Infant and maternal behaviors regulate infant reactivity to novelty at 6 months

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Abstract:

Three issues were investigated: (a) the regulatory effects of presumed infant and maternal regulation behaviors on infant distress to novelty at 6 months, (b) stability of infant regulatory effects across contexts that vary in maternal involvement, and (c) associations and temporal dynamics between infant and maternal regulation behaviors. Participants were 87 low-risk infants and their mothers, observed at 6 months postpartum during infant exposure to novel toys. Contingencies derived from sequential analyses demonstrate that, by 6 months, some infants reduce their own distress to novelty by looking away from the novel toy or self-soothing, maternal engagement and support have comparable effects, and certain infant and maternal behaviors co-occur. Moreover, infants whose mothers engaged contingently when they looked away from the novel toy expressed less distress than comparable infants whose mothers did not. These findings implicate both infants and mothers in the development of emotion regulation during the infant's first year.

Keywords: infant behaviors | maternal behaviors | emotion regulation | infant-maternal regulation behaviors | infant reactivity | novelty | distress | maternal involvement

Article:

There is considerable agreement that infant temperament includes both reactive and regulatory components (Calkins & Fox, 1994; Rothbart & Derryberry, 1981) and recognition also that mothers play a role in the process by which infants modulate their distress (Tronick, 1982). Nevertheless, evidence of the regulating effects of presumed infant regulating behaviors is contradictory and, for maternal regulating behaviors, scant, limiting the understanding of dyadic processes involved in infant emotion regulation. Thus, we addressed several related issues in this study: (a) the regulatory effects of infant and maternal behaviors on infant reactivity to novelty, (b) stability of infant regulatory effects across contexts that vary in maternal involvement, and (c) associations and temporal dynamics between infant and maternal regulatory behaviors.

Infant Regulation Behaviors

Infant behaviors that begin to develop during the first year of life are thought to regulate infant negative emotions (Rothbart, Ziaie, & O'Boyle, 1992). Central among them is the development

of orienting toward visual locations (the posterior attention system; Posner & Peterson, 1990), which demonstrates important changes between 3 and 6 months postpartum. These include the increasing ability to disengage gaze from an external stimulus and the ability to anticipate the location of upcoming visual events (Johnson, Posner, & Rothbart, 1991), both relevant for the early self-regulation of emotion. Evidence that 4-month-old infants disengaged from a stimulus more readily than younger infants and that those who disengaged more easily were less susceptible to negative affect (Johnson et al., 1991) indicates that the regulation of attention and the expression of negative emotions are linked during the first half year of life.

Recently, researchers have used contingency analyses to determine if infant behaviors presumed to serve a regulatory function are in fact associated with reductions in infant negative affect. In a sample of 5- and 10-month-old infants, Stifter and Braungart (1995) found that during frustrating events (i.e., toy removal, arm restraint), self-comforting and orienting were more likely to occur when infant distress was decreasing, whereas avoidance and communication behaviors were more likely when distress was increasing. In contrast, in a study of 6-month-old infants, Buss and Goldsmith (1998) found that decreases in fear distress were more frequent than expected only after infant withdrawal, whereas decreases in anger distress were more frequent than expected following infant distraction and interaction with the stimulus. On this basis, Buss and Goldsmith proposed that behaviors that regulate reactivity to novelty develop after 6 months, when fear of strangers emerges. Additionally, Diener and Mangelsdorf (1999) reported that contingencies between the regulation behaviors of toddlers and changes in distress varied as a function of maternal involvement and whether the context was expected to elicit fear or anger. For example, infant avoidance was associated with a decrease in fear, consistent with Buss and Goldsmith's finding with younger infants, but not with a decrease in frustration. Given these discrepancies, more data are needed to determine (a) if infants use their ability to control attention, soothe themselves, and to withdraw, all apparent prior to 6 months of age, to regulate their negative reactions to novel stimuli during the first half year; and (b) whether maternal involvement alters the effectiveness of these infant behaviors in modulating distress.

Data are needed also on the possible “upregulation” (i.e., distress-increasing) effects of infant activity, behavior that with infant crying predicts later behavioral inhibition. Kagan, Snidman, Arcus, and Reznick (1994) regarded high activity as a dimension of infant negative reactivity, hence their view that it is negative reactivity that predicts later behavioral inhibition. In contrast, Rothbart et al. (1992) identified *body stimulation,* infant activity that includes arm movement, banging, body movements, kicking, and repeated hand movements, as a behavior that may increase arousal. We tested these competing views by determining whether increases in infant distress occurred in conjunction with the onset of infant activity.

Maternal Regulation Behaviors

Global measures of maternal sensitivity are associated with better emotion regulation in children of many ages (see Crockenberg & Leerkes, 1999; Thompson, 1994, for reviews), and certain maternal behaviors (e.g., distraction, calming vocalizations, touch, and positive affect) correlate negatively with infant/toddler distress or stress reactivity in emotionally arousing contexts (Grolnick, Kurowski, McMenamy, Rivkin, & Bridges, 1998; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996). In contrast, negative maternal affect and intrusiveness correlate positively

with infant distress (Hornik, Risenhoover, & Gunnar, 1987). Although correlational data preclude causal inferences, results of human experimental studies in which infant affect varied as a function of caregivers' responses support the view that mothers influence emotion regulation during infancy (see, e.g., Campos, 1989; Cohen, 2002; Klinnert, 1984; Walden & Ogan, 1988). Animal studies have provided additional support for the mother's role in organizing the stress system in offspring. On the basis of her analysis of rodent and primate study results, Gunnar (2000) argued that contingent, responsive stimulation, rather than stimulation per se, is the aspect of early experience that has the greatest impact on regulation. If maternal behavior occurs when infants signal increasing arousal through changes in their behavior, circumstances are optimal for learning. Infants are in a state that requires modulation (as opposed to a relaxed state), and the caregiver's contingent response at that point can elicit or prompt a modulating response.

