Infant-Mother Face-to-Face Interaction: Age and Gender Differences in Coordination and the Occurrence of Miscoordination

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TRONICK, EDWARD Z., and COHN, JEFFERY F. *Infant-Mother Face-to-Face Interaction: Age and Gender Differences in Coordination and the Occurrence of Miscoordination.* CHILD DEVELOPMENT, 1989, **60**, 85–92. To evaluate the extent to which infants and mothers are able to coordinate their behavior, the interactions of 54 mother-infant pairs—18 each at 3, 6, and 9 months of age—were videotaped. Coordination was evaluated with 2 measures: (1) matching—the extent to which mother and infant engage in the same behavior at the same time; and (2) synchrony—the extent to which mother and infant change their behavior with respect to one another. Mother-infant pairs increase their degree of coordination with infant age, but the proportion of time they are coordinated is small. Mother-son pairs spend more time in coordinated states than mother-daughter pairs. The results suggest that interactions be characterized in terms of their movement from coordinated to miscoordinated states rather than only in terms of their degree of coordination. The gender differences are discussed in terms of their importance for the developmental differences in females and males.

A feature of infant-caretaker face-to-face exchanges is the degree to which the pair is able to coordinate their behavior. Such coordination is thought to be critical for the establishment of a successful relationship and mutual understanding between the infant and the caregiver as well as the infant's learning and elaboration of social skills and conventional forms of communication and culture (Brazelton, Koslowski, & Main, 1974; Schaffer, Collis, & Parson, 1977; Stern, 1985; Trevarthan, 1977; Tronick, 1980; Tronick, Brazelton, & Als, 1978). Many terms—interactive synchrony, co-occurrence, attunement, matching, reciprocity, and coherence—have been used to describe this coordination. Each term is an attempt to describe the characteristic structure of the interaction and in particular a quality of the interaction that indicates that it is "going well." Each term varies in the precision of its definition, what it sees as being coordinated (e.g., behaviors, clusters of behaviors, the temporal or directional characteristics of behaviors), and the extent to which it is a theoretical construct (e.g., reciprocity) or a more quantitative variable (e.g., co-occurrence). Because of these differences in definition we defined two terms, matching and synchrony, as indices of coordination (see below).

There have been several studies of the degree to which infant and caretaker are able to achieve this coordination. These studies have looked at the coordination of different interactive characteristics: the coordination of movements, and movements with speech (Condon & Sander, 1974; Dowd & Tronick, 1986), gaze patterns (Peery & Stern, 1976; Stern, 1971), clusters of behaviors (Bakeman & Brown, 1977; Cohn & Tronick, 1987; Fafouti-Milenkovic & Uzgiris, 1979; Fogel, 1977; Kaye & Fogel, 1980; Uzgiris, Benson, & Vasek, 1983), levels of engagement (Beebe & Gerstman, 1980; Lester, Hoffman, & Brazelton, 1985; Tronick, Als, & Brazelton, 1985), and the additive qualities of behaviors to produce the coordinated state of reciprocity (Brazelton et al., 1974). Depending on the definition employed, which often is related to the

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time unit analyzed and the method of analysis, coordination is found to occur 30%–40% of the time (Fogel, 1977, 1982; Pawlby, 1977; Tronick, Als, & Brazelton, 1980; Uzgiris et al., 1983), as little as 12% (Lester et al., 1985), and sometimes not at all (Dowd & Tronick, 1986; Gottman & Ringland, 1981).

The differences in results are in part related to whether the researcher analyzed unselected or selected portions of an interaction. Selecting interactions according to some criteria (e.g., absence of negative affect) typically results in a greater proportion of the interaction being characterized as coordinated. Selected or not, the variability among pairs is generally considerable (Cohn & Tronick, 1987; Lester et al., 1985; Tronick et al., 1980; Uzgiris et al., 1983). Developmentally evidence exists that coordination increases with age (Pawlby, 1977; Uzgiris et al., 1983). Little evidence exists for sex differences, although some theoretical perspectives predict differences between mother-son and mother-daughter pairs (Chodorow, 1978).

