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Developmental Changes in Mother–Infant Face-to-Face Communication: Birth to 3 Months

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This study documented the growth of the earliest form of face-to-face communication in 16 mother–infant dyads, videotaped weekly during a naturalistic face-to-face interaction, between 1 and 14 weeks, in 2 conditions: with the infant in the mother's arms and with the infant semi-reclined on a sofa. Results showed a curvilinear development of early face-to-face communication, with a significant increase occurring between Week 4 and Week 9 depending on the dyad. After 2 months, trajectories diverged into 2 groups: 1 whose duration of face-to-face communication continued to increase and 1 whose duration peaked and then began to decrease. After the 1st month, the duration of face-to-face communication was significantly longer when the infant was on the sofa rather than in the mother's arms. In the latter condition, during the 3rd month, girls spent a significantly longer time than boys in face-to-face communication. These findings suggest that context (infant being held vs. not being held) interacts with the infant's age and sex in affecting mother–infant communication.

Psychological literature has shown that the processes of mutual regulation involved in early mother–infant interaction provide foundations for communication (Kaye, 1982), social cognition (Rochat & Striano, 1999), and the emergence of self-regulation and social fittedness (R. Feldman, Greenbaum, & Yirmiya, 1999). Early face-to-face interaction processes therefore constitute an essential condition for subsequent cognitive (R. Feldman, Greenbaum, Yirmiya, & Mayes, 1996; Papousek & Papousek, 1987; Tamis-LeMonda & Bornstein, 1989), social and emotional (Ainsworth, Bell, & Stayton, 1974; Bakeman & Brown, 1980; Emde, 1991; Kochanska, Forman, & Coy, 1999), and language development (Bruner, 1983). Nevertheless, with the exception of a study conducted by Brazelton, Trevarthen, and Richards in the late 1960s (Brazelton, Koslowski, & Main, 1974; Trevarthen, 1977; see Trevarthen, 1998, for a review) and a few other studies (Keller & Schölmerich, 1987; Kugiumutzakis, 1999; Papousek & Papousek, 1977; van Wulfften Palthe & Hopkins, 1993), most longitudinal research on early face-to-face interaction starts observations when infants are at least 6–8 weeks old or, more frequently, 3 months old. This means that longitudinal observations tend to start coincident with or only after the key developmental transition related to the acquisition of exogenous control (Emde & Buchsbaum, 1989; Emde, Gaensbauer, & Harmon, 1976).

This transition, related to the well-known transformation in neural functions that occurs toward the end of the 2nd month, has recently been shown to indicate a radical turn in the way infants interact with social partners and express themselves. In these terms, the study of developmental processes across the 2-month transition is a subject of renewed interest (e.g., see Rochat, 1998). The transition is clearly indexed by the onset of social smiling (Spitz, 1965; Wolff, 1987) and, a short time later, by cooing and prespeech movements (Trevarthen, 1979). Such unambiguous signs of social response act as positive feedback for caretakers, who start to relate to the infant through more playful interactions (Fogel, 1993a). Other indices of behavioral change include a sudden shift in the amount of time spent in an alert active state (Wolff, 1987); changes in the ability to maintain visual attention for a long time and to explore systematically the internal features of the face (Acerra, de Schonen, & Burnod, 1999; Haith, Bergman, & Moore, 1977); and improvements in head control and attainment of symmetrical spatially oriented posture (Hopkins, Lems, van Wulfften Palthe, Hoeksma, Kardaun, & Butterworth, 1990). These behavioral transformations, as well as their effect on caretakers' behavior, provide the infant with enriched possibilities of face-to-face communication (Adamson, 1995). Microanalysis of films and of video and audio recordings of mother–infant face-to-face interaction around and after this transition, employed in descriptive studies since the 1970s (Fogel, 1977; Stern, 1974; Trevarthen, 1977, 1979), revealed typical sequences of coordinated vocalizations, eye contact, smiling, and hand gestures emitted in turn by mother and infant that resemble the exchange of utterances in a

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conversation (M. C. Bateson, 1975). In particular, it was found that during these sequences of face-to-face communication, mothers typically attune to (Stern, Hofer, Haft, & Dore, 1985) or complement what the infant is expressing with exaggerated mimicry (Papousek & Papousek, 1989; Stern, 1985), and infants typically look attentively at the mother's face and couple their own expressive behaviors with the mother's expressions, revealing early capabilities of intersubjective communication (Trevarthen, 1979, 1998).

The focalization on "protoconversational" behaviors, the relatively infrequent occurrence of face-to-face communication during the 1st month, and the objective difficulties of data collection with newborn infants might explain the scant attention paid to face-to-face interaction during the first 6–8 weeks of life (i.e., prior to this key developmental transition). Aside from the few studies mentioned in the first paragraph, most of the sparse information on this topic comes from microdescriptive accounts, such as those documented by Trevarthen (1979, 1984, 1993) or Wolff (1963, 1987), or from nonlongitudinal studies.

The scarceness of systematic data on mother–infant face-to-face interaction during the very first months of life appears in strong contrast to the large amount of experimental data on neonatal perception of social stimuli (see Slater & Butterworth, 1997, for a review) which suggest that neonates show a special readiness for communication with other human beings. Neonates show a preference for human over nonhuman stimuli (e.g., Eisenberg, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991) and for the mother's voice (De Casper & Fifer, 1980), face (Bushnell, Sai, & Mullin, 1989; Walton, Bower, & Bower, 1992) or, at least, hairline (Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995), and smell (Cernoch & Porter, 1985) over the voice, face or hairline, and smell of an unfamiliar woman. Newborn infants perceive—and respond to—a human face as a coherent and unchanging whole regardless of its position and distance from them (Slater, 1997). Finally, if carefully solicited, neonates are capable of reproducing some facial, vocal, and gestural movements (Meltzoff & Moore, 1977; see Trevarthen, Kokkinaki & Fiamenghi, 1999, for a review) and of showing exploratory effort and self-corrective changes in the imitation of a model's movements (Meltzoff, 1994). Although these data are evidence of the interactive abilities of neonates, in the literature it is also claimed (van Wulfften Palthe & Hopkins, 1993) that the infant's socially directed behaviors during face-to-face interaction are related to the maturation of underlying neural subsystems (e.g., postural control, vision) that are still relatively immature for a few weeks after birth.