Few investigators have examined contingencies between specific maternal behaviors and shifts in infant distress. In one of the first studies of this type, Jahromi, Putnam, and Stifter (2004) reported that maternal holding/rocking, vocalizing, and feeding/pacifying preceded reductions in negative affect during inoculation, implicating maternal soothing as an effective regulatory behavior in response to pain at both 2 and 6 months postpartum. The researchers noted also that mothers' use of vocalizing and distraction increased between 2 and 6 months, consistent with the development of infant distance receptors (Kopp, 1989). To our knowledge, there have been no comparable studies of contingencies between maternal behavior and infant distress in novel contexts, the focus of the present investigation. This is a significant gap because data on mothers are necessary to understand how the dyad works to regulate infant negative arousal and possibly to explain discontinuity in infant temperament and linked behaviors over the course of development (Wachs & Kohnstamm, 2001).

On the basis of these data, we identified three types of maternal behavior implicated in the development of emotion regulation during the first year: behavior that draws or maintains the infant's attention away from the novel stimuli, behavior that soothes through gentle touch and vocalization, and so-called negative behavior, expected to increase infant distress because of its aversive affective quality (e.g., frowning in response to mild distress) or encouragement of behavior likely to increase distress (e.g., prompting a distressed infant to approach the source of the distress). Additionally, we observed that some maternal soothing occurred when mothers and infants were jointly focused toward the novel toy. We reasoned that this might allow infants to maintain their attention on the novel toy without becoming distressed, and thus, we incorporated it as a fourth maternal regulation behavior, labeled *support.*

Infant-Mother Reciprocity in Infant Emotion Regulation

If both infant and maternal behaviors regulate infant emotion, the possibility arises that early in development, they operate as a system, such that mothers both elicit and respond to infant behaviors as part of the emotion regulation process. Tronick (1982) introduced this mutual regulation model, arguing that the system works because the infant signals an affective state, the mother responds, and the infant responds to her. We applied a critical tenet of the model, that infant and mother share the same focus of attention during the regulatory process, to the infant and maternal behaviors identified above as presumed regulation behaviors. To illustrate: From prior research (e.g., Johnson et al., 1991), we know that infants shift their attention away from an

attractive stimulus when there is a competing event of sufficient intensity and complexity to draw their attention elsewhere. For young infants whose mobility is limited and whose ability to shift visual attention is just developing, caregivers are instrumental in producing diverting events of this sort by using animated facial and vocal cues and by providing other attractive visual stimuli (e.g., toys). Thus, parents who engage in these behaviors foster redirection of infant attention in the service of emotion regulation. At the same time, caregivers respond to infant signals (i.e., looks and vocalizations), following the direction of their infant's gaze, consistent with a reciprocal influence of mothers and infants during regulation of infant emotion. As a first step in testing this model of infant emotion regulation, we examined contingencies between specific infant and maternal regulation behaviors.

Summary and Hypotheses

In sum, there are conceptual and empirical bases for expecting infant and maternal behaviors to correlate with each other and with infant distress, to regulate infant negative affect at 6 months, and to occur contingently when infants are exposed to novel stimuli. We tested the following hypotheses.

1. Infant regulation behaviors (look away, self-soothe, and withdrawal) are associated with reductions in infant distress to novelty, whereas upregulation behavior (activity) is associated with greater infant distress to novelty. Specifically, regulation behaviors correlate negatively with infant distress and occur at greater than chance levels with decreases in negative affect. Infant activity correlates positively with distress and occurs at greater than chance levels with increases in negative affect. Associations and effects of infant regulation behaviors vary as a function of mothers' involvement because mothers encourage certain infant behaviors and preempt others by intervening before infants have time to act.

2. Maternal regulation behaviors (engage, soothe, and support) are also associated with reductions in infant distress to novelty, whereas maternal upregulatory behavior (negative) is associated with increased distress to novelty. Regulation behaviors correlate negatively with infant distress and occur at greater than chance levels with reductions in negative affect; negative maternal behavior correlates positively with infant distress and occurs at greater than chance levels with increases in negative affect.

3. Infant and maternal regulatory behaviors occur together in novel contexts, implicating them jointly in emotion regulation. Specifically, infant look-away behavior correlates positively with and occurs at greater than chance levels with engaged maternal behavior.

Method

Participants

Eighty-seven primiparous mothers participated. Mothers' mean age was 29 years (range: 20–41 years), their mean education was 15 years (range: 11–20 years), and the mean family income was $60,000 (range: $8,000–$200,000). The majority (93%) were Caucasian and married or living with the baby's father (99%). Infants were healthy full-term infants; 60% were male.

Procedure

Mothers were recruited at birthing classes during their 7th-8th months of pregnancy; they completed a demographic questionnaire by phone at that time. At 6 months postpartum, mothers and infants were videotaped during an assessment of infant affect and regulation.

Measures

Following a 5-min warm-up, mothers placed their infants in a car seat, then sat three feet away, situated so that, by turning, infants could see them. Two novel toys (a bumble ball and a fire truck) were introduced in counterbalanced order to control for toy effects, as described below.