The present study is an analysis of the normative course of coordination during the first year of life. For purposes of this study coordination was defined and analyzed in two ways: (1) as behavioral matching, that is, the degree to which infant and mother are in the same behavioral state at the same time (Tronick et al., 1980; Uzgiris et al., 1983); and (2) as synchrony, that is, how consistently the pair are able to move together over time regardless of the content of their behavior (Beebe, Jaffe, Feldstein, Mays, & Alson, 1985; Lester et al., 1985). These measures differ in that matching focuses on the content of the behaviors of mother and infant at one point in time (i.e., the achievement of a joint state) and can be assessed using standard statistical techniques such as analysis of variance for evaluating the proportion of time match states are achieved. The second focuses on how mother and infant change with respect to one another and can be analyzed using time-series techniques (Beebe, 1982; Beebe et al., 1985; Cohn & Tronick, in press; Gottman, 1977; Lester et al., 1985; Tronick et al., 1977).

From recent work we know that at 3, 6, and 9 months both mother and infant are responsible for the coordination observed (Cohn & Tronick, in press). Neither the behavioral matching nor the synchrony measures used here evaluates who is responsible for the degree of coordination observed. But that issue is different from the issues of concern here, which are the extent to which mother and infant are able to coordinate their behaviors and if there are differences in relation to age and sex. It was expected that the degree of coordination as assessed with each of these measures would increase with age and that there would be no significant sex differences.

To evaluate these issues, the face-to-face interactions of mothers and infants at 3, 6, and 9 months of age were videotaped and coded with the Monadic Phase scoring system (Tronick et al., 1980). This coding scheme segments the interaction into units of combinations of expressive behaviors for mother and infant (i.e., monadic phases). The phases allow for the determination of the degree to which mother and infant are matching the content of their interactive behaviors and the extent to which they are able to synchronize their behaviors when the phases are arranged along a univariate scale of affective/attentional involvement (Lester et al., 1985).

Method

Subjects

The sample consisted of three different groups of infant-mother pairs, 18 each at 3 (M = 98.4 days, SD = 3.8), 6 (M = 186.3 days, SD = 3.2), and 9 months (M = 280.6 days, SD = 3.9). Age groups were balanced for gender of the infant. Infants were all full-term caucasians and from intact homes.

Study participants were recruited through birth announcements published in local newspapers in the Amherst/Northampton, Massachusetts, area. Potential participants were telephoned and told of our Infant Studies Program at the University of Massachusetts. Mothers who expressed interest in participating in the current study were scheduled to bring their infants to a taping session at a time when they judged that their infant would be alert.

Eighty-one mother-infant dyads were tested to produce the final sample of 54 mother-infant pairs. Eight infants who had sustained substantial medical complications were excluded, as their experiences might have biased the data in unknown ways. Three additional mother-infant pairs (one 3-month- and two 9-month-olds) were not included because of technical problems. An additional 9-month-old infant was excluded because the mother used an object during the taped episodes. Fifteen infants (four 3-, six 6-, and five 9-month-olds) were excluded because of fussing, operationally defined as crying for more than a minute prior to or during the taping session.

Setting and Equipment

The laboratory consisted of a video studio with an adjoining room. The studio was equipped with an infant seat mounted on a table, an adjustable stool for the mother to face the infant, two videocameras, and a microphone. One camera was focused on the mother and the other on the infant. Both pictures were transmitted through a digital timer and splitscreen generator into a video-recorder. Digital timer, split-screen generator, and video-recorder were located in the adjoining room (See Als, Tronick, & Brazelton, 1979, and Tronick et al., 1980, for details).