There are two main theoretical positions in approaching the study of early mother–infant face-to-face communication. The first one tends to point out that infants are capable of face-to-face communication with their mothers, especially through the possibility of visual contact (Blass, 1997; Trevarthen, 1979; Wolff, 1987), from the very first months of life. In particular, it is argued that infants can play an active role in face-to-face communication, regulating their actions and feelings in accordance with the actions and feelings of the mother even before the age of 2 months (Kugiumutzakis, 1999; Murray, 1998; Reddy, Hay, Murray, & Trevarthen, 1997; Trevarthen, 1993, 1998). The second theoretical position, implicitly shared by most studies that start their observations when infants are between 2 and 3 months old, tends to bind the emergence of socially directed behaviors to neurological maturation, especially to the development of active postural control of the head and the maturation of the visual system (van Wulfften Palthe & Hopkins, 1984, 1993). In these terms, this second position tends to recognize a real possibility of active engagement in face-to-face communication only from the 3rd month of life. The apparent mutual regulation in mother–infant communication before this period is thought to be due essentially to the skills and the imagination of the adult partner, who, seeking to find communicative significance in infant behavior, fills in the pauses in an autonomous sequence of infant behavior (Hopkins, 1983; Kaye, 1982). With regard to this issue, Reddy et al. (1997) argued that the evidence that communicative behavior even in the 2nd month of life can be indeed mutual is provided by studies that examine young infant communicative behavior outside the normal relationship with the mother, such as during experimental and clinical perturbations of mother–infant communication. In particular, a variety of studies based on either the still face paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) or the closed circuit television paradigm (Murray & Trevarthen, 1985) provide evidence of the sensitivity of infants between 6 and 12 weeks of age to the emotional quality and contingence of the mother's response. This sensitivity does not seem to be reducible to a simple detection of changes because of the specificity of the infant behavior to different forms of perturbation (Murray, 1998). Further evidence of young infants' sensitivity to the quality of the partner's communication is provided by studies comparing infants' face-to-face communication with postpartum depressed and nondepressed mothers (Cohn, Campbell, Matias, & Hopkins, 1990) or with a female researcher (Murray, 1998).

Although these kinds of studies represent important opportunities to measure the infant's own contribution to early mutual exchanges, longitudinal systematic observations of mother–infant face-to-face communication during the first 2 months of life are still needed because relatively little is known about face-to-face interaction in the first 6–8 weeks of life. In addition, this period is of theoretical interest because there is a major developmental transition at 2 months. Processes of developmental change are best revealed when intensive observations of a dynamic developing system (in this case, the mother–infant communication system) are conducted before, during, and after, a key developmental transition (Fogel & Thelen, 1987; Thelen, 1990).

In this study we aimed to document the process of developmental change in mother–infant face-to-face communication during the first 14 weeks of life by observing the growth process using weekly observations within individual cases. The choice to conclude observations at the 14th week was based on the fact that during the 4th month, infants start to shift their attention from the mother's face to objects (Fogel, Hsu, Pantoja, & West-Stroming, 2001; Legerstee, Pomerlau, Malcuit, & Feider, 1987).

The use of a frequent-observation, multiple-case, longitudinal research design creates the opportunity to study the shape of the developmental trajectory. Such data can give us information about the presence or absence of developmental change, the rate of change (the slope of the trajectory), and possible increases or decreases in the rate of change (changes in slope) that indicate the presence or absence of a marked developmental transition or a more gradual one. Although questions about overall patterns and individual differences in developmental trajectories inspired the founders of developmental psychology, statistical tools for decom-

posing individual and group variability in change over time did not exist, nor did theory (except for the work on stage vs. continuous changes) for explaining the shape of change. It is only recently that developmental scientists have had methodological tools and theoretical constructs for dealing with such data (van Geert, 1998).

In our study, we use multilevel modeling, a new method for preserving variability across individuals and across observations, for the purpose of examining trajectories of change. We also use the dynamic systems perspective as a metatheoretical framework for trying to understand developmental change. The dynamic systems perspective suggests that developmental change is the result of an increasing destabilization of a previously stable organized pattern of behavior. Small changes from within the organized system eventually may become amplified in such a way that the whole system changes. The trajectory of a system variable, one that represents the duration in which the features of that organized system are observed to occur, increases or decreases in slope during such periods of system change (Thelen, Kelso, & Fogel, 1987). In our case, the organized patterns that we examine are in the communication system rather than in the individual per se. Our attention is focused on the development of face-to-face communication as an organized pattern of dyadic interaction characterized by mutual gaze and/or facial actions, vocalizations, and gestures that indicate a mutual engagement between mother and infant.

Of crucial significance to our study are the propositions, from dynamic systems theory (Thelen & Smith, 1994), (a) that the period of developmental transition (i.e., the amount of time it takes for the slope of the trajectory to change from increasing to decreasing, or from increasing to constant) is relatively brief compared with the longer periods of time over which the earlier and later forms of organization remain the same and (b) that during these relatively brief transition periods, the system is highly sensitive to small perturbations, which results in the emergence of individual differences in developmental trajectories during and immediately following that relatively brief transition. If individual trajectories begin to diverge only at or near transition periods (at times when the slope of the developmental trajectory is changing), the propositions from dynamic systems theory would be supported. These propositions would not be supported (a) if there was a marked developmental transition but individual trajectories diverged at random across the period of observation (the slope of the curve for each dyad changing unsystematically with respect to the changes in slope for other dyads) or (b) if there was no clear-cut developmental transition and thus the emergence of any observed individual variability could not be linked to a transition period.

Three main issues—the process of developmental change, individual differences, and the role of context—guided this study. These issues are summarized in the following specific aims:

1. To document the developmental trajectory of mother–infant face-to-face communication during the first 14 weeks of life. On the basis of the literature that documents several indices of change in infant behavior coincident with the 2-month developmental transition, we expected a curvilinear developmental trajectory of mother–infant face-to-face communication with at least one significant developmental change occurring at around 2 months.

2. To examine the emergence of interdyad differences across the 14 weeks, in particular across the key developmental transition. The focus on individual differences was based on both a consideration of the literature (e.g., data about individual differences in visual attention during the first months of life) and a consideration that the study of interindividual variability may shed light on developmental processes. As a main research hypothesis informed by the dynamic systems perspective, we expected that interdyad differences would be more likely to emerge at around 2 months because of the increase in variability that is presumed to characterize developmental transition periods.

3. To investigate whether the two conditions of the infant being held by the mother and not held by the mother (i.e., contextual features such as postural position and closeness to the mother's body) would be related to the developmental trajectory of early mother–infant face-to-face communication. Previous research conducted with infants between 3 and 6 months of age has shown that postural position affects the duration of gazing at the mother during mother–infant face-to-face communication (Fogel, Dedo, & McEwen, 1992). We also thought that for neonates and very young infants, the closeness to the mother's body might co-determine the duration of gazing at the mother's face. On the basis of the previous findings and the latter consideration, we hypothesized that features of face-to-face communication contexts such as postural position and closeness to the mother's body would interact with the infant's age in affecting the duration of mother–infant face-to-face communication.

