INFANT BEHAVIOR AND DEVELOPMENT 11, 493–505 (1988)

Effect of Contingent Changes in Mothers' Affective Expression on the Organization of Behavior in 3-Month-Old Infants

JEFFREY F. COHN AND MARQUITA ELMORE

University of Pittsburgh

During face-to-face interactions, the mother's positive expressions (e.g., smiles or rhythmic vocalizations) precede the onset of the infant's positive expressions and are maintained while the infant cycles between positive and neutral expression toward the mother. This pattern suggests that both partners are responsive to the other's affective expressions. To test the hypothesis that the organization of the infant's behavior is influenced by the mother's, we instructed 10 mothers to become still-faced whenever their infant became positive; we instructed 10 other mothers to interact normally. Mothers' and infants' behavior was described with behavioral descriptors using a 1-s sampling interval. Infants in the contingent still-face condition showed a reduced probability of transitions from *play* to *attend* and a corresponding increased probability of transitions from *play* to *avert*. Empirical indicators suggested that the mother's influence was greater in the contingent still-face condition. These data strongly support earlier studies showing that the organization of the infant's affective expression is closely related to that of the adult partner.

mother–infant behavioral organization contingency log-linear time-series

During face-to-face interactions, the mother's positive expressions (e.g., smiles or rhythmic vocalizations) precede the onset of the infant's positive expressions and are maintained while the infant cycles between neutral and positive expression toward the mother (Cohn & Tronick, 1987; Kaye & Fogel, 1980). This dyadic pattern characterizes face-to-face interactions until the infant is 6 to 9 months of age, when she or he begins to initiate bouts of joint positive engagement (Cohn & Tronick, 1987). But even then, the predominant pattern is for mothers to become positive before the infant and to remain positive until the infant sobers and looks away. This pattern suggests that both partners are responsive, although to different degrees, to the other's affective expressions.

The hypothesis that the organization of infants' affective expression is related to that of the adult partner has been tested with both quasi-experimental

The research reported in this article was supported in part by a Biomedical Research Support Grant from the NIH to the University of Pittsburgh.

Correspondence and requests for reprints should be sent to Jeffrey F. Cohn, Clinical Psychology Program, 4015 O'Hara Street, University of Pittsburgh, Pittsburgh, PA 15260.

(Sackett, 1987) and experimental procedures. The former rely on statistical analyses of mother–infant interactions. Studies of this type (Jaffe, Stern, & Peery, 1973; Kaye & Fogel, 1980; Moran, Krupka, Tutton, & Symons, 1987; Tronick, Als, & Brazelton, 1977) have been consistent with the hypothesis. A serious shortcoming of many of these studies, however, is that they failed to control for autocorrelation effects, which can lead to spurious inferences about one person's influence on another (Gottman & Ringland, 1981; Thomas & Malone, 1979). Several recent investigations have controlled for autocorrelation effects. Some (Beebe, Jaffe, Feldstein, Mays, & Alson, 1985; Cohn & Tronick, 1988; Lester, Hoffman, & Brazelton, 1985) but not all of these studies (Hayes, 1984; Gottman & Ringland, 1981) supported the hypothesis. Because none of the studies cited experimentally controlled the mothers' behavior, however, their findings must be viewed with some caution.

In an experimental study, Symons and Moran (1987) compared infants' response to three types of interaction: a normal interaction, an interaction in which the mother was instructed to imitate the infant, and an interaction in which the mother was instructed to get the infant's attention. The percentage of infants' gaze toward the mother did not vary among conditions (cf. Field, 1977), but another behavioral measure suggested that infants were responsive to changes in their mother's behavior during the normal and imitative, but not attention-getting, interactions. The responsivity measure was whether infants changed one or more of four behaviors (gaze, nonfussy vocalization, smile, or cry) in response to a change in their mother's behavior (gaze, vocalization, smile, or physical contact with the infant). Their results were consistent with the hypothesis about infants' responsiveness. However, neither the experimental control of the mothers' behavior nor the responsitivity measure they used was sufficient to determine what aspects of the mothers' behavior were associated with changes in the infants' behavior.