Procedure

Mothers were greeted by an experimenter and escorted to the laboratory. Mothers were encouraged to make themselves and their infants comfortable in the adjoining room. Informed, written consent for her own and her infant's participation was obtained from the mother. Mothers were then interviewed and asked about the infant's perinatal status, general health, and other demographic information about the family.

Mother and infant were then escorted to the video studio and the infant was situated in the infant chair. The experimental procedure was explained to the mother. It consisted of three episodes: 2 min of normal interaction, followed by 2 min during which mothers either interacted normally or maintained a still-face, followed by a final 2 min of normal interaction. Mothers were simply instructed "to play with your baby." At the end of the session mothers were allowed to view the videotape of their interaction. Only the data for the first period of normal interaction are included in this report.

Coding.—Videotapes were coded by teams of two coders using the Monadic Phases Manual (Als et al., 1979; Tronick et al., 1980). Monadic phases for mother and infant are: Protest (infant only), Avert, Pick-me-up gesture, Positive Away, Object Attend and Object Play, Social Attend, Social Play, and Talk (See Als et al., 1979, and Tronick et al., 1980, for details).

Monadic phases were coded with the tape running at normal speed. Whenever a change in phase was observed, the tape was reversed and replayed at normal or slow speed to determine the change point. Times, read from a digital display on the videotape, were rounded to the nearest .25 sec (i.e., phases were coded to the nearest .25 sec). To assess interobserver agreement, videotapes of 12 mothers and five babies were recoded by a second team of coders. Agreement, defined as both sets of coders observing the same phase within .5 sec of the other, ranged from .81 to .97 for mothers' monadic phases and .90 to 1.0 for babies' phases (kappas = .60 and .72, respectively).

Data reduction.—We differentiated two types of matches: (1) Social Match—the proportion of time of the total interaction that the infant and mother were in Social Attend or Social Play at the same time; and (2) Object Match—the proportion of total time of the interaction that the infant and mother were in Object Attend or Object Play at the same time. We made this distinction because mutual engagement with objects as well as one's social partner both appear to be coordinated states, especially given the infant's interest in objects at this age (Kaye, 1982; Malatesta & Izard, 1984; Trevarthan, 1977). The definitions of these matching states are relatively global when compared to definitions used by others (e.g., Beebe et al., 1985; Brazelton et al., 1974). This feature increases the likelihood of finding matches. Matches involving Avert were not analyzed since the mothers were in Avert less than 1% of the time.

Synchrony, a term with many meanings, was defined as the proportion of shared variance at lag 0 as indexed by the square of the cross-correlation between each mother's and infant's time series. To generate this index of synchrony, the monadic phases were scaled along an affective/attentional dimension. A score of 1 assigned to "protest" represented maximum negative involvement; a score of 9, assigned to "talk" within the Social Play phase, maximum positive involvement (See Als et al., 1979, and Tronick et al., 1980, for details). For comparability with previous work, which used a similar scaling of attentional/affective involvement but a 1-sec scoring interval (Als et al., 1979; Lester et al., 1985; Tronick et al., 1977), we averaged scaled scores within 1-sec blocks. The cross-correlations were then computed using these scaled scores and used as the test statistic for synchrony. The relation of infant and mother behaviors at lags other than 0 were not computed because our focus was on the ability of infant and mother to coordinate their behavior at the same time and not at some temporal delay.

These definitions and our analyses utilize data from the entire interaction and not just portions that met some selection criteria. We thought that this was appropriate so as not to generate a supposed characterization of the interaction that in fact only represented a selected portion of the interaction.

