	38	**74**	<.01	25	**83**	<.01
Holding/rocking with no vocalization	**66**	41	<.05	**59**	36	<.05
Vocalization with no holding/rocking	**111**	21	<.01			
Feeding/pacifying	20	**37**	<.05	15	**34**	<.01
			Level 1			
Holding/rocking and vocalization	41	**66**	<.05	40	**77**	<.01
Vocalization with no holding/rocking	**118**	20	<.01			
Feeding/pacifying	7	**44**	<.01	5	**46**	<.01
Affection	**60**	38	<.05	**65**	43	<.05

Note. $n = 141$ at 2 months; $n = 133$ at 6 months. Only dyads for which the observed frequency of a given contingency was unequal to the expected frequency are included in this table. Boldface values highlight the higher number of dyads in each comparison.

and vocalization combined and feeding/pacifying. A similar pattern of results occurred at 6 months. Holding/rocking with no vocalization (at 2 and 6 months) and vocalization with no holding/rocking (at 2 months) were found to be associated with Level 2 decreases less often than expected by chance.

Finally, we conducted the analyses of decreases in infant reactivity from Level 1 (i.e., a decrease from Level 1 to Level 0). At both 2 and 6 months, the behaviors that occurred contingently with a Level 1 decrease in reactivity significantly more often than expected by chance were holding/rocking and vocalization combined and feeding/pacifying, whereas affection contingently occurred with a Level 1 decrease in reactivity significantly less often than expected by chance (at 2 and 6 months), as did vocalization with no holding/rocking (at 2 months). In other words, when infant distress was mild, holding/rocking and vocalization combined and feeding/pacifying were effective, whereas affection and vocalization with no holding/rocking were not effective at this level of distress.

Discussion

In an effort to more fully understand infant responses to inoculations and maternal attempts to soothe the pain experienced by infants, in the present study we investigated changes in infant distress across age, the specific soothing behaviors used by mothers, and the effectiveness with which these maternal behaviors relieved infant distress. Findings revealed a decline in the intensity and duration of infant crying from 2 to 6 months. This result is consistent with previous literature suggesting an overall decrease in infants' vocal expressions of pain across the 1st year (e.g., Craig et al., 1984) and faster quieting at 6 months of age than at 2 months of age in response to an inoculation (Ramsay & Lewis, 1994). Importantly, these findings provide further compelling evidence of the developmental shift in the intensity and duration of crying even after we controlled for a baseline measure of the infant's general irritability prior to the inoculation. Possible influences on infants' general irritability may have included contextual factors causing irritation prior to the inoculation and temperamental fussiness. By incorporating the infants' state prior to inoculation, we obtained a more accurate representation of infant reactivity in response to the inoculation stimulus. Interestingly, in a study of predictors of infant pain behavior during immunization, infant difficulty, as measured by maternal report, was found to be a significant predictor of pain behavior at 6 months (Sweet, McGrath, & Symons, 1999).

As expected, the present study revealed differential patterns of developmental change for different maternal soothing behaviors. Specifically, affection and touching behaviors were shown to decrease across age, whereas vocalizing and distracting behaviors increased. These results offer empirical support for Kopp's (1989) developmental theory regarding a shift in caregivers' soothing techniques from a reliance on tactile strategies to an emphasis on more expressive vocalizations, and they illustrate mothers' appreciation of the salience of the near receptors (e.g., touch) for very young infants and of the distance receptors (e.g., vision and audition) for older infants. Our finding is also in line with that of Craig et al. (1984), who showed that mothers of infants used vocal soothing more frequently for younger infants and vocal distraction more frequently for older infants. Furthermore, these results confirm our speculation that previous studies that examined overall soothing may have failed to capture important intricacies in mothers' soothing efforts. For example, Lewis and Ramsay (1999) reported a significant decline in overall soothing behavior from 2 to 6 months. By examining specific putative regulatory behaviors, we found that although mothers showed a decline in what might be considered less-mature forms of soothing, they also showed an increase in soothing techniques that reflected their infants' burgeoning attention and vocalizing abilities.