Other studies have manipulated the mother's behavior by asking her to remain unresponsive, by either maintaining a stillface (Fogel, Diamond, Langhorst, & Demos, 1982; Tronick, Als, Adamson, Wise, & Brazelton, 1978) or simulating depression (Cohn & Tronick, 1983; Field, 1984). These studies found dramatic changes in the infant's behavior in response to the experimental distortions of the mother's behavior. Cohn and Tronick (1983) found that in response to simulated depression, infants showed a pattern of brief positive expressions followed by gaze aversion and negative affect. Because the mother never became positive, however, it was impossible to assess whether the infant's affective expression was related to changes in the mother's affective expression. To determine whether the organization of the infant's affective behavior is related to the mother's, it is necessary to change the organization of the mother's affective behavior and evaluate the infant's response.

Thus, we asked mothers to become briefly still-faced contingent on their infant's showing positive expression; to remain still-faced until after their infant became neutral, and then to resume normal interaction. With this manipulation, we tested two hypotheses: (a) In response to contingent still-face, infants show a decreased probability of cycling between positive and neutral expression toward the mother and a corresponding increased probability of transition from positive expression to disengagement (i.e., gaze directed away from the mother); and (b) relative to a normal interaction, the mother's influence on the infant will be increased.

The second hypothesis is based on the assumption that during normal interactions, the mother's behavior influences the onset of the infant's cycling between positive and neutral expression toward her (Cohn & Tronick, 1987; Kaye & Fogel, 1980), but because she remains positive, the offset of positive cycling is determined by the infant's own limitation in maintaining high arousal (cf. Brazelton, Koslowski, & Main, 1974; Fogel et al., 1982). The offset of positive cycling in the normal interaction is thus not associated with any change in the mother's behavior.

The mother's sustained positive expression serves to scaffold and aid the infant's actions (Bruner, 1977), or what Stern (1984) described as "affect attunement." This dependence of the infant on the mother's sustained positive expression becomes apparent (and can be quantified) only when the mother sobers or otherwise disrupts the infant's behavior (in a related context, see Stern, 1984, pp. 7–8). From this perspective, the contingent still-face manipulation should influence the offset of the infant's positive cycling as well as its onset and thus increase quantitative estimates of the mother's influence on the infant relative to a normal interaction.

METHOD

Subjects

Subjects were 20 white, full-term healthy, middle-class 3-month-old infants (*M* age = 93 days, *SD* = 4 days) and their mothers. Each mother was her infant's primary caregiver. The subjects were recruited from published birth reports. Fourteen infants were female and 6 were male, with equal numbers of male and female infants in each condition.

Setting and Procedure

The observation room was equipped with an infant seat mounted on a table, a facing stool for the mother, two video cameras, one for each partner, and a microphone. The video and audio output was transmitted into an adjoining recording room where it was integrated by means of a split-screen generator and recorded along with a digital time code on a Panasonic NV8950 video recorder.

Mother–infant pairs were randomly assigned to either the experimental (contingent still-face) or control condition. Equal proportions of infant boys and girls were in each group. Both conditions involved 3 min of interaction following a 1-min warm-up (i.e., normal) interaction.

In the contingent still-face condition, whenever the infant became positive, an audible, continuous tone was transmitted through the headphones until 5 s had elapsed from the offset of the infant's positive expression. Mothers were instructed to become still and silent in response to the tone but to continue to direct their gaze toward the infant. The tone was simultaneously recorded on a second channel of the video recorder. Mothers were instructed to resume normal interaction at the tone's offset. In the control condition, mothers interacted normally for the entire 3 min.

The minimal duration of the contingent still-face (5 s) was chosen arbitrarily, but with two considerations. One, we wanted a duration that was sufficiently long to communicate a change and to provide the infant with time to respond. Pauses typically have mean durations under 1 s. Stern, Beebe, Jaffe, and Bennett (1977) and Cohn and Tronick (1987) found that on those occasions when mothers became briefly neutral while their infant was positive, the mothers quickly repaired the mismatch. The mothers resumed positive expression before their infant changed from positive to neutral expression. Two, we did not want the still face to last so long that the mother's behavior was no longer contingent on the infant's. Therefore, 5 s seemed like a reasonable minimum duration.