Method

Participants

Sixteen primiparous mothers and their neonates (6 girls and 10 boys) participated in the study. Our first contact with the mothers, which was aimed at presenting our study and checking the mother's availability, took place 1 month before childbirth during one of the meetings of the mothers' prenatal education classes at the hospital in Lecco, a town in the north of Italy. Of all the mothers approached in several meetings, about 25% agreed to participate. From the pool of primiparous mothers interested in our study, mother–neonate dyads were selected on the basis of (a) absence of obstetrical and neurological complications (no particular medication given during pregnancy and delivery, spontaneous full-term delivery, normal birth weight [i.e., above 2,500 g], and 1- and 5-min Apgar scores of 8 or above), (b) absence of indications of physical or psychological problems on the part of the mothers, (c) the mother's age being above 20 years, and (d) both the mother and the father living in the home. All the dyads were Italians. Mothers ranged in age from 21 to 38 years ($M = 28.8$ years); none of them returned to work during the 14 weeks of observation. Fourteen out of 16 infants were initially breast-fed; 3 of them turned to bottle-feeding within the 2nd month.

The sample was balanced in relation to parents' education and socioeconomic status (SES). In particular, 25% of mothers had compulsory schooling, 37% had a high school education, 19% had post-high-school training, and 19% had a university degree. All of the fathers, except for two, had educational levels and occupations similar to those of their wives. Using the Nakao and Treas (1992; reprinted in Entwisle & Astone, 1994) Socio-Economic Index of Occupations, we found that the occupational prestige scores of the infants' parents ranged widely ($M = 51.5$, $SD = 24.4$). Participants' individual characteristics are detailed in Table 1.

Research Design

Because of the focus on the process of developmental change and on individual differences in early mother–infant communication, this study was based on a longitudinal multiple-case design. In psychology, case study designs have been used by Piaget, in single-case behavioral analysis

Table 1
Participants' Individual Characteristics

Dyad no.	Infant's sex	Infant's gestational age (weeks)	Infant's birth weight (grams)	Infant's type of feeding	Mother's age (years)	Mother's education (years)	Mother's SES	Mother's length of marriage (months)
1	M	39	3,040	turned to bottle	27	16	69.19	24
2	F	40	2,820	turned to bottle	25	13	73.23	12
3	M	40	3,630	breast	27	13	43.70	36
4	F	39	3,240	breast	32	18	81.91	72
5	M	41	3,530	breast	32	13	42.29	60
6	F	40	3,100	breast	24	8	22.45	48
7	M	42	3,800	breast	29	13	38.40	66
8	F	39	2,920	bottle	21	8	21.25	18
9	M	41	3,600	breast	30	8	21.25	60
10	M	38	2,700	breast	25	13	43.70	48
11	F	40	3,400	breast	29	18	83.22	18
12	M	41	2,880	turned to bottle	34	16	68.80	42
13	M	39	3,130	breast	28	20	85.06	36
14	M	40	3,520	breast	34	16	68.06	48
15	M	41	3,100	breast	30	13	42.29	47
16	F	39	2,630	bottle	38	8	22.45	18

Note. M = male, F = female, SES = socioeconomic status.

research, and in studies of child language development (Thorngate, 1987; Wallace, Franklin, & Keegan, 1994). In this study, we used frequent-observation case histories of mother–infant face-to-face communication in a longitudinal design across a key developmental transition. This means that individual developmental trajectories of mother–infant face-to-face communication were used as a primary data source. In order to capture the dynamics of developmental changes, we conducted intensive observations over a relatively short (3½ months) but rapidly changing period.

Procedure

Videotaping. Mother–infant dyads were videotaped during spontaneous face-to-face communication in a naturally occurring context in their homes, weekly, between the ages of 1 week and 14 weeks. Because of the importance of behavioral states for young infants' reactivity, the requisite state for videotaping was the alert state. To be present when infants were alert, the researcher kept in close phone contact with the mothers; nevertheless, the neonates' unpredictability often required several hours of waiting in participants' homes for the babies to calm down or naturally awake. Because of the high individual variability in sleep–wake cycles, the best moment to observe mother–infant face-to-face communication was immediately or 10–20 min after feeding for some neonates but after a calm awakening 2–3 hours after the last feeding for others.

Each week, mother–infant face-to-face communication was videotaped for at least 6 min, 3 min in each of two different conditions. In Condition 1, the infant was held in the mother's arms and faced the mother (at about 20–30 cm from the mother's face). The infant's head was supported by the mother's arm, and the infant was held in a semi-reclined position. In Condition 2, the infant was semi-reclined on a sofa, that is, not held by the mother but facing the mother. The infant's head and upper body were supported by a soft pillow, which helped to maintain a frontal orientation, and the mother was kneeling in front of the baby (at a distance of about 30 cm) to make possible visual contact easier. The order of the two conditions was counterbalanced so as to avoid a possible order effect.

Mothers were asked to talk naturally to their infants and to possibly adapt their head positions to those of their infants to facilitate possible visual contact. To avoid using two videocameras, we placed a mirror (measuring 50 × 70 cm) behind the infant to reflect the mother's face. The time (in minutes, seconds, and tenths of a second) was registered on all videotapes. If the infant and the mother were still actively engaged in face-to-face communication at the end of the 3 min of observation for each condition, videotaping was prolonged until the end of the sequence. In these cases, a continuous segment of 3 min of video was then selected for coding on the basis of the maximum proportion of face-to-face communication. Out of the 448 planned sessions (16 subjects × 14 age levels × 2 conditions), only 2 sessions were missing, owing to a lack of infants in the quiet or active alert state.

Coding. Because one purpose of this study was simply to document the developmental trajectories and interdyad differences in the duration of face-to-face communication during the early months of life, we chose a coding system that distinguished periods of face-to-face communication—defined by mutual gaze and/or facial expressions, vocalizations, and gestures that indicated a mutual engagement between mother and infant—from other types of early mother–infant communication observed on our videotapes. Communication is what affects the behavior of another person (e.g., Papousek & Papousek, 1986; Watzlawick, Beavin, & Jackson, 1967; Wolff, 1987). In these terms, communication cannot be inferred from the behavior of one person only, and communication may not be intentional (e.g., simple exploration of the mother's face by the infant, regardless of the infant's intentions, may communicate interest or attention to the mother and then affect her behavior). We thus required a coding system that (a) focused on the co-participation of both members of the dyad and (b) captured the macroscopic patterns in the interaction that distinguished periods of face-to-face communication from other forms of communication.

We chose frame analysis (Fogel, 1993a, 1993b; Goffman, 1974; Kendon, 1985), that is, the identification and analysis of the most frequently occurring dyadic patterns of communication. *Frames* (G. Bateson, 1955) are stable patterns of joint behaviors of both participants in a communication system that suggest different ways of mutual engagement. A single frame is characterized by the consistent or regular occurrence of (a) the direction of attention between partners, (b) the location of and distance between partners, (c) their postural co-orientation, and (d) the topic or theme of their joint activity (Kendon, 1985). On the basis of these characteristics and repeated watching at our videotaped sessions, we identified three mother–infant communication frames—attention getting, face-to-face communication, and calming—as mutually exclusive categories for each condition (in mother's arms vs. on the sofa). We also identified two

subframes for the frame of face-to-face communication: simple gazing and active engagement.