During the first novelty task (*mother uninvolved*), mothers remained neutral so that we could observe infants' responses to the toy, both reactive and regulatory, without maternal intervention. During the second task (*mother involved*), mothers interacted with their infants any way they liked but were asked not to intervene directly (e.g., touch the novel toy) or remove their child from the seat unless they wished to end the activity.[1] Mothers soothed their infants between tasks to reduce carryover. Measures of infant affect and behavior were obtained from both conditions, which allowed us to assess the degree to which infant regulatory behaviors and their correlates and contingencies were stable (i.e., consistent across contexts that varied on mothers' involvement). Measures of discrete maternal behaviors and contingencies between infant and maternal behaviors were derived from the mother-involved condition.

Novelty tasks. During the novelty tasks, the infant seat was tucked into a table with a clear plastic barrier that prevented the toys from touching the infant. The fire truck approached from the opposite end of the table with a voice and siren sounding and lights flashing. When it reached the barrier, it stopped, while lights and siren continued. This sequence lasted 25 s and was repeated three times. After the third approach, the siren, voices, and flashing lights continued for 35 s. Then, the experimenter placed the silent fire truck within the infant's reach for 1 min. For the bumble ball, another barrier was added, two feet from the first, to ensure that the bumble ball would bounce in close proximity to the infant. The experimenter placed the ball between the two barriers and turned it on. It bounced unpredictably for 30 s, then remained still, emitting a high-pitched giggle for 15 s. This sequence repeated three times. Then, the experimenter turned off the ball and placed it within the infant's reach for 1 min.

Behavioral rating and coding. Infant affect was rated, and infant and maternal behaviors were coded continuously from videotapes, using a computerized, event-based coding system. Trained students coded in pairs to maintain accuracy while watching a videotape, operating the VCR, and entering codes; those who coded one type of affect or behavior were masked to other codings and to data from the larger study (e.g., infant temperament ratings). Pairings varied to prevent pair-linked coder drift. We coded 25 videotapes independently at the beginning and midway through the process to assess reliability and to prevent coder drift for each type of coding.

Infant affect. Infant affect was rated continuously on a 7-point scale adapted from Braungart-Rieker and Stifter (1996). Scores included 1 = *high positive,* 2 = *moderate positive,* 3 = *mild*

positive, 4 = *neutral,* 5 = *mild negative,* 6 = *moderate negative,* and 7 = *high negative,* based on infant facial expressions, body tension, and vocalizations. Kappas for each level of affect ranged from.68 to.98 (mean κ =.83) across conditions.

This system yielded several measures of observed infant distress (peak intensity of negative affect, latency to first negative, mean affect, and the ratio of time negative to positive or neutral). Factor analyses were run on these behavioral measures separately for the mother-uninvolved and mother-involved conditions. Factor loadings ranged from.73 to.95 (absolute value) for each task. Therefore, they were standardized and averaged to create two infant distress composites: mother-uninvolved distress to novelty and mother-involved distress to novelty. In both conditions, observed distress was comparable for infants exposed to the bumble ball and the fire truck: *M*s =.05 and −.06, *SD*s =.57 and.69, $t(85) = .39$, *ns,* for the mother-uninvolved condition; and *M*s = −.11 and.00, *SD*s =.63 and.62, $t(78) = 0.42$, *ns,* for the mother-involved condition.

Three new codes reflecting changes in infant affect were created using Bakeman and Quera's (1995) Generalized Sequential Querier (GSEQ) program for use in the contingency analyses. A reduction of negative affect occurred when there was a change from a higher to a lower state of distress (e.g., 7 to 6, 7 to 5, 6 to 5). Calming occurred when distress ended and was followed by a neutral or positive state (i.e., 7, 6, 5 to 4, 3, 2). Escalation of negative affect occurred when a distressed state followed a positive or neutral state (e.g., 3 to 5, 4 to 5) or a more distressed state followed a less intensely distressed state (e.g., 5 to 6, 5 to 7, 6 to 7). Each instance of reduction, calming, or escalation was identified by the program within a 0.10-s window to identify precisely the infant behaviors most likely to co-occur with the shift.

Infant behaviors. Twelve mutually exclusive behavioral codes, adapted from Rothbart et al. (1992), were used to code infant behavior. Brief descriptions are provided in Table 1; complete definitions and coding instructions are available from Susan C. Crockenberg. Thirteen additional codes were created during coder training to identify instances in which infants engaged in two or more behaviors simultaneously (e.g., self-soothe and look at mom). Intercoder reliability for all codes within a 1-s interval ranged from.65 to.87 (mean κ =.75).

Table 1
Brief Definitions of Infant Behaviors

Infant behavior	Definition
Inspect	Looks at novel toy
Approach	Touches (or tries to touch) novel toy
Attack	Hits or bangs novel toy
Partial reach	Movement or action in direction of novel toy
Withdraw	Increases distance from novel toy (e.g., turns head, arches back, retracts hands, closes eyes)
Startle	Jumps back and blinks
Visual regard	Looks at other object or experimenter (not at novel toy)
Look at mom	Turns head and looks at mother
Communication	Verbal or nonverbal communication directed at the mother
Stimulation	Actively moves hands or limbs (e.g., bangs hands on or rubs table vigorously)
Self-soothing	Behaviors that resemble calming (e.g., sucks fingers, gums, gentle rubbing)
Respiration	Yawns or sighs