Coding

Mothers' gaze and facial expression and infants' gaze, facial expression, and vocalization during the 3 min of interaction following the warm-up period were coded with behavioral descriptors based on a 1-s time base and were computer-recoded as affective states. The behavioral descriptors were from Tronick's Monadic Phases Coding System (Cohn & Tronick, 1987; Tronick, Als, & Brazelton, 1980). Mothers' states were *attend* (attention to the infant and neutral expression) and *positive* (attention to the infant and positive expression, such as smile or surprise). Consistent with prior research, mother's gaze was directed consistently to the infant (Cohn & Tronick, 1987; Kaye & Fogel, 1980).

Infants' states were *negative, avert, attend,* and *positive. Negative* refers to negative affective expressions ranging from cry or grimace to wary (Monadic Phases *protest* and *wary*); expressions coded as *negative* are classified by Izard's (1983) Maximally Discriminative Facial Movement Coding System (MAX) as pain or as a subset of interest, in which brows are drawn together and lowered (Matias, Cohn, & Ross, in press). *Avert* refers to neutral to bright facial expression with gaze directed away from the partner. *Attend* refers to slightly negative to slightly bright facial expressions, with gaze directed at the mother. *Attend* corresponds to MAX interest expressions in which brows are relaxed or raised and gaze is directed at the mother. *Positive* refers to smiles or positive vocalizations that correspond to what MAX classifies as joy or an interest/joy blend.

Mother's and infant's behavior were coded independently from the videotapes. To ensure that coders remained blind to experimental condition, the mother's image was covered during the coding of the infant's behavior. Also, coders could not hear the auditory signal, which was recorded on a separate audio track from that for vocalizations. Videotapes were played in real time, and whenever a change in behavior was observed, the videotape was stopped and replayed at regular or slow speed to determine the type of change and its time. Times were read from the digital time code on the videotape.

For comparison, one-third of the videotapes were recoded by a second coder. Exact agreement for the mothers' and infants' states was quantified with coefficient kappa, which corrects for chance agreement. Kappa coefficients (Cohen, 1960) were .82 and .84, respectively.

Data Analysis

To assess between-group differences in the conditional probabilities of transition among *positive, attend,* and *avert,* we used log-linear modeling (Bakeman, Adamson, & Strisik, in press; Bishop, Feinberg, & Holland, 1975) to evaluate the first-order transitions among infant affective states. Because we had no hypotheses about the duration of infant states, all log-linear models were fit after deleting transitions from each state to itself. The data were, therefore, event-sequential (Bakeman et al., in press; Sackett, 1987).

In log-linear modeling, the use of significance tests differs from what is common in factorial designs. Models are used to generate expected transition frequencies (or conditional probabilities; the two are conceptually equivalent). As in analysis of variance, these models are linear and consist of main effects and interactions. To test a model, we evaluate how closely the cell frequencies estimated from the model compare with observed frequencies. If the omission of an interaction term results in a significant chi-square, that is evidence that the variables in that interaction term are associated (i.e., not independent of each other). A suitable model is one that both allows a close fit of the observed frequencies and contains the fewest necessary parameters (Cohn & Tronick, 1987).

As a preliminary analysis, we used a t test to determine whether or not the frequency of infant transitions varied with condition. A significant difference in total frequency would suggest the need to include a main effect for Condition in any log-linear model (see the Results section). We also used t tests to compare the durations of infant states for both conditions.

To test the hypothesis that the mother's influence would be greater in the contingent still-face condition, we used Williams and Gottman's (1982) time-series regression program, BIVAR. For these analyses, we followed Cohn and Tronick (1988) and Lester et al. (1985) and scaled each infant's and mother's time series along an affective axis from *negative* to *positive:* 1 = *negative,* 2 = *avert,* 3 = *attend,* 4 = *positive.* Scaled scores for the mothers were limited to two: 3 = *attend* and 4 = *positive.*

The time series were then individually examined to ensure that they were stationary (see Cohn & Tronick, 1988). First-order differencing (McCleary & Hay, 1980) was required to bring about stability in the time series of four dyads. All time series were first- or second-order autoregressive and thus were appropriate for analysis with BIVAR. We then used BIVAR to assess each mother's influence on her infant's behavior. The z statistics generated by BIVAR quantify the mother's influence on the infant after autocorrelation effects in the time series of each partner are controlled for. The z statistics from these analyses were our test statistics for between-group comparisons (Cohn & Tronick, 1988; Sackett, 1987).