Detailed descriptions of frames and subframes are given in the Appendix. In the attention getting frame, for example, the mother's attention is on the infant but the infant's attention is elsewhere (a, direction of attention), the mother is approaching the infant but the infant's head is turned away or not facing the mother (c, postural co-orientation), and the topic of the frame is the mother trying to attract the infant's attention or, in any case, to stimulate the infant (d, topic or theme). In the face-to-face communication frame, there is mutual joint attention (a) and mutual postural co-orientation (c), and the topic is the sharing or co-participation of emotions and behavior (d). These two frames differ in features (a), (c), and (d), therefore, but not in feature (b) because in both frames the location of and distance between the mother and the infant are similar within condition; that is, they are defined by condition (in mother's arms vs. on the sofa). As can be observed from the descriptions in the Appendix, frames and subframes represent a first, macro level of analysis aimed at capturing, to use Trevarthen's language, the mother's and infant's overall "motive" for being engaged with each other in certain ways. Note that frame identification requires observation of both participants.

Tapes were played in slow-motion for coding; the coding strategy was continuous event coding. Because frames are joint occurrences of a certain range of maternal and infant behaviors, rather than co-occurrences of single actions, single actions by the infant or the mother were seen in the light of their global behavior in that moment and, especially, in the light of the partner's joint behavior. For example, if during face-to-face communication the infant looked away for a few moments, it was still considered within the face-to-face communication frame if (a) there were other indices of infant gesture and postural orientation that indicated mutual engagement and (b) the mother continued with her playful (rather than attention-getting or calming) actions. Moreover, in the absence of (a) and (b), if the infant's looking away lasted less than 3 s, it was still considered to be within the face-to-face communication frame. Subframes were coded within the face-to-face communication frame in a second coding pass, without any minimum duration.

Reliability. Interobserver reliability for the mother–infant communication frames coding was calculated on a random sample of 80 out of 446 sessions (18%). Each time the two independent coders entered the same code with less than 2 s of difference, it was considered agreement; otherwise, it was considered disagreement. The average Cohen's kappa was .84.

Statistical Analysis

A multilevel modeling technique (Bryk & Raudenbush, 1992; Hoeksma & Koomen, 1992; Woodhouse, 1996) was used to determine developmental trajectories of mother–infant communication frames across the 14 weeks and the interdyad differences. In this statistical technique, repeated measures multilevel models are used to depict the developmental trajectories of variables by fitting polynomial growth curves to the data. Polynomial functions have been shown to be particularly suitable for modeling individual growth (van den Boom & Hoeksma, 1994; Bryk & Raudenbush, 1992; Hoeksma & Koomen, 1992). Thanks to their great flexibility, these functions can assume almost every kind of shape according to the number and the numerical values of the function coefficients (van den Boom & Hoeksma, 1994). In the repeated measures models that we used, data are structured as a two-level hierarchy. Level 1 units are measures from repeated observation sessions (the infant's age in weeks), which are nested within Level 2 units—dyads. In these models, statistics are estimated at both group and dyad levels. The average developmental curve of all dyads as a group is modeled by an *n*th degree polynomial function of age. The parameter weights for the age variable in determining the shape of the average developmental curve estimated from the data, that is, the fixed parameters, are comparable to regression coefficients in a regression model. Parameter weights must be at least twice as large as their standard errors to be included in the model. Inclusion of an intercept (initial status) and a first-order age parameter indicates that development is best described by a linear trend. Inclusion of higher order age parameters (i.e., Age^2, Age^3, etc.) indicates a curvilinear developmental trend.

Besides being useful for capturing developmental changes, the multilevel modeling technique is particularly useful for comparing individual developmental curves, which are expressed as deviations from the average developmental curve. In particular, the individual differences among dyads (or Level 2 variation) are expressed by three kinds of random parameters: intercept variance (σ_0^1), slope (first- or higher order age parameters) variance (σ_1^2, σ_2^2, etc.), and covariance (σ_{01}, σ_{02}, σ_{12}, etc.). The intercept and slope variances are deviations of the intercept and of the first- and higher order parameters of the individual developmental curves from the respective parameters of the average developmental curve. Inclusion of the intercept variance indicates differences among dyads at their initial status. Inclusion of slope variance indicates individual differences in growth rate among dyads. Inclusion of covariance reflects a significant correlation between intercept and slope across time. Individual differences are tested by comparing the model with and without the Level 2 random parameters. Significance is tested by a likelihood ratio statistic, which follows a chi-square distribution with degrees of freedom equal to the number of random parameters added to the model.

After collapsing the data into three temporal intervals or age periods (1st, 2nd, and 3rd months), we assessed the effects of age period and condition by applying a 3 (age period) $\times$ 2 (condition) repeated measures analysis of variance (ANOVA) to the average session duration for each frame and subframe. A *t* test was applied matching the different age periods within and between conditions; it served the function of a post hoc test.

The proportions of simple gazing and of active engagement by age and condition, as well as correlations between their average session durations collapsed in monthly periods, were calculated to examine the relations between these two subframes of mother–infant face-to-face communication according to the infant's age and the specificity of the context.

Cluster analysis was applied to the estimated parameters used to model individual developmental trajectories to assess whether there was statistical evidence for the groups of dyads distinguished on the basis of their developmental trajectories. Finally, a first exploration of the emerged interdyad differences was conducted by examining possible sex and maternal education or SES effects.

Results

Developmental Changes in Mother–Infant Face-to-Face Communication

All of the mean durations for the three different mother–infant communication frames over the 14 weeks and the two conditions are presented in Table 2. The corresponding average modeled trajectories are plotted against observed values in Figure 1. No trajectories were modeled for the duration of calming because in both conditions calming was independent of the infant's age and very brief compared with the durations of attention getting and face-to-face communication, as can be seen from the observed values shown in Figure 1. However, a 3 (age period) $\times$ 2 (condition) repeated measures ANOVA calculated on the duration of calming showed a significant main effect for condition, $F(1, 15) = 10.69$, $p < .01$. *T* tests used as post hoc tests revealed that the amount of time the mother spent calming the infant was significantly more elevated in Condition 1 (infant held by the mother) than in Condition 2 (infant not held) during the 2nd month (Condition 1, $M = 11.7$ s; Condition 2, $M = 1.8$ s), $t(15) = 4.36$,