TABLE 1

MEAN PERCENTAGE OF MOTHERS' AND INFANTS' TIME IN EACH MONADIC PHASE

	Avert	Obj Att	Obj Play***	Soc Att***	Soc Play*
Mother:					
3 months.....	.7	19.9	1.4_a	35.4_a	42.6_a
6 months.....	.2	23.1	7.9_b	26.6_{ab}	42.2_a
9 months.....	.3	15.1	8.2_b	19.2_b	57.2_b
	Avert*	Obj Att***	Obj Play	Soc Att	Soc Play***
Infant:					
3 months.....	36.4_a	21.0_a	1.9	25.3	15.5_a
6 months.....	21.5_b	40.8_b	1.5	23.0	13.2_a
9 months.....	26.3_{ab}	24.6_a	3.5	20.4	25.1_b

NOTE.—Abbreviations: obj = object; att = attend; soc = social. Column means with dissimilar subscripts differ significantly, $p < .05$, Newman-Keuls, following the finding of a significant age effect for that behavior using a univariate analysis of variance as indicated by the asterisks.

* p (df = 2,51) < .10.

** p (df = 2,51) < .05.

*** p (df = 2,51) < .01.

Results

Coordination in individual dyads.—Mothers and babies could match each others' behavior or change together over time (synchrony) purely by chance. If this were the case, analyses of matching or synchrony would be of little interest. To rule out this possibility, we conducted two sets of analyses. The first was a χ^2 test of independence to evaluate the null hypothesis that the distributions of mothers' and babies' monadic phases were independent. The second was to compute cross-correlation functions from the time series of each mother-infant pair. A finding of no statistically significant cross-correlations is sufficient to rule out synchrony between infant and mother (i.e., that the covariance between each mother's and baby's series was due to chance) (see Cohn & Tronick, in press, for details). Both sets of tests were performed separately for each mother-infant pair.

The joint distributions of mothers' and infants' monadic phases were not independent. For 52 of the 54 dyads, the χ^2 tests (df = 6) were highly significant ($p < .01$). Similarly, all pairs had significant cross-correlations ($p < .05$). The results of these two analyses indicate that coordination is found in almost all of the individual dyads examined, that it is a dyad-by-dyad phenomenon and not simply the product of group analyses of the data.

Percentage of time in monadic phases.—The percentage of time that mothers and infants spent in each monadic phase was analyzed with univariate analyses of variance with age and sex of infant as the between-groups factors. Because percentages typically have skewed distributions, we used an arcsine transformation prior to these and all other analyses of percentage data. We were unable to use multivariate analyses of variance because of the absolute degree of association among the mothers' and infants' monadic phases. The results, therefore, are interpretable in terms of patterns of relations among measures rather than as independent tests.

Table 1 shows the means for the percentage of time that mothers and infants spent in each monadic phase. The percentages are pooled across sex of infant since there were no differences due to this factor. Mothers showed an increase in Object Play, a decrease in Social Attend, and a trend ($p < .10$) toward an increase in Social Play from 3 to 9 months. These findings suggest that the mothers become more affectively positive and more willing to focus on objects as their infants develop. The infants show a decrease in averting. They have a peak interest in objects at 6 months, but at 9 months, this returns to the 3-month level. There is a growth in social play. These findings suggest that infants maintain their interest in social play over this time period and that a focus on objects does not come to dominate the interaction, as some have suggested (Kaye, 1982; Trevarthan, 1977).

Percentage of matches.—To analyze the percentage of object compared to social matches for age and gender effects it was necessary to adjust for differences in the base rates of object and social phases. The adjusted, or relative, percentage of object matches was computed as the percentage of

TABLE 2

MEANS AND (Standard Deviations) FOR ADJUSTED PERCENTAGES OF OBJECT AND SOCIAL MATCHES BY INFANTS' AGE AND SEX

	Object Match	Social Match
Mother-daughter dyads:		
3 months	6 (9)	24 (18)
6 months	11 (11)	14 (9)
9 months	14 (13)	27 (13)
Mother-son dyads:		
3 months	7 (7)	24 (19)
6 months	19 (14)	28 (13)
9 months	20 (20)	36 (19)

NOTE.—F ratios are: age: 3.64 (df = 2,48), $p < .05$, 3 < 6 = 9; sex: 5.98 (df = 1,48), $p < .025$, mother-daughter < mother-son; type of match: 20.17 (df = 1,48), $p < .001$; interactions: N.S.

time in object match divided by the total time that mother or baby were in an object phase, and the adjusted percentage of social match as the total time in social match divided by the total time that mother or baby were in a social phase. These adjusted percentages were analyzed with an analysis of variance for correlated measures, with age and sex of infant as the between-groups factors.