To reduce the data and maintain an adequate subject-to-variable ratio, we combined infant behaviors based on both conceptual considerations and their simple correlations, as reported

in Table 2. This yielded six variables. To control for between-task time differences, each variable was defined as the percentage of time the infant engaged in the behavior. Four of these were identified a priori as regulation (look away, self-soothe, and withdraw) or upregulation (activity) behaviors. Look away included visual regard of another object and look at mom,[2] combined because both involved looking away from the novel stimulus and toward something else and because they correlated significantly in both conditions. Soothe included self-soothe alone, self-soothe with look at mom, and self-soothe and inspect the novel toy, combined because each involved self-soothing and intercorrelated significantly in both conditions. Activity included stimulation and partial reach because both involved active movement and correlated significantly in both conditions. In the uninvolved condition, both behaviors correlated significantly also with stimulate/inspect, indicating that the baby was watching the toy while engaged in stimulating behavior; thus, this combined behavior was included in the uninvolved activity composite. Withdraw was a single category, defined by closed eyes and/or movement away from the novel toy, which correlated positively with none of the other regulation behaviors. These variables were positively skewed and therefore transformed; for ease of interpretation, descriptive data are presented for the nontransformed variables in Table 2. For the sequential analyses, the three combined categories were created in GSEQ using the lump command, as recommended by Bakeman and Quera (1995; e.g., look at mom and look at object were renamed look away).

Table 2
Correlations Among Infant Behavior Codes

Infant behavior code	1	2	3	4	5	6	7	8	9
1. Look at mom	—	.31**	−.26*	−.24*	−.12	−.02	−.02	−.02	−.27*
2. Visual regard	.31**	—	−.04	−.21	−.24*	−.02	−.13	−.11	−.21
3. Soothe	−.19	−.37**	—	.54**	.44**	.10	−.09	−.18	−.05
4. Soothe/inspect	−.21	−.44**	.62**	—	.55**	.31**	.06	−.12	−.17
5. Soothe/look at mom	−.11	−.22*	.39**	.22*	—	.14	.12	−.11	−.09
6. Stimulate	.26*	.04	.00	.01	−.17	—	.27*	.15	−.25*
7. Partial reach	.16	.05	−.05	.03	.01	.34**	—	.02	−.09
8. Stimulate/inspect	.36**	.09	−.06	−.03	−.05	.47**	.30**	—	−.16
9. Withdraw	−.16	.00	−.14	−.21*	−.02	−.22*	−.14	−.19	—

Note. Mother-uninvolved condition correlations are reported above the diagonal (n = 87); mother-involved condition correlations are reported below the diagonal (n = 83).
* $p < .05$, two-tailed. ** $p < .01$, two-tailed.

Maternal behavior. Twelve behavior codes were created based on existing schemes (Farran, Kasari, Comfort, & Jay, 1986; van den Boom, 1994). Intercoder reliability (kappas) within a 1-s interval ranged from.65 to.85 for the 12 codes (mean κ =.75) using procedures described above. Detailed descriptions of all codes are available from Esther M. Leerkes; target maternal behaviors are defined below.

Four maternal behaviors were identified: three putative regulation behaviors (engage, soothe, support) and one upregulation behavior (maternal negative). These correlated significantly with an independent, global rating of sensitivity (rs ranged from −.32 [for maternal negative] to.61, p levels <.05 or lower), supporting their validity.

Maternal engage included verbal or visual interaction that occurred when infant attention was directed away from the novel stimuli or that attempted to draw the infant's attention away from the novel toy (e.g., by calling the infant's name or presenting another toy within the infant's line

of sight). Maternal soothe included gentle touch and/or vocalizations that appeared designed to calm the infant or maintain a calm state. Maternal support combined soothe (as defined above) with maintaining the infant's attention on the novel toy. Negative maternal behavior included four low-frequency behaviors, combined a priori as types of insensitive behavior. These included negative affect (annoyed vocalizations or facial expressions directed at infant), intrusiveness (e.g., placed infant's hand on novel toy), mismatched affect (mother's affect incongruent with infant's, e.g., laughed when infant upset), and distracted (mother did not watch infant or watched from a distance when infant was distressed).

Variables representing the percentage of time mothers engaged in a behavior were created, tested for skew, and transformed if necessary. Descriptive data for the nontransformed variables are presented in Table 3. Because of technical difficulties with the time code, maternal data are missing for four mothers, and in three other cases the protocol differed from the standard, limiting analyses of maternal and infant behavior in the involved condition to $n = 80$.

Table 3
Descriptive Statistics

Variable	Mother-uninvolved task				Mother-involved task			
	N	*M*	*SD*	Range	*n*	*M*	*SD*	Range
Infant affect shifts (frequency)								
Reduce	87	4.72	4.32	0–16	80	5.11	5.14	0–21
Calm	87	3.37	3.00	0–14	80	3.73	3.67	0–16
Escalate	87	4.82	4.42	0–15	80	5.33	5.32	0–20
Observed distress to novelty	87	0.00	0.63	−1.01–1.68	80	−0.05	0.62	−1.05–1.65
Infant regulation behaviors (percentage of time)								
Look away	87	15.83	9.92	0–47.58	80	12.29	10.11	0–43.58
Self-soothe	87	13.95	20.62	0–91.89	80	13.66	16.64	0–71.17
Withdraw	87	5.82	11.33	0–69.26	80	4.62	9.83	0–44.68
Activity	87	6.28	7.89	0–33.24	80	4.56	6.20	0–35.56
Maternal behavior (percentage of time)								
Engage					80	19.22	14.34	0–73.90
Soothe					80	8.57	14.44	0–65.66
Support					80	11.52	19.44	0–87.94
Negative					80	4.25	9.12	0–59.35

Results

Data analyses proceeded in several steps. First, we correlated observed infant and maternal regulation behaviors and observed infant distress within and across conditions to assess the extent of covariation among each set of measures, to test associations between infant and maternal behaviors within tasks, and to determine the degree of stability of infant behavior and its correlates across conditions. Second, we used sequential analyses to calculate the probability of reductions, calming, or escalations in observed negative affect as a function of each putative regulation behavior for infant and maternal behaviors separately. Third, we used sequential analysis to examine the frequencies of onset of specific maternal behaviors while infant behaviors were ongoing and then the onset of infant behaviors during maternal behaviors to determine if identified maternal and infant regulating behaviors were contingent on each other. Post hoc analyses are described below.