Test of Internal Validity

We evaluated the internal validity of the experimental manipulation several ways. First, we asked whether the experimenter's signals to the mother in the contingent still-face condition agreed with the coder's determination of the infant's positive expression. Agreement was defined as concurrence within 1 s between the experimenter and coder. The two determinators were highly consistent ($\kappa = .84$).

Second, we evaluated how well mothers in the contingent still-face condition complied with the experimenter's instructions. Eighty-one percent became still-faced within 1 s of the tone; 96% became still-faced within 2 s; and the mothers maintained the still face until signaled to resume normal behavior.

Third, we evaluated other aspects of the procedure on the mothers' behavior. Two indices of mothers' positive expression differed between conditions in the expected direction. The mean duration of *positive* was significantly less in the contingent still-face than in the normal condition (respective mean durations were 6 s and 17 s, $t(18)2.50$, $p < .025$. Similarly, the percentage of time that mothers were *positive* was also less in the contingent still-face than in the normal condition (respective means were 29% and 67%, $t(18)4.97$, $p < .01$. These were expected effects of the experimental procedure.

When mothers in the contingent still-face condition were not signaled to remain neutral, they did not compensate by becoming more positive than normal. The percentage of *positive* (74%) while the tone was off did not significantly differ from the percentage observed in the normal condition $t(18)0.94$, n.s. Thus, the manipulation did not bias the mothers' behavior during those times when they were free to behave naturally. By these criteria, the manipulation was internally valid.

We also assessed the number of still-face trials for each infant. The mean number of trials was 7 (range = 4–9). The distribution of still-face durations was positively skewed: The median duration of all trials was 12 s (range = 5–44 s.

RESULTS

Hypothesis 1: Probability of Transition Among Infants' States

Infants in the contingent still-face condition showed a higher total frequency of transitions, $t(18)2.07$, $p < .05$. The frequency of *away* was marginall greater in the contingent still-face condition, $t(18)1.84$, $p < .10$, but otherwise no one state accounted for the total increase. The duration of *attend* was marginally briefer in the contingent still-face condition (3.7 s) than in the normal condition (6.1 s) $t(18)1.79$, n.s. Durations of other states didnot vary with condition.

The difference in frequency of transition with condition indicated the need to include a main effect for Condition in the log-linear model for the null hypothesis. The null hypothesis that the organization of infants' affective expression is unrelated to mothers' affective expression corresponded to the log-linear model:

$$u_{(ijk)} = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{23(jk)} \qquad \text{(model 1)}$$

where i = experimental condition (normal interaction or contingent still-face), j = Event 1, and k = Event 2. In this model, expected frequency (i.e., transition probability) is a product of main effects for Condition, Infant State at Event 1 and Event 2, and the Interaction between infant state at Event 1 and Event 2. The main effect for Condition represents the higher frequency of transitions in the contingent still-face condition. Not included in the model are any interaction terms involving experimental condition. Interactions involving condition would suggest differences in the organization of infant behavior as a function of Condition.

This model resulted in an unsatisfactory fit of the observed transitions, $\chi^2(11) = 43.30$, $p < .0001$. By examining the standardized residuals for this model, we evaluated which transitions contributed to the significant chi-square. Table 1 presents the event-sequence transitions, expressed as transitional probabilities, for each condition. The total frequency of each infant state appears in the last column. Cells that contributed to the significant chi-square appear with superscripts. These cells are ones for which the estimated probability was either over- or underestimated by Model 1 (standardized residual greater than plus or minus 2, $p < .05$).

TABLE 1
Transition Probabilities for Event-Sequence Transitions in the Contingent Still-Face and Normal (Control) Conditions

		Event 2				
Condition	Event 1	Negative	Avert	Attend	Positive	n
Still-face	Negative	—	.03	.73	.25	29
	Avert	.05	—	$.75^a$	.20	97
	Attend	.12	.38	—	.51	172
	Positive	.09	$.27^b$	$.64^c$	—	119
Normal	Negative	—	.13	.70	.17	30
	Avert	.15	—	$.64^a$	.21	39
	Attend	.15	.21	—	.64	125
	Positive	.06	$.08^b$	$.86^c$	—	99

Note. $\chi^2(11) = 43.30$, $p < .0001$. Transitional probabilities marked with superscripts have standardized residuals greater than plus or minus 2.0 ($p < .05$). Corresponding cells with identical superscripts have significant standardized residuals of opposite sign. Cells along the main diagonals are structurally zero.