The mean percentage of time in match states varied with infants' sex and age (Table 2). Matching was less at 3 months than at 6 and 9 months. Mother-son dyads were more likely than mother-daughter dyads to be in matching states. Social matches were more frequent than object matches.

Synchrony.—Synchrony scores were analyzed with a univariate analysis of variance with age and sex of infant as the between-groups factors. The scores were transformed with Fisher's z transformation prior to analysis.

There was no age-related change in synchrony. The percentages of shared variance were similar at 3, 6, and 9 months (Table 3). However, we found a significant age × sex interaction. Mother-son dyads had higher synchrony scores than mother-daughter dyads at 6 and 9 months, $F(1,48) = 3.24$, $p < .05$.

TABLE 3

MEAN SYNCHRONY SCORES FOR MOTHER-DAUGHTER AND MOTHER-SON DYADS AT 3, 6, AND 9 MONTHS

	Synchrony Score			
	Mother-Daughter		Mother-Son	
Infants' Age	Mean	SD	Mean	SD
3 months	.20	.19	.11	.17
6 months	.09	.09	.23	.10
9 months	.11	.09	.22	.10

NOTE.—F ratio for age × sex interaction is 3.24 (df = 1,48), $p < .05$.

Rates of change between matching and nonmatching states.—To describe the movement of the interactions between coordinated and miscoordinated states, we evaluated the rate of change between the two states. Table 4 presents the rate of change between matching and mismatching states. The rate of change between matching and mismatching ranged from .20 to .32 per second. There were no age and no gender-of-dyad differences. The rate measure indicates that the interaction moves from matching to nonmatching states on a frequent basis.

TABLE 4

RATE OF CHANGE PER 1 SEC BETWEEN MATCHED AND MISMATCHED STATES

	Mother-Daughter			Mother-Son		
	3	6	9	3	6	9
Rate of change per 1 sec	.24	.24	.24	.20	.32	.24

Discussion

The matching of particular social-affective behaviors and of the temporal flow of these behaviors are features of infant-mother face-to-face interaction. These features can serve to establish mutuality or intersubjectivity between mother and infant (Beebe & Gerstman, 1980; Brazelton et al., 1974; Lester et al., 1985; Tronick et al., 1980; Uzgiris et al., 1983). As expected, the ability of a mother-infant pair to coordinate their behavior increases with age. This probably reflects the increase in the infant's interactive skill and the interactive experience infant and mother have had together (Pawlby, 1977; Uzgiris et al., 1983). But, as opposed to typical earlier interpretations of similar results, we also must recognize that even in low-risk pairs matching/synchrony is less common than periods of mismatching and dissynchrony. More than 70% of the time of these interactions was spent in mismatched/dissynchronous states.

The rate-of-change data between matched and mismatched states demonstrate that the interaction frequently moves from coordinated states to less coordinated states. This movement has been noted before, but little attention has been paid to it. Brazelton et al. (1974) and Tronick, Als, and Adamson (1979) described periods of disengagement. Stern and Gibbon (1978) noted that periods of engagement came in bursts, implying that they were surrounded by periods of disengagement. Tronick et al. (1980) described periods of mismatching, and Cohn and Tronick (1988) and Kaye and Fogel (1980) have noted that periods of coordination are stochastic in their distribution. Yet in each of these studies the focus and emphasis were on the ability of the infant and mother to be in coordinated states. We would now suggest that a characterization of the interaction that emphasizes the movement of the interaction from coordinated to miscoordinated states and back again as one that is more accurate than one emphasizing matching/synchrony as the typical and critical feature of the interaction. This is a process-oriented characterization in which miscoordinated states and the transitions between them and coordinated states would be as critical to the quality of the interaction as is the coordinated state and its maintenance.