Our final goal in the present study was to examine the association between specific maternal soothing behaviors and decreases in infant reactivity. We approached this issue in two different ways. First, in a manner consistent with the methodology used in previous research, we conducted bivariate correlations between overall crying and overall use of each specific maternal behavior. The results of our analyses revealed that, on average, more touching behavior was associated with a lower average intensity of crying at 2 months. Also, more caretaking behavior was related to a higher average intensity of crying at 2 months and 6 months as well as to a longer duration of crying at 6 months. Finally, distracting behaviors were related to an increased duration of crying at both 2 and 6 months. Because these findings were correlational, we cannot speculate as to the direction of the influence between infant reactivity and maternal behaviors. For example, using distracting at 2 months may have been an ineffective strategy because the younger infants do not have the capacity to shift attention. On the other hand, mothers may have used distraction to soothe their children after having exhausted the other forms of regulation. Nevertheless, these findings are in contrast to previous accounts of no relation between overall maternal soothing and infant reactivity during an inoculation (Lewis & Ramsay, 1999), again perhaps reflecting the limitation of using an overall measure of maternal soothing rather than considering specific behaviors. Indeed, Lewis and Ramsay suggested, in an interpretation of their own findings, that a "fine-grained" analysis of specific maternal behaviors might have resulted in different findings from those they obtained. The results of the present study support this interpretation.

The results of the contingency analyses offered considerably more information than those from the correlations. Specifically, our findings showed that at 2 and 6 months, holding/rocking and vocalizing combined and feeding/pacifying behaviors were significantly related to reductions in infant crying. Indeed, our results demonstrated that these behaviors were effective at all levels of distress, even those in which the infant was highly distressed. These findings are consistent with research that has examined effective regulation of pain produced by stimuli other than an inoculation, such as a heel-stick procedure (Campos, 1989, 1994; Gormally et al., 2001) and circumcision (Gunnar et al., 1984). Furthermore, our results lend support to theories regarding the efficacy of holding and rocking behaviors as well as that of sucking (Blass & Ciaramitaro, 1994; Campos, 1994).

Holding/rocking and vocalization were revealed to occur more often in combination than independently, and this combination of behaviors was most effective at reducing all levels of infant distress. Importantly, these behaviors by themselves either tended to show no association with decreases in reactivity or were associated with decreases in crying less often than one would expect by chance. Thus, holding/rocking and vocalizing behaviors were only

effective if they occurred together. Previous research has found that when an infant is picked up and put to a shoulder in response to spontaneous crying, a decrease in crying as well as an increase in alertness and scanning of the environment result (Korner & Grobstein, 1966). Studies have also shown the powerful attraction of maternal vocalization in eliciting infant attention (Stevenson, ver Hoeve, Roach, & Leavitt, 1986) and maintaining it (D'Entremont & Muir, 2000). Thus, the combined effect of holding/rocking and vocalization might be explained as an additive effect of vocalization once the infant has responded to the effect of holding/rocking. That is, it may be that holding/rocking begins the process of affect regulation and that vocalization continues this process by maintaining attention. Microanalytic work that captures moment-by-moment change in maternal soothing behaviors is needed to address this issue.

It is interesting, as well, that holding/rocking and vocalizing behaviors were found to be among those most frequently used by mothers at both ages and were also significantly likely to co-occur with decreases in infant reactivity at both ages. This may mean that mothers are aware of the efficacy of these behaviors and consequently use them more frequently. It is important to note that although holding/rocking and vocalizations occurred with great frequency, our measure of efficacy controlled for chance co-occurrences by accounting for variability in the base rates of behaviors among the dyads.