Because the table has but two levels, if a cell was significant in one level (i.e., condition), the corresponding cell in the other level was likely to be significant also. Corresponding cells with the same superscripts had standardized residuals greater than 2 ($p < .05$), with opposite signs.

Consistent with Hypothesis 1, infants in the contingent still-face condition had a higher probability of transitions from *positive* to *avert* and a lower probability of transitions from *positive* to *attend* than infants in the control condition. Transitions to or from *negative* did not vary with condition.

Hypothesis 2: Mother's Influence on the Infant

Consistent with Hypothesis 2, the mother's influence was greater in the contingent still-face condition: Mean z scores were 3.79 and 1.25 in the contingent still-face and normal conditions, respectively $t(18)1.91$, $p < .05$, one-tailed. The proportion of infants with significant z scores ($z > 2$) also was significantly greater in the contingent still-face condition: 7 of 10 and 2 of 10, respectively ($p = .035$, one-tailed Fisher's Exact Test).

DISCUSSION

Results from quasi-experimental studies generally support the hypothesis that during face-to-face interactions, the organization of the infant's affective expression is influenced by its temporal relation to the mother's affective expression. This hypothesis remains controversial, however, because some of these studies failed to support it or used statistical analyses that failed to control adequately for autocorrelation, and many of them lacked experimental controls. We manipulated the temporal relation between mothers' and infants' behavior to test this hypothesis directly.

In the experimental condition, mothers became still-faced contingent on their infant's becoming positive. This violation of the usual temporal relation between mothers' and infants' behavior attenuated the infants' cycles of positive and neutral expression. Infants responded with a decreased probability of transitions from *positive* to *attend* and a corresponding increased probability of transitions to *avert*. Moreover, when we quantified the mother's influence on the infant using time-series techniques, we found evidence of increased influence in the experimental conditions. Both the average z score and the number of infants with significant z scores were higher in the contingent still-face condition. These data indicate that the organization of the infant's affective expression is closely related to the mother's. The mother's sustained positive expression encourages the infant's cycles of positive and neutral expression.

Our results are consistent with the finding of some but not all correlational studies. It may be more difficult to detect the mother's influence in the absence of experimental control. In the normal interaction, only 2 of 10 infants had significant z scores. Cohn and Tronick (1988), in a larger study, reported a higher proportion of significant z scores, but still lower than what we found in the experimental condition. During the normal interaction, the proportion of variance related to interpersonal influence may be small relative to that related to autocorrelation effects, an interpretation that is consistent with a report of Cohn and Tronick (1988). In the normal interaction, the onset of the mother's positive expression influences the onset of the infant's positive cycling but not its offset. The mother's affect expression supports the infant's affect expression, but statistically this influence cannot be distinguished from autocorrelation effects in the infant's behavior. The only way to test whether the mother's continuous positive expression is necessary to the organization of the infant's expression is to modify the mother's behavior so that the infant's responsiveness to the mother's ongoing behavior is highlighted. Without an experimental manipulation, the interdependence of mother's and infant's behavior is more difficult to isolate statistically.

Much recent work has focused on whether or not the mother influences the organization of the infant's affective behavior. Our experimental findings add to correlational evidence from several large, carefully conducted time-series analyses of normal interactions in arguing for an affirmative answer to this question. Our findings suggest further that it may prove useful to begin concentrating on the size of influence effects. As we noted, interpersonal influence was greater in the distorted (still-face) interaction. One implication is that, with respect to interpersonal influence, more may not be better. Increased interpersonal influence may indicate an interaction that is not going well. Too much influence may be as detrimental as too little (cf. Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986). Further research is needed to determine whether there is an optimal range of interpersonal influence, as a function of the interactant's developmental level, context, and type of interaction.