We (Gianino & Tronick, 1987; Tronick, 1980; Tronick, Cohn, & Shea, 1985; Tronick & Gianino, 1986b) have referred to the miscoordinated state as an interactive error and the transition from a miscoordinated state to a coordinated state as a process of repair. The reparatory process has been demonstrated in a number of studies. Infants attempt to repair experimentally induced interactive errors (Cohn & Tronick, 1983; Fogel, Diamond, Langhorst, & Demos, 1983; Tronick, Als, Adamson, Wise, & Brazelton, 1978). Tronick and Gianino (1986a) reported that during normal face-to-face interactions at 6 months of age about one-third of the interactive errors are repaired in the next step of the interaction. Cohn and Tronick (1983) found specific repair sequences at 3, 6, and 9 months and that infants, as well as their mothers, were responsible for the structure of the interaction (Cohn & Tronick, in press). In this study, the repair rate ranges from about once every 3 sec to once every 5 sec. Reparations are typical features of the interaction.

What might be the developmental function of miscoordination and repair? Given the developmental changes in the infant and the interaction, it is likely that reparations serve different functions at different ages. We have suggested that for younger infants the reparation of interactive errors may induce the development of interactive skills (Spitz, 1965; Stern, 1977; Tronick, 1982) and the learning of the rules of interaction (Cohn & Tronick, 1983). Later in development, Tronick, Ricks, and Cohn (1982) have argued that the extent to which the infant is able to successfully repair interactive errors produces a sense of effectance, whereas an inability to successfully resolve them induces a feeling of helplessness. Tronick and Gianino (1986a) demonstrated that infants who experienced more repairs during normal interaction were more likely to elicit their mothers during experimentally manipulated perturbated interactions. In the older infant, Stechler and Kaplan (1980), following Winnicott (1975), argue that reparation may function to help in the formation of an early sense of self as the infant experiences discrepancies between his behavior and goals and his partner's behavior and goals (see also Tronick, 1980). These formulations and the data presented here suggest that more research focused on interactive errors and their repair would be extremely useful.

A significant gender difference was found in the degree of matching/synchrony. Mothers and their sons were more likely to be in matching states than were mothers and their daughters. Haviland (1977) found that mothers tend to ignore their sons' expressions of pain but respond with a knitted brow to their daughters' expressions of pain. Moreover, when sons expressed anger it was reciprocated by a knitted-brow expression by the

mother, whereas daughters' angry expression was responded to with an angry expression. These findings are suggestive of a different form of emotional attunement between mothers and their daughters compared to mothers and their sons (Stern, 1985). Such a difference would be expected to have important consequences for the emotional responsiveness and the formation of the self in females and males. For example, sons may develop a greater sense of their own effectance. These results tend to contradict the hypothesis by Chodorow (1978) of greater maternal empathy with daughters than with sons.

Lastly, these data and suggested conceptualization serve as a cautionary note to those concerned with the assessment of early interactive disorders and possible pathologies. Normal interaction is not always well coordinated, and it is differentially coordinated between mothers and sons and mothers and daughters. A lack of coordination is common and expected. It is normal, indeed. Assessments that focus on coordination or similar optimality characteristics are likely to see interactive failure or pathology when neither is present. An alternative formulation is that assessment should focus on the interactants' capacities to repair interactive errors and to move smoothly from miscoordinated states into coordinated states (Tronick & Gianino, 1986b). In such an interaction, both partners have the opportunity to experience reparation and to further elaborate their interactive and coping skills as well as gain a sense of effectance. To observe coordination in a dyad is phenomenally impressive, and to discover it was critical to our initial theorizing, but now we also need to look at and examine miscoordination and its reparation as a significant factor affecting the infant's development.

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