Preliminary Analyses Identifying Demographic, Sex, and Novelty Toy Differences

Correlational analyses revealed that maternal characteristics (age, education, and income) were unrelated to mother and infant behaviors in either condition. Nor were there differences in maternal or infant behaviors as a function of the novelty toy (fire truck or bumble ball) tested within conditions using independent-samples *t* tests. There was only one difference in maternal or infant behavior as a function of child sex; male infants engaged in more activity (M =.03, SD =.03) than female infants (M =.01, SD =.02), $t(78) = 2.28$, $p < .05$, in the mother-involved condition.

Zero-Order Correlations of Infant and Maternal Variables

As shown in Table 4, correlations between the same infant behaviors across conditions were all positive and significant, indicating some degree of stability. However, correlations were only partially consistent with the expected regulating effects of both infant and maternal behaviors. Infant looking away was negatively related to both self-soothing and withdrawal, although all are presumed regulating behaviors, and contrary to expectation, only looking away was associated with less infant distress. Similarly, maternal engagement was negatively related to the other presumed maternal regulation behaviors, soothing and support, and was the only maternal behavior associated with less infant distress and more infant looking away. In contrast, infant withdrawal correlated positively with distress in both conditions and with maternal negative behavior. As predicted, correlations among infant behaviors varied by condition, presumably as a function of maternal involvement. The only correlation between infant behaviors observed in both conditions was the negative association between looking away and self-soothing, significant when mothers were not involved, a trend when they were involved.

Table 4
Correlations Between and Among Infant and Mother Behaviors

Behavior	1	2	3	4	5	6	7	8	9
1. Look away	**.22***	−.47**	−.05	.29**	−.17				
2. Self-soothe	−.20†	**.32****	−.09	.00	−.02				
3. Withdraw	−.29**	−.11	**.57****	−.33**	.70**				
4. Activity	−.03	.22†	−.26*	**.25****	−.26**				
5. Observed infant distress	−.31**	.13	.59**	−.19†	**.67****				
6. Maternal engage	.39**	.22*	−.19†	.11	−.25*	—			
7. Maternal soothe	−.40**	.02	.74**	−.06	.64**	−.30**	—		
8. Maternal support	−.23*	.07	.20†	.05	.33**	−.19†	.40**	—	
9. Maternal negative	−.19†	−.03	.40**	−.08	.29**	−.08	.36**	−.18	—

Note. Mother-uninvolved task correlations are reported above the diagonal (N = 87); mother-involved task correlations are reported below the diagonal (n = 80); correlations between parallel constructs assessed in mother-uninvolved and mother-involved conditions are reported on the diagonal and appear in boldface type (n = 80).
† $p < .10$. * $p < .05$. ** $p < .01$.

Taken together, these findings suggest that one or more of the infant and maternal behaviors presumed to regulate infant distress may serve no regulatory function, but the findings are inconclusive because it is not possible to establish direction of effects from concurrent correlations or even to determine if the correlated infant and maternal behaviors were linked contingently. Thus, a series of sequential analyses was conducted to test hypothesized regulating effects of infant and maternal behaviors by determining which behaviors reliably co-occurred

with changes in infant affect and to examine the temporal dynamics of maternal and infant behaviors during the regulation process.

Sequential Analyses: Hypothesis 1

Regulating effects of presumed infant regulating behaviors were assessed in both conditions (mother uninvolved and mother involved) to determine the stability of regulation effects across contexts that varied in maternal involvement, whereas the regulating effects of maternal behaviors were assessed only in the mother-involved condition, as were the contingencies between infant and maternal behaviors.

We used two approaches to sequential analysis, as recommended by Bakeman and Gottman (1997). First, we pooled data across all infants and examined frequencies of co-occurrence (within 0.10 s) of reductions, calming (reductions to neutral or positive), and escalations of negative affect with each infant and maternal behavior, using Pearson chi-squares to determine if the frequency of observed co-occurrence was more or less likely than chance. Using chance-expected frequencies as the comparison indicates how likely a particular behavior is to be associated with decreases or increases in infant distress in contrast to all other behaviors, including other regulatory behaviors, and thus provides a more conservative test than using expected frequencies based on what happens when no other regulatory behavior occurs.

If the pooled analyses were significant, we then conducted Pearson chi-squares for each infant to determine whether co-occurrences with each behavior occurred significantly more than expected by chance on an individual basis. Using these data, we calculated sign tests to determine if a significant number of infants displayed particular patterns of co-occurrence.

The best evidence that a behavior is linked reliably to changes in negative affect occurs when the pooled chi-squares and sign tests for the same co-occurrence are both statistically significant. Thus, contingencies that are significant in the pooled data and at the dyadic level are boldfaced in Table 5 and summarized below.