Table 2
Duration (in Seconds) of Mother–Infant Communication Frames

Age and condition	Attention getting		Face-to-face communication				Calming	
	M	*SD*	*M*	*SD*	% simple gazing	% active engagement	*M*	*SD*
1 week								
Infant held	147.0	29.7	28.5	27.6	99.3	0.7	4.6	9.6
Infant not held	134.2	50.7	28.4	30.1	98.6	1.4	17.0	40.5
2 weeks								
Infant held	139.0	33.8	27.6	22.3	92.1	7.9	13.5	18.1
Infant not held	148.9	27.0	28.7	26.3	95.9	4.1	2.3	6.3
3 weeks								
Infant held	122.0	34.6	49.8	34.6	79.7	20.3	7.8	15.0
Infant not held	127.2	37.3	40.9	38.8	79.7	20.3	11.8	21.5
4 weeks								
Infant held	113.0	47.8	49.7	36.2	79.5	20.5	16.8	31.8
Infant not held	126.5	39.9	40.9	38.3	57.3	42.7	7.6	13.3
5 weeks								
Infant held	102.4	50.9	66.3	58.0	64.3	36.6	11.1	14.9
Infant not held	102.1	63.6	77.4	63.8	47.8	52.2	0.5	1.7
6 weeks								
Infant held	102.9	56.1	66.2	58.1	64.9	35.1	10.7	12.1
Infant not held	86.5	53.8	88.1	55.8	47.5	52.5	5.4	12.4
7 weeks								
Infant held	102.5	70.8	68.9	75.1	40.8	59.2	8.6	16.4
Infant not held	64.7	50.7	112.0	53.4	41.6	58.4	3.8	9.4
8 weeks								
Infant held	124.0	49.8	45.1	52.9	35.7	64.3	11.2	14.3
Infant not held	52.3	45.6	128.0	45.7	30.6	69.1	0.0	0.0
9 weeks								
Infant held	105.0	57.0	56.4	64.9	36.8	63.2	18.3	31.1
Infant not held	40.7	40.5	139.0	43.2	23.0	77	0.0	0.0
10 weeks								
Infant held	107.0	63.1	59.0	68.9	32.4	67.6	14.1	17.8
Infant not held	44.7	59.7	133.0	59.0	19.2	80.8	2.1	5.6
11 weeks								
Infant held	111.0	68.3	57.7	69.8	36.3	63.7	11.2	15.5
Infant not held	43.3	37.7	134.0	40.6	20.1	79.7	2.4	6.1
12 weeks								
Infant held	111.0	70.6	61.0	75.7	25.0	75	7.9	16.3
Infant not held	57.0	62.0	119.2	69.5	28.6	71.4	3.4	8.9
13 weeks								
Infant held	122.0	63.2	55.3	62.1	23.8	76.2	2.4	5.3
Infant not held	51.9	61.4	125.2	59.9	19.3	80.7	2.9	4.9
14 weeks								
Infant held	119.8	53.0	44.2	53.7	22.0	78	15.8	24.3
Infant not held	51.2	54.0	128.0	54.9	21.1	78.9	0.7	2.0

$p < .01$, and the 3rd month (Condition 1, $M = 8.7$ s; Condition 2, $M = 2.1$ s), $t(15) = 3.80$, $p < .01$.

As shown by the average modeled trajectories in Table 3, the durations of attention getting and face-to-face communication in Condition 1 (infant held by the mother) were modeled by a second-degree polynomial function; in Condition 2 (infant not held), they were modeled by fourth- and fifth-degree polynomial functions, respectively. All of these functions are indicative of a curvilinear developmental trend over the age range investigated. As shown in Figure 1, in both conditions the developmental trajectories of attention getting and face-to-face communication were almost mirror images, with a negative trend for attention getting and a positive trend with a strong increase during the 2nd month for face-to-face communication. It is interesting to observe that in Condition 2, the developmental trajectories of attention getting and face-to-face communication cross each other exactly at 6 weeks, separating the first month and a half (the 1st month being characterized by relatively scant attention to the mother's face) from the following period (marked by high durations of mother–infant face-to-face communication).

This separation was confirmed by a 3 (age period) × 2 (condition) repeated measures ANOVA conducted on the duration of both attention getting and face-to-face communication. With regard to attention getting, the ANOVA showed a significant main effect for age period, $F(2, 30) = 11.03$, $p < .01$, and condition, $F(1, 15) = 22.01$, $p < .01$, as well as a significant Age Period × Condition interaction effect, $F(2, 30) = 26.86$, $p < .01$. *T* tests used as post hoc tests revealed that in both conditions the amount of time the mother spent getting the infant's attention was significantly longer during the 1st month (Condition 1, $M = 124.6$ s;

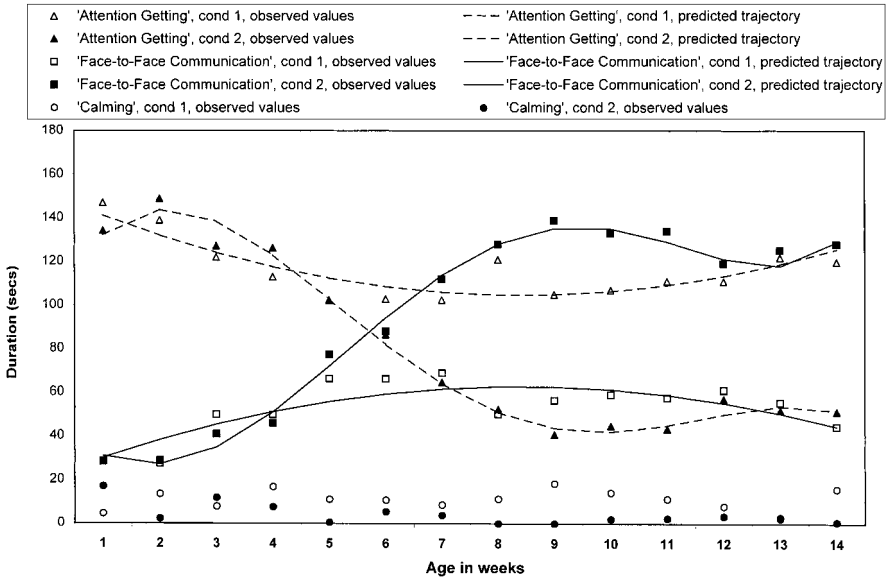

Figure 1. Observed versus predicted average developmental trajectories for attention getting and face-to-face communication and observed values for calming. Condition (cond) 1 = infant held by mother; Condition 2 = infant not held by mother.