Other studies that used the still face and related manipulations (Field, 1984; Fogel et al., 1982; Stoller & Field, 1982; Tronick et al., 1978) reported increased gaze aversion and reduced positive affect. We found a marginally greater frequency of gaze aversion only. The differences we found between normal and still-face conditions were also less dramatic than those reported by Cohn and Tronick (1983) in a study of infants' response to simulated depression. That study, like the present report, found a pattern of positive expressions leading to gaze aversion but also extensive cycling among negative affects and gaze away from the mother. The differences in findings are likely related to the longer duration of the distorted maternal behavior in studies by Cohn and Tronick (1983) and others and the absence of any contingent relationship between the infant's and the mother's behavior. Of course, it is also possible that depressed maternal behavior is a particularly disturbing experience for young infants (Cohn et al., 1986).

Several clinical reports (Massie, 1978; Stern, 1971) have described naturally occurring perturbations similar to the contingent still-face manipulation. Stern (1971) described a mother who, after eliciting successfully her infant's attention, would abruptly avert her own gaze. Seemingly frustrated by his failure to make contact, the infant would then look away, at which point the mother would elicit his attention again, and the process would continue. Both Stern and Massie suggested that repeated experiences of this type might lead to psychopathology. Our data demonstrate that infants as young as 3 months not only are capable of participating in such a distorted pattern of interaction but also will engage in it repeatedly. We found little evidence of negative affect in any of our contingent still-face interactions. Thus, the potential to learn maladaptive patterns of interaction during infancy appears to be high. Further research with clinical populations will be needed to explore this hypothesis further.

Some studies have indicated that aspects of behavioral organization may differ between male and female infant–mother pairs. Malatesta and Haviland (1982), for instance, found that mothers responded more contingently to a son's smile at 6 months than to a daughter's. Because our sample size was small and contained fewer male than female infants (i.e., 3 boys and 7 girls in each condition), we were unable to examine main effects or interactions related to infants' sex. It is possible, then, that the effects of the contingent still-face manipulation might vary with sex of infant in ways that we were unable to determine.

We discount this possibility, however. At least two relatively large studies found that infants cycle between neutral and positive expression while their mothers remain positive (Cohn & Tronick, 1987; Kaye & Fogel, 1980). Neither of these studies found differences in behavioral organization related to infants' sex. Moreover, gender effects, when they have been found, have been ephemeral. Malatesta and Haviland (1982) found some effects of gender in the behavioral organization of full-term infants, but these effects were not replicated by Malatesta, Grigoryev, Lamb, Albin, and Culver (1986). Moran et al. (1987), in a related study, did not find differences between male and female infant–mother pairs in the dyadic organization of discrete facial expression. Thus, we believe that our results apply equally to male and female infants. Further empirical work, however, will be necessary to confirm this view.

Mother–infant interaction has been described within a learning-theory framework that emphasizes the role of reinforcement (Malatesta & Haviland, 1982; Moran et al., 1987). Malatesta and Haviland (1982) found that mothers responded contingently to their infant's affective expressions: For instance, they ignored negative expressions and matched interest expressions. Moran et al. (1987) found that mothers responded contingently to other types of facial expressions (e.g., lip or eye movements) as well. Malatesta and Haviland speculated that this pattern of ignoring undesired expressions and contingently matching desired expressions was differentially reinforcing positive affect in infants. They speculated further that this was a mechanism for the socialization of emotions.

The contingent still-face manipulation provides a limited test of Malatesta's speculation. In so far as the mother's positive expression is reinforcing, its withdrawal upon the infant's entering *play* should decrease the subsequent occurrence of *play*. The mother becoming positive in response to the infant's sustained nonpositive expression should increase the subsequent likelihood of nonpositive expression by the infant (i.e., differential reinforcement of non-positive behavior). Did this pattern of behavior bring about learning?