Reduction, calming, and escalation in negative affect associated with infant behaviors. In both conditions, reductions in negative affect were significantly more likely than chance to occur when infants looked away, and a significant number of dyads displayed this pattern. Reductions in negative affect were significantly more likely also in relation to self-soothing, but the number of dyads that displayed this pattern was significant only when mothers were uninvolved. Reductions in negative affect in relation to withdrawal were more likely than chance only in the mother-uninvolved condition. Results were identical for calming (reductions from any level of distress to neutral or positive affect) except that calming was not more likely than chance in relation to infant withdrawal in either condition.

Escalations in negative infant affect were significantly more likely than chance in conjunction with withdrawal, and a significant number of infants displayed this pattern in both conditions. Contrary to our hypothesis, activity was unrelated to escalations in infant negative affect in either condition.

Table 5
Co-Occurrence of Reduce, Calm, and Escalate With Mother and Infant Behaviors

	Mother-uninvolved task			Mother-involved task		
Behavior	Reduce	Calm	Escalate	Reduce	Calm	Escalate
Infant						
Look away	**61 (49)**** **27, 0****	**50 (33)*** **25, 0****	42 (57)* 5, 3	**55 (42)*** **11, 0****	**45 (33)*** **7, 0***	35 (47)†
Self-soothe	**57 (45)*** **23, 0****	**45 (34)*** **23, 0****	30 (52)** 1, 2	65 (49)* 4, 2	49 (38)* 4, 1	65 (54)†
Withdraw	**34 (18)**** **14, 0****	10 (14)	**129 (21)**** **35, 0****	16 (16)	0 (12)** 0, 4	**70 (17)**** **6, 0***
Activity	20 (19)	17 (15)	14 (22)	20 (16)	19 (12)	19 (18)
Maternal						
Engage				**95 (77)**** **10, 0****	**79 (56)**** **10, 0****	96 (82)†
Soothe				84 (33)** 4, 0	40 (24)** 3, 0	56 (35)** 2, 2
Support				62 (48)* 2, 0	**47 (32)**** **5, 0***	67 (46)** 5, 2
Negative				20 (16)	11 (12)	22 (17)

Note. Within a cell, the first line includes observed frequencies, followed by expected co-occurrences in parentheses, from the pooled chi-square ($df = 1$), based on 87 infants for the mother-uninvolved task and 80 infants for the mother-involved task. If the pooled chi-square is significant, the second line of the cell includes data from the sign tests; the first number indicates the number of infants with a contingency significantly greater than chance, the second indicates the number with a contingency significantly less likely than chance. Contingencies significant at both the pooled and individual level appear in boldface type.
† $p < .10$. * $p < .05$. ** $p < .01$.

Reduction, calming, and escalation in negative affect associated with maternal behaviors. Using the procedures described above, we found that maternal behaviors showed a similar pattern of contingencies with infant negative affect. Reductions in negative infant affect and calming were significantly more likely when mothers were engaged with their infants around something other than the novel toy. Calming was significantly more likely also when mothers provided support (e.g., soothed while sharing their infant's focus on the novel toy). No maternal behavior co-occurred reliably with escalations in infant negative affect.

In sum and as hypothesized, infant looking away from the novel toy and self-soothing were associated with reductions in negative affect and/or complete calming, as were maternal engagement and support. In contrast, infant withdrawal was associated with reduced distress when mothers were not involved, but not with calming in either condition; it was the only infant behavior linked to increases in infant distress in both conditions.

Contingencies between infant and maternal behaviors. To determine if maternal and infant regulation behaviors were contingent on each other, we used the two approaches to sequential analysis described above to examine frequencies of the onset of specific maternal behaviors while infant behaviors were ongoing and the onset of infant behaviors during ongoing maternal behaviors. Activity was not included in these analyses because we had neither expected nor found any regulatory effects of this behavior. Contingencies significant in the pooled data and at the dyadic level are boldfaced in Table 6. As illustrated, mothers were significantly more likely

than chance to engage with their infants when the infants were looking away from the novel toy, to begin negative behaviors and soothing during infant withdrawal from the novel toy, and to provide support when infants were already self-soothing. Similarly, infants were more likely than chance to look away from the novel toy and to self-soothe when mothers were engaged with them around something other than the novel toy, to begin self-soothing when mothers provided support, and to withdraw from the toy when mothers were negative.

Table 6
Onset of Infant Behaviors and Maternal Behaviors Contingent on One Another

	Infant look away		Infant self-soothe		Infant withdraw	
Behavior	Mother first	Infant first	Mother first	Infant first	Mother first	Infant first
Maternal engage	**193 (173)*** **18, 7***	**184 (108)**** **43, 0****	**68 (55)*** **10, 1***	73 (64)	16 (35)** 2, 0	12 (35)** 2, 1
Maternal soothe	31 (59)** 3, 6	13 (30)** 3, 1	26 (19)†	19 (18)	55 (12)** 2, 0	**48 (10)**** **6, 0***
Maternal support	55 (74)** 4, 7	8 (21)** 2, 0	**45 (24)**** **5, 0***	**26 (12)**** **6, 0***	12 (15)	4 (7)
Maternal negative	29 (31)	16 (22)	14 (10)	9 (13)	**18 (6)**** **7, 0***	**26 (7)**** **5, 0***

Note. Within a cell, the first line includes observed frequencies, followed by expected co-occurrences in parentheses, from the pooled chi-square ($df = 1$) based on 80 dyads. If the pooled chi-square is significant, the second line of the cell includes data from the sign tests; the first number indicates the number of dyads with a contingency significantly greater than chance, the second indicates the number with a contingency significantly less likely than chance. Contingencies significant at both the pooled and dyadic level appear in boldface type.
† $p < .10$. * $p < .05$. ** $p < .01$.