Condition 2, $M = 127.7$ s) than during the 2nd month (Condition 1, $M = 108.3$ s; Condition 2, $M = 57.8$ s), $t(15) = -2.36$, $p < .05$ (Condition 1), $t(15) = -11.94$, $p < .01$ (Condition 2), as illustrated by the corresponding developmental trajectories (see Figure 1). During the 3rd month, the time the mother spent getting the infant's attention was significantly shorter than during the 1st month, but only in Condition 2 ($M = 50.8$ s), $t(15) = -5.56$, $p < .01$. This finding indicates that by the 3rd month, getting the

Table 3
Means and Standard Errors for Estimated Parameters of the Multilevel Models for Mother–Infant Communication Frames

	Infant held by mother				Infant not held by mother			
	Attention getting		Face-to-face communication		Attention getting		Face-to-face communication	
Parameter	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
				Average curve				
Intercept	151.80	9.33	20.78	9.66	95.95	23.62	48.40	19.32
Age	−11.22	3.86	9.95	3.82	51.30	19.68	−24.71	12.74
Age^2	0.66	0.27	−0.59	0.26	−16.63	5.08	7.30	2.10
Age^3					1.56	0.50		
Age^4					−0.04	0.01	−0.07	0.01
Age^5							0.003	0.0009
				Random				
σ_0^2					448.8	231.5		
σ_1^2	107.90	47.22	93.66	42.84			55.74	20.55
σ_{12}	−8.13	3.76	−6.35	3.20				
σ_2^2	0.69	0.31	0.50	0.25				
σ_{04}					−0.02	0.01		
σ_{14}							−0.04	0.01
σ_{24}							0.002	0.0007
σ_4^2					2.657e-06	1.264e-06		
σ_{05}							0.008	0.002
				Error				
σ^2	1,604	163.7	1,720	175.5	1,753	179.8	1,726	179.3

infant's attention to the mother's face was harder when the infant was in the mother's arms.

Also, an ANOVA conducted on the duration of mother–infant face-to-face communication demonstrated a significant main effect for both age period, $F(2, 30) = 8.55$, $p < .01$, and condition, $F(1, 15) = 13.37$, $p < .01$, and, overall, a significant Age Period × Condition interaction effect, $F(2, 30) = 14.00$, $p < .01$. *T* tests revealed that when the infant was not held by the mother, the duration of face-to-face communication during the 2nd month ($M = 120.0$ s) and that during the 3rd month ($M = 126.6$ s) were significantly longer than that during the 1st month ($M = 43.3$ s), $t(15) = 6.20$, $p < .01$, and $t(15) = 5.15$, $p < .01$, respectively, as can be observed in the corresponding developmental trajectories (see Figure 1). No significant differences in the duration of face-to-face communication were found between the 2nd and 3rd months. These findings highlight a main developmental change in the duration of mother–infant face-to-face communication between the 1st and 2nd months but no significant increases after the 2nd month.

Simple gazing and active engagement were identified as qualitatively different levels of engagement in face-to-face communication on the part of the infant. Regarding the duration of these subframes, it is interesting to observe that a significant increase between the 1st month and the following months, but not later, was found for active engagement in both conditions. Figure 2 compares the average developmental trajectories for simple gazing and active engagement with the observed values in both Condition 1 (respectively modeled by third- and second-degree polynomial functions) and in Condition 2 (respectively modeled by second- and third-degree polynomial functions). Simple gazing (i.e., the duration of the infant's gazing at the mother's face without any other sign of engagement) was predominant until the end of the 1st month (and until 6 weeks when the baby was held by the mother) and then began to decline. A 3 (age period) × 2 (condition) repeated measures ANOVA demonstrated a significant Age Period × Condition effect, $F(2, 30) = 6.04$, $p < .05$, and *t* tests indicated that when the infant was held by the mother, but not in the opposite condition, the duration of simple gazing decreased significantly from the 1st and 2nd months ($M = 36.01$ s and $M = 26.10$ s, respectively) to the 3rd month ($M = 14.35$ s): $t(15) = 3.07$, $p < .01$, and $t(15) = 2.25$, $p < .05$, respectively. Moreover, during the 2nd and 3rd months, the duration of simple gazing was significantly longer when the infant was not held (2nd month, $M = 37.96$ s; 3rd month, $M = 28.37$ s). No main effects for age period or condition were found.

On the contrary, active engagement in face-to-face communication emerged for some dyads from as early as 4 weeks after birth and began to strongly increase, especially in Condition 2, after the first month. A 3 (age period) × 2 (condition) repeated measures ANOVA demonstrated a significant main effect for both age period, $F(2, 30) = 23.26$, $p < .01$, and condition, $F(1, 15) = 40.75$, $p < .01$, and a significant Age Period × Condition interaction effect, $F(2, 30) = 16.53$, $p < .01$. *T* tests revealed that in both conditions the amount of time the infant was actively engaged was significantly longer during the 2nd month (Condition 1, $M = 32.01$ s; Condition 2, $M = 83.15$ s) and the 3rd month (Condition 1, $M = 40.20$ s; Condition 2, $M = 99.15$ s) than during the 1st month (Condition 1, $M = 9.56$ s; Condition 2, $M = 13.42$ s): $t(15) = 2.84$, $p < .05$, and $t(15) = 2.29$, $p < .05$, respectively, in Condition 1; $t(15) = 11.55$, $p < .01$, and $t(15) = 7.728$, $p < .01$, respectively, in Condition 2. No significant differences in active engagement were found between the 2nd and 3rd months. These findings suggest that infants already played an active role in face-to-face communication with their mothers during the 2nd month.

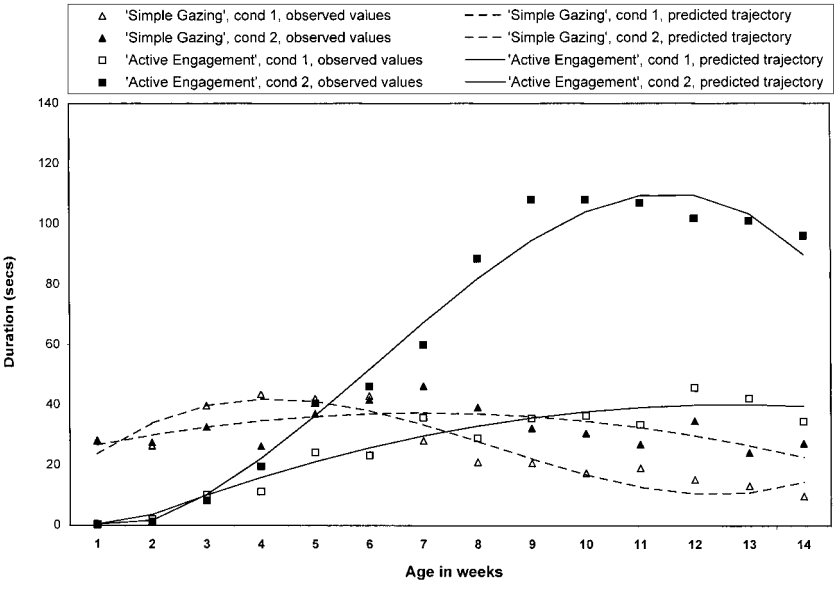

Figure 2. Observed versus predicted average developmental trajectories for simple gazing and active engagement, subframes of face-to-face communication. Condition (cond) 1 = infant held by mother; Condition 2 = infant not held by mother.