The manipulation was effective initially in decreasing the probability of infants' positive expression, which is consistent with a learning-theory interpretation. In response to the contingent still-face, infants averted gaze and briefly withdrew from the interaction. Other findings, however, were less suggestive of differential reinforcement taking place. The percentage of *play* did not vary between conditions. One reason, of course, was that infants became positive while their mothers were still-faced. Cohn and Tronick (1983) observed a similar pattern of infants positively eliciting their mothers' responses, which they interpreted as the infant trying to reinstate the normal interaction. From the perspective of reinforcement history, these elicitations during the contingent still-face could be interpreted as extinction bursts. However, not all infants' positive expression can be interpreted as reactions to withdrawal of reinforcement. Despite experience with the contingent still-face, infants continued to become positive after their mothers had become positive: During periods when the mother was positive, each infant became positive anywhere from four to nine times. Thus, they showed little evidence of learning the new contingency. Infants responded to immediate stimulus conditions (i.e., withdrawal of the mother's positive expression), but they showed no learning.

Rather than demonstrate evidence of learning, what the infants showed was a sensitivity to the mother's current or immediately preceding behavior (Kaye & Fogel, 1980; Moran et al., 1987). Recent history of reinforcement was not of functional importance. On the other hand, some contingencies may be more difficult to learn by virtue of our evolutionary history. Learning *not* to reciprocate positive affect may be one such example. Also, the interaction period was brief, only 3 min, and the manipulation was not intended as a critical test of the differential reinforcement hypothesis. Our findings suggest, however, that if emotion socialization occurs in the way Malatesta has proposed, it may require experience (or learning trials) over the course of many interactions.

In summary, we found that infants were highly responsive to changes in their mothers' affective expression. The mother's continuous positive expression increased the probability of the infant's cycles of positive affect. With interruptions in the mother's positive expression, the organization of the infant's behavior changed. Infants showed a decreased probability of transitions from *play* to *attend* and an increased probability of transitions from *play* to *avert*. Empirical indicators suggested that the mother's influence was greater in the contingent still-face condition. Experimental manipulations such as the contingent still-face may provide a more sensitive assessment of interpersonal influence than that afforded by correlational means.

REFERENCES

Bakeman, R., Adamson, L.B., & Strisik, P. (in press). Lags and logs: Statistical approaches to interaction. In M.H. Bornstein & J. Bruner (Eds.), *Interaction in human development*. Hillsdale, NJ: Erlbaum.

Beebe, B., Jaffe, J., Feldstein, S., Mays, K., & Alson, D. (1985). Interpersonal timing: The application of an adult dialogue model to mother-infant vocal and kinesic interactions. In T.M. Field & N.A. Fox (Eds.), *Social perception in infants*. Norwood, NJ: Ablex.

Bishop, Y.M.M., Feinberg, S.E., & Holland, P.W. (1975). *Discrete multivariate analysis: Theory and practice*. Cambridge, MA: MIT Press.

Brazelton, T.B., Koslowski, B., & Main, M. (1974). The origins of reciprocity: The early mother-infant interaction. In M. Lewis & L.A. Rosenblum (Eds.), *The effect of the infant on its caregiver*. New York: Wiley.

Bruner, J. (1977). Early social interaction and language acquisition. In H.R. Schaffer (Ed.), *Studies in mother-infant interaction*. London: Academic.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20,* 37–46.

Cohn, J.F., Matias, R., Tronick, E.Z., Connell, D., & Lyons-Ruth, K. (1986). Face-to-face interactions, spontaneous and structured, of mothers with depressive symptoms. In T.M. Field & E.Z. Tronick (Eds.), *Maternal depression and infant disturbance, New Directions for Child Development, No. 34.* San Francisco: Jossey-Bass.

Cohn, J.F., & Tronick, E.Z. (1983). Three-month-old infants' reaction to simulated maternal depression. *Child Development, 54,* 185–193.

Cohn, J.F., & Tronick, E.Z. (1987). Mother-infant interaction: The sequence of dyadic states at 3, 6, and 9 months. *Developmental Psychology, 23,* 68–77.

Cohn, J.F., & Tronick, E.Z. (1988). Mother-infant interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology, 24,* 386–392.

Field, T. (1977). Effects of early separation, interactive deficits, and experimental manipulations on infant-mother face-to-face interaction. *Child Development, 48,* 763–771.

Field, T. (1984). Early interactions between infants and their postpartum depressed mothers. *Infant Behavior and Development, 7,* 527–532.

Fogel, A., Diamond, G.R., Langhorst, B.H., & Demos, V. (1982). Affective and cognitive aspects of the 2-month-old's participation in face-to-face interaction with the mother. In E.Z. Tronick (Ed.), *Social interchange in infancy: Affect, cognition, and communication*. Baltimore: University Park.