In sum, two of the three maternal regulation behaviors, engage and support, were contingent on specific infant regulation behaviors, look away and self-soothe, respectively, and the infant regulation behaviors look away and self-soothe were contingent on maternal engage and support, respectively. Maternal negative and infant withdrawal behaviors were contingent on each other as well. From their mutual contingency, we infer that the dyadic partners, mothers and infants, were responsive to each other during exposure to novel toys and thus are implicated jointly in the regulation of infant distress or lack thereof. We explore this implication below.

Post hoc analyses. We reasoned that if contingency were important in the emotion regulation process, infants in contingent dyads would exhibit less distress than other infants. Thus, we compared the distress displayed by infants whose mothers responded contingently with engagement when they looked away from the novel toy ($n = 43$) with all other infants ($n = 37$).[3] An independent-samples t-test comparison was significant, $t(78) = 5.11$, $p < .001$; infants whose mothers responded contingently displayed less distress ($M = -.34$, $SD = .54$) than other infants ($M = .29$, $SD = .55$). To ensure that this difference was a function of maternal contingency and not of differences in the frequency of infant looking away, we identified two groups of infants both of whose members looked away at or above levels expected by chance but which varied in contingent maternal behavior. Consistent with results from the full sample, infants whose mothers engaged contingently were less distressed overall than infants whose mothers did not respond contingently ($n = 33$, $M = -.40$, $SD = .53$, and $n = 12$, $M = .07$, $SD = .35$, respectively), $t(43) = -3.40$, $p < .01$. In contrast, there was no difference in infant distress when dyads in which infant looking away was contingent on maternal engagement ($n = 18$, $M = -.21$, $SD = .11$) were compared with all other dyads ($n = 62$, $M = -.01$, $SD = .08$), $t(78) =$

1.18, *ns.* Taken together, these findings suggest that maternal engagement contingent on infant attention has an especially powerful effect on emotion regulation in 6-month-old infants.

Discussion

By 6 months of age, a significant number of infants reduced their own distress to novelty by soothing themselves and looking away from the novel toy when mothers were present though not involved. When mothers were involved, they appeared to foster these regulatory effects through their contingent responsiveness to their infants' attention cues. In so doing, mothers participated with their infants in the development of the emotion regulation system during the first year.

Infant Behaviors Regulate Negative Affect in Novel Contexts

Sequential data indicating a decline in negative affect when infants looked away from the novel toy or engaged in soothing behaviors at the point of change validate their identification as regulatory behaviors in relation to novelty-linked distress at 6 months and extend previous findings. In a prior study, only withdrawal demonstrated a regulatory effect on infant distress to novelty at 6 months, leading researchers to propose that other effective regulation behaviors emerge later in the first year (Buss & Goldsmith, 1998). Of particular note is the regulating effect of infant attention control (i.e., looking away from the novel toy), as predicted by Rothbart et al. (1992). In fact, in the mother-involved condition, looking away was the only infant behavior to co-occur with reductions in infant negative affect more frequently than expected (at both group and dyadic levels) and to correlate negatively with infant distress. It follows that inferences about the regulatory effects of certain infant behaviors should be qualified by the context in which they occur, specifically, by mothers' availability to respond to their infants' distress.

On the basis of previous research, we expected the third presumed regulation behavior, infant withdrawal, to be as effective as looking away and self-soothing in reducing negative affect, and the results linking withdrawal with more distress overall and with increases in infant negative affect require explanation. Possibly, the assessment context precluded withdrawal sufficient to reduce negative affect because the car seat restricted infant movement. Infants could close their eyes and turn or twist their heads and, to a lesser extent, their bodies, but they could not leave the vicinity of the novel toy. On the other hand, at 6 months, mobility is limited for most infants even without the restrictions imposed by a car seat. Thus, withdrawal may become a more effective regulation strategy, though not necessarily a more adaptive one, as infants get older.

At the same time, the positive correlation and contingencies between maternal negative behavior and infant withdrawal suggest that withdrawal is not simply a function of the context or of the infant's physical maturation. It appears from these data that some mothers reacted negatively when their infants withdrew from the novel toy but also that they elicited withdrawal when they reacted negatively to their babies. This is consistent with Klinnert's experimental findings in which infants whose mothers grimaced at them backed away from the deep end of the visual cliff and with Tronick, Cohn, and Shea's (1986) finding that mismatched affect sets the stage for behavioral and physiological disorganization in infants.

The differential effects of looking away and withdrawal in relation to infant emotion regulation are noteworthy given that both involve turning away from the novel toy. What distinguishes the two behaviors is the focus of the infant's attention. When infants look away, they focus on mothers or on other stimuli, whereas typically during withdrawal, they close their eyes or appear to focus exclusively on getting away. This difference parallels the finding in the adult coping literature that turning away from the stressor reduces the person's experience of stress if it includes engagement in some other thought or activity, whereas simple avoidance does not. Apparently, the ability to reorient one's attention to something else is effective in regulating negative emotion in 6-month-old infants as well as in adults.

Although infant activity did not co-occur with reductions in negative affect, as did looking away and self-soothing, neither was it associated with escalations of negative affect, as was withdrawal. Thus, there is no support in these data for the view that infant activity is a type of upregulation, as Rothbart et al. (1992) implied, although the possibility remains that activity operates differently for infants with different temperaments.