Finally, our examination of contingencies between maternal regulation and different levels of infant reactivity revealed an interesting pattern of results that may have implications for the types of behaviors that work to soothe and those that do not. First, holding/rocking and vocalizing combined were found to be effective at reducing all levels of infant reactivity. Second, feeding/pacifying was most effective when the infant was either at a low or moderate level of crying. When an infant was crying at the highest level, however, touching and caretaking behaviors (at 2 months) and distracting behaviors (at 6 months) were significantly less likely to bring on reductions in crying. These results are consistent with those of Cohen (2002), who reported that distracting was not effective during the injection phase of an inoculation (i.e., the actual moment of tissue damage), which suggests that shifting attention toward an object may not be appropriate when infants are at the highest level of distress. These findings are not surprising, as infants who are experiencing such an extreme level of distress might find caretaking behaviors (e.g., cleaning the face, changing a diaper) to bring more discomfort than relief because they do not address the primary concern of the infant. In addition, because infants often close or squint their eyes during this level of crying, one might expect any efforts to distract to be unproductive. Thus, the ineffectiveness of distraction when the infant is at the highest level of distress may be indicative of parental insensitivity to the infant's needs. In light of the hypothesis that external regulation of distress is central to the development of infant self-regulation of emotion (Kopp, 1989), it is interesting to note that in a study of infant regulation, reorienting or self-distracting behavior was also not effective at high levels of crying (Stifter & Braungart, 1995).

The contingency analyses at different levels of crying shed greater light on the process of maternal regulation of infant distress and suggest that varying levels of infant distress may indeed warrant different types of regulatory behaviors. Specifically, because distress was associated with the infants' perceived pain, it may be that soothing behaviors that provide rhythmic (holding/rocking) or orogustatory/orotactile (feeding/pacifying) stimulation that keep the mother close are more effective in this context than those that take the mother away from addressing this pain, such as caretaking behaviors, which require the mother to place her infant on the table, or distracting behaviors, which require the mother to focus her attention on something other than the infant.

Whereas the present study has extended our understanding of the regulatory function of maternal soothing, our findings may be highly context specific. We studied a predominantly Caucasian sample in an inoculation setting, which may not reflect the contingencies we might find in other populations or in other situations involving infant distress. Elements of the inoculation situation may elicit the usefulness of certain maternal behaviors but not others. Future research on the efficacy of specific maternal behaviors should explore this possibility by examining these behaviors in other contexts as well as with mother–infant pairs of different cultures and ethnicities.

In addition, our coding system did not consider the manner in which the maternal behaviors were executed. In an effort to further clarify the efficacy of specific behaviors for reducing infant reactivity, future studies may benefit from measuring the degree to which the maternal behavior was carried out in a sensitive versus an inappropriate manner. Another direction for future research would be to further categorize specific maternal behaviors on the basis of their types and functions. For example, gentle versus playful holding and rocking may convey distinct messages to the infant and may be differentially related to infants' level of crying. In addition, it will be important to further explore other aspects of specific maternal behaviors that may influence their efficacy in reducing infant negative reactivity. For example, it may be that brief occurrences of certain behaviors are effective, whereas other behaviors must be present for greater durations of time before they become regulatory. Finally, in line with other research that has incorporated physiological measures of reactivity in the study of infants' responses to painful stimuli (e.g., Gunnar, Porter, Wolf, Rigatuso, & Larson, 1995; Porter, Porges, & Marshall, 1988; Sweet et al., 1999), it will be important to extend the present study of the efficacy of specific maternal behaviors in reducing physiological components of infant reactivity.

In summary, the present study extends previous work on the developmental course of infants' responses to a painful stimulus by providing a richer description of the discrete maternal behaviors that are used to soothe infants in this context, and it advances our understanding of how young infants are externally comforted. Having established the effectiveness of maternal behaviors in soothing infant distress, research in this area should turn toward exploring individual differences in the use of these behaviors as well as the social-emotional outcomes associated with varying soothing repertoires.

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