Gottman, J.M., & Ringland, J.T. (1981). The analysis of dominance and bidirectionality in social development. *Child Development, 52,* 393–412.

Hayes, A. (1984). Interaction, engagement, and the origins and growth of communication: Some constructive concerns. In L. Feagans, C. Garvey, & R. Golinkoff (Eds.), *The origins and growth of communication*. Norwood, NJ: Ablex.

Izard, C. (1983). *The maximally discriminative facial movement scoring system* (rev. ed.). Unpublished manuscript, University of Delaware.

Jaffe, J., Stern, D., & Peery, C. (1973). "Conversational" coupling of gaze behavior in prelinguistic human development. *Journal of Psycholinguistic Research, 2,* 321–329.

Kaye, K., & Fogel, A. (1980). The temporal structure of face-to-face communication between mothers and infants. *Developmental Psychology, 16,* 454–464.

Lester, B., Hoffman, J., & Brazelton, T.B. (1985). The rhythmic structure of mother-infant interaction in term and preterm infants. *Child Development, 56,* 15–27.

Malatesta, C.Z., Grigoryev, P., Lamb, C., Albin, M., & Culver, C. (1986). Emotion socialization and expressive development in preterm and full-term infants. *Child Development, 57,* 316–330.

Malatesta, C.Z., & Haviland, J.M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development, 53,* 991-1003.

Massie, H. (1979). The early natural history of childhood psychosis: Ten cases studied by analysis of family home movies of the infancies of the children. *Journal of the American Academy of Child Psychiatry, 17,* 29-45.

Matias, R., Cohn, J.F., & Ross, S. (in press). A comparison of the systems to code infants' affective expression. *Developmental Psychology.*

McCleary, R., & Hay, R.A. (1980). *Applied time series analysis for the social sciences.* Beverly Hills, CA: Sage.

Moran, G., Krupka, A., Tutton, A., & Symons, D. (1987). Patterns of maternal and infant imitation during play. *Infant Behavior and Development, 10,* 477-491.

Sackett, G.P. (1987). Analysis of sequential social interaction data: Some issues, recent developments, and a causal inference model. In J. Osofsky (Ed.), *Handbook of infant development* (2nd ed.). New York: Wiley.

Stern, D. (1971). A micro-analysis of mother-infant interaction: Behavior regulating social contact between a mother and her 3½-month-old twins. *Journal of the American Academy of Child Psychiatry, 10,* 501-517.

Stern, D. (1984). Affect attunement. In J.D. Call, E. Galenson, & R.L. Tyson (Eds.), *Frontiers in infant psychiatry* (Vol. 2). New York: Basic Books.

Stern, D., Beebe, B., Jaffe, J., & Bennett, S.L. (1977). The infant's stimulus world during social interaction: A study of caregiver behaviors with particular reference to repetition and timing. In H.R. Schaffer (Ed.), *Studies in mother-infant interaction.* London: Academic.

Stoller, S.A., & Field, T. (1982). Alteration of mother and infant behavior and heart rate during a still-face perturbation of face-to-face interaction. In T.M. Field & A. Fogel (Eds.), *Emotion and interaction.* Hillsdale, NJ: Erlbaum.

Symons, D.K., & Moran, G. (1987). The behavioral dynamics of mutual responsiveness in early face-to-face mother-infant interactions. *Child Development, 58,* 1488-1495.

Thomas, E.A.C., & Malone, T.W. (1979). On the dynamics of two-person interactions. *Psychological Review, 86,* 331-360.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T.B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry, 17,* 1-13.

Tronick, E., Als, H., & Brazelton, T.B. (1977). Mutuality in mother-infant interaction. *Journal of Communication, 27,* 74-79.

Tronick, E., Als, H., & Brazelton, T.B. (1980). Monadic phases: A structural descriptive analysis of infant-mother face-to-face interaction. *Merrill-Palmer Quarterly, 26,* 3-24.

Williams, E.A., & Gottman, J. (1982). *A user's guide to the Gottman-Williams time series analysis computer programs for social scientists.* New York: Oxford University Press.

31 May 1988; Revised 18 August 1988