Maternal Behaviors Regulate Infant Negative Affect in Novel Contexts

We had hypothesized that maternal engagement would be especially effective in reducing distress by encouraging infants to redirect their attention in the service of emotion regulation, either by drawing the infant's attention away from the novel toy or by responding to the infant's efforts to engage with something else. That maternal engagement both followed and preceded the onset of infant looking away at greater than chance levels lends credence to the thesis that mothers and infants operate jointly to regulate negative infant emotion in the middle of the first year and that shared attention is a critical element of this process. Moreover, the finding that, in dyads in which mothers responded contingently to their looking away, infants were less distressed than infants whose mothers did not respond contingently identifies contingent maternal responsiveness as a key feature of the emotion regulation system in infancy.

Nevertheless, by 6 months, infants may not require their mothers' active engagement to regulate negative emotion effectively. Even when mothers were not involved, infant looking away co-occurred more frequently than expected with decreases in negative affect, suggesting either that merely seeing their mothers exercises a regulatory effect or that by 6 months, infants have learned to modulate arousal by redirecting their attention. We tend to favor the second explanation because the look-away composite included both looking at mother and looking at something else, only the first of which involved seeing the mother. Resolution of this issue rests on future studies, however.

Maternal support co-occurred more frequently also with reductions in infant negative affect, providing additional support for the proposition that a shared focus between infant and mother is central to the regulatory process. Although joint infant and mother attention characterizes both maternal support and maternal engagement, they differ in that, during support, infant and mother focus on the novel toy, whereas, during engagement, infant and mother focus away from the novel toy and toward something else. On the basis of the negative correlation between infant looking away and maternal support, we speculate that mothers' focusing with their infants on the novel toy while providing vocal and tactile soothing may be effective in regulating negative

affect in dyads in which infants tend not to look away from the novel toy as their distress increases. As such, support may be a transitional strategy, adaptive until infants develop greater control over attention, or it may reflect differences in infants' interest in and inclination to approach the novel toy. Such infants may require support in the form of shared attention and soothing from mothers to help them regulate emotion in pursuit of goals. Notably, maternal support was contingent on infant self-soothing at greater than chance frequencies, and the reverse also occurred, although few dyads demonstrated these contingent patterns above chance levels.

It is unexpected, and therefore noteworthy, that—unlike maternal support, with which it correlated—maternal soothing did not co-occur with reductions in infant negative affect and in fact correlated positively with infant distress. This could be an artifact of the protocol that required mothers to leave their infants in the car seat, thereby precluding holding and rocking, behaviors effective in reducing infant distress in other contexts (Jahromi et al., 2004). It could also reflect the circumstances in which mothers soothe their infants, rather than engaging or supporting them. If mothers delay soothing until their infants are already quite distressed, a plausible interpretation of the positive correlation between infant distress and maternal soothing, they may be less effective than if they had intervened earlier. Of course, if infants' negative affect escalates rapidly during exposure to a novel toy, as is sometimes the case, mothers may have little opportunity to respond to low-level distress cues.

Limitations and Directions for Future Research

As noted above, the laboratory protocol, which restricted infant movement and required mothers to leave infants in their seats, may have limited the effectiveness of infant withdrawal and maternal soothing in reducing negative affect. Additionally, inferences about development are constrained by the nonrepresentative sample and cross-sectional data. However, evidence that infant attention control at 6 months moderates the link between distress at novelty and later anxious behavior (Crockenberg & Leerkes, 2003) suggests that this infant behavior has long-term significance for development.

The findings suggest several directions for future research. First, clarification of some findings requires investigation of change in infant emotion regulation behaviors over the course of the first year, in conjunction with maternal behavior and infants' developing capacities. For example, does withdrawal become a more effective regulation strategy as infants get older, and do mothers foster withdrawal when they respond slowly to their infants' low-level distress cues? Second, are infant behaviors that are effective in regulating negative affect in novel situations equally effective when infants experience barriers to goals? Contingency data reported by Stifter and Braungart (1995) and by Buss and Goldsmith (1998) suggest such an effect based on reactions of 5- to 6-month-old infants in contexts designed to elicit frustration. Third, are there multiple steps in the regulation process that current methods of analysis fail to identify? For example, are infants more likely to withdraw from novelty when mothers respond slowly to their affective and behavioral cues, or does the speed with which some infants escalate distress preclude intervention by mothers? Fourth, are infants' regulatory behaviors identified in structured laboratory tasks linked with their behaviors in more naturalistic contexts that include novel elements concurrently or longitudinally? Finally, can emotion regulation (i.e., attention control) be fostered by teaching mothers to respond positively and contingently when their infants look

away from the novel toy and toward something else? If so, we may have identified a way to prevent some regulation problems by intervening proactively with infants and parents.

Footnotes

1. Mothers followed these directions, remaining uninvolved when requested to do so; thus, maternal behavior was not coded in this context. Three mothers stopped the procedure because their infants were highly distressed; data from these dyads were not used.

2. Looking at mother and visual regard (of something else) correlated similarly with other infant behaviors in most instances, although often associations were not significant for both (see Table 2). In particular, they both correlated negatively with the three soothe behaviors (soothe, soothe and look at mom, soothe and inspect) in both conditions and similarly with each of the maternal variables, supporting the internal validity of the look-away composite.

3. The small number of dyads ($n = 6$) for whom maternal support was contingent on infant self-soothe at greater than chance levels precluded comparing dyads varying in contingent maternal support on their levels of infant distress.

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