In particular, the analysis of the relative proportions of simple gazing and active engagement in the face-to-face communication frame across the 14 weeks revealed that in both conditions, the relation between these two "phases" of communication reversed at around 7 weeks, when active engagement reached 60% of the duration of face-to-face communication. After that age, the infant's active engagement continued to increase until a peak at 9 weeks when the infant was not held by the mother and until a peak at 12 weeks when the infant was held (see Table 2). In the latter condition, the proportion of active engagement was lower (besides being slower to emerge) than when the infant was not held (see Table 2 and Figure 2). These findings suggest a context specificity of the relation between simple mutual gazing and more active engagement in face-to-face communication on the part of the infant. This context specificity is also supported by the positive correlation found between simple gazing in the 1st month and active engagement during the 2nd and 3rd months in Condition 1 (see Table 4) but not in Condition 2. In other words, correlation results showed that only when the infant was in the mother's arms did the greater time spent in mutual gazing during the 1st month predict higher rates of active engagement in face-to-face communication during the 2nd and 3rd months.

Interdyad Differences

To investigate the emergence of interdyad differences across the 14 weeks, we used a multilevel modeling technique to model individual developmental trajectories for the duration of the attention getting and face-to-face communication frames, as well as the active engagement subframe, in both conditions. Because, like their corresponding average developmental curves, the individual developmental trajectories for attention getting were almost mirror images of those for face-to-face communication in both conditions, we focus our presentation of the results on the latter.

As shown in Table 3, inclusion of the Level 2 random parameters (variances and covariances) in both polynomial functions used to model face-to-face communication in Condition 1 (infant held by the mother) and Condition 2 (infant not held by the mother) revealed significant age-dependent differences among dyads in both conditions, $\chi^2(3) = 12.9$, $p < .01$, and $\chi^2(1) = 14.3$, $p < .01$, respectively. Although no significant interdyad differences were found in initial status in both conditions (see in Table 3 the absence of the intercept variance) and in the relationship between initial status and growth rate in Condition 1, there were significant interdyad differences in growth rate. Figures 3 and 4 show that in both conditions, the variance in mother–infant face-to-face communication was limited during the first weeks of life but increased during the 2nd month, especially when the infant was held by the mother, with a divergence of the individual trajectories at around 2 months, that is, coincident with the key developmental transition related to the acquisition of exogenous control. These findings confirmed the hypothesis that interdyad differences are more likely to emerge in a developmental transition period.

Figures 3 and 4 also show that after 7–8 weeks in Condition 1 (infant held by the mother) and after 8–10 weeks in Condition 2 (infant not held by the mother), two different groups of dyads can be distinguished on the basis of their developmental trajectories. One group shows trajectories for the duration of face-to-face communication that continue to increase or, especially in Condition 2, reach a high level and then tend to stabilize at that level (see Figures 5 and 6). The other group shows trajectories that peak around the transition period (7–8 weeks in Condition 1 and 8–10 weeks in Condition 2) and then begin to decrease (see Figures 7 and 8). However, the comparison of individual developmental curves across conditions within each dyad revealed that there was a group of dyads that showed very low trajectories, that is, scant communication, across the 14 weeks when infants were held by the mother but increasing trajectories when the infants were not held (see dyads marked with an asterisk in Figures 5, 6, and 7). All of the other dyads showed individual consistency across conditions in both the duration and shape of the trajectories for face-to-face communication across time (see Figures 5 through 8; e.g., for high durations and increasing trajectories, see Dyad 4 in Figures 5 and 6; for high durations and peaking and decreasing trajectories, see Dyad 5 in Figures 7 and 8). Finally, only one dyad (Dyad 10) showed developmental trajectories that were particularly low and different from the patterns identified, in both conditions (see Dyad 10 in Figures 6 and 7).

To assess whether there was statistical evidence for the groups of dyads distinguished on the basis of their developmental trajectories, we applied cluster analysis (with an option for two groups: higher/increasing trajectories vs. lower/decreasing trajectories) to the estimated parameters used to model individual developmental trajectories for face-to-face communication for each condition during the 3rd month—that is, after the divergence of individual trajectories at around 2 months. As can be seen in Table 5, the cluster results replicate our grouping almost perfectly except for Dyad 5 in Condition 2 and Dyad 12 in Condition 1, both of which ended up in the increasing—instead of decreasing—trajectories group because of their high durations of communication. On the whole, these findings suggest that differences between dyads can be studied in terms of the overall pattern of their developmental trajectories, which supports the method of making weekly observations across a key developmental transition.

With regard to the individual developmental trajectories of the active engagement subframe of face-to-face communication, in both conditions the variance was very limited at the intercept but was more pronounced for the slope. At around 2 months, the individual trajectories started to diverge, supporting the hypothesis that individual differences are more likely to emerge in a crucial developmental transition period. However, for active engagement we cannot clearly distinguish two different patterns of trajectories,

Table 4
Concurrent and Predictive Correlations Between Simple Gazing and Active Engagement in Condition 1 (Infant Held by Mother)

Variable	1	2	3	4	5	6
1st month						
1. Simple gazing	—					
2. Active engagement	.022	—				
2nd month						
3. Simple gazing	.414	.113	—			
4. Active engagement	.687**	.519*	.332	—		
3rd month						
5. Simple gazing	.131	.293	.284	.128	—	
6. Active engagement	.565*	−.144	.144	.552*	.161	—

* $p < .05$. ** $p < .01$.

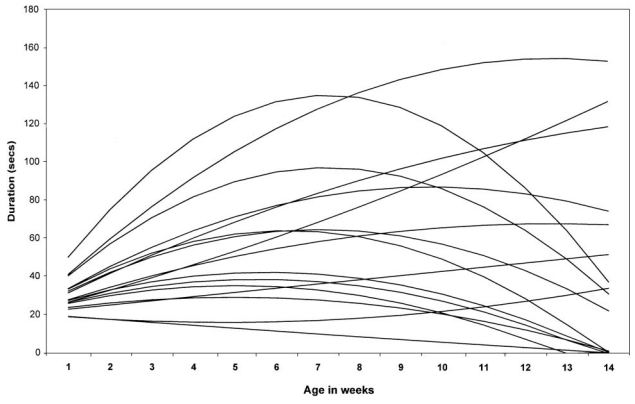

Figure 3. Individual developmental trajectories for Face-to-Face Communication, Condition 1 (infant held by mother).

as occurred for the total duration of face-to-face communication. Except for two dyads in Condition 1, all individual trajectories had a curvilinear positive trend over the age range investigated. Inter-dyad differences were found in the level of active engagement reached after a strong increase between Week 5 and Weeks 10–12 and were also shown by the fact that during the 3rd month, some dyads continued to slightly increase the amount of time they were actively engaged in face-to-face communication, whereas others maintained a stable, often high, level and only toward the end of the 3rd month started to decrease slightly. This pattern indicates that although during the 3rd month, one group of dyads decreased in the overall duration of face-to-face communication, these same dyads maintained a high level of active engagement during face-to-face communication. For the group that decreased in the overall level of face-to-face communication, then, the decrease was due primarily to a decline in simple gazing.

Finally, we conducted a first exploration of the possible factors that may be associated with the two divergent trajectories, as well as with the low trajectories in Condition 1, by comparing the groups of dyads distinguished by their developmental trajectories on the basis of data already available. First, we assessed sex effects, because in the group that increased in the duration of communication in both conditions, the infants were all girls, whereas in the group that showed scant communication while in the mother's arms, 6 of the 7 infants were boys, and the only girl (Dyad 11) had a quite low level of communication in both conditions. In 2 (infant's sex) × 3 (age period) × 2 (condition) repeated measures ANOVAs conducted on the duration of each frame and subframe, there was a significant Sex × Age Period interaction effect, $F(2, 13) = 5.75$, $p < .05$, and an almost significant Sex × Condition interaction effect, $F(1, 14) = 3.91$, $p = .068$, for face-to-face communication. *T* tests used as post hoc tests revealed that during the 3rd month, but only when infants were held by their mothers, girls spent a significantly longer time in face-to-face communication ($M = 95.74$ s) than did boys ($M = 29.87$ s), $t(14) = -2.79$, $p < .05$. This significant difference seems to correspond to longer durations of active engagement in communication on the part of girls when they were in their mothers' arms, because the ANOVA conducted on the duration of active engagement indicated an almost significant Sex × Age × Condition interaction effect, $F(2, 13) = 3.27$, $p = .07$. *T* tests, as for face-to-face communication, revealed that during the 3rd month, girls spent significantly more time ($M = 75.99$ s) than did boys ($M = 18.75$ s) actively engaged in face-to-face communication with their mothers, $t(14) = -2.61$, $p < .05$. No sex effects were found for simple gazing.

On the basis of the literature on gender differences that documents that male infants display more irritability, crying, and lability of emotional states than do female infants (J. F. Feldman, Brody, & Miller, 1980; Osofsky & O'Connell, 1977), we compared the group of scant communicators in the holding condition (6 boys out of 7 infants) with the other infants for the mean durations of calming shown during the considered age periods and conditions. *T* tests revealed that in the condition in which infants were held, during the 2nd month, the amount of time mothers spent soothing their infants was significantly longer for the group that showed a scant communication in that condition ($M = 18.61$ s) than for the other group ($M = 6.32$ s), $t(14) = 3.65$, $p < .01$. This finding suggests that infants showing low developmental trajectories of face-to-face communication when held by their mothers, and increasing trajectories when not held, might have lower adaptations to maternal holding and/or be more irritable than their peers. No significant differences were found when we compared the groups of dyads on the basis of maternal demographic characteristics.

Difference Between Conditions

As mentioned previously, the developmental trajectories for early mother–infant face-to-face communication frames and for the active engagement subframe were significantly different between conditions (see Figures 1 and 2). In particular, *t* tests revealed that in both the 2nd and 3rd months, the amount of time the mother spent getting the infant's attention was significantly less in Condition 2 (infant not held by the mother) than in Condition 1 (infant held): $t(15) = 5.65$, $p < .01$ for the 2nd month; $t(15) = 5.17$, $p < .01$ for the 3rd month (see developmental trajectories in Figure 1). *T* tests also revealed that after the 1st month, the duration of mother–infant face-to-face communication was significantly longer when the infant was semi-reclined on the sofa than when the infant was in a more upright position in the mother's arms: $t(15) = -3.71$, $p < .01$ for the 2nd month; $t(15) =$

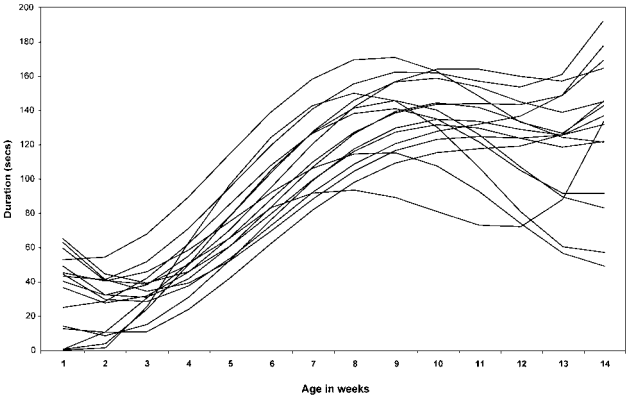

Figure 4. Individual developmental trajectories for Face-to-Face Communication, Condition 2 (infant not held by mother).

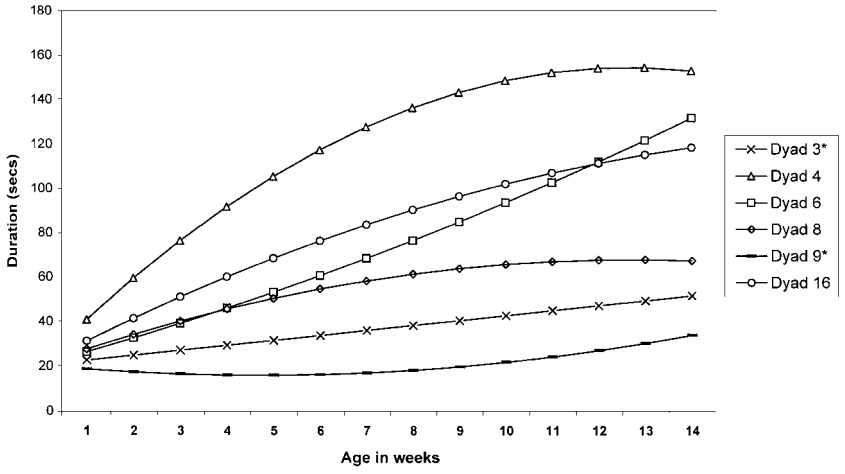

Figure 5. Group of individual developmental trajectories that increase (or increase and remain constant) in the duration of Face-to-Face Communication, Condition 1 (infant held by mother). * Low trajectories only in Condition 1.

-4.10, $p < .01$ for the 3rd month (see developmental trajectories in Figure 1). No significant differences between conditions were found during the 1st month.

With regard to the active engagement subframe, similar findings were found. *T* tests indicated that after the 1st month, the amount of time the infant was actively engaged in face-to-face communication was significantly longer when the infant was on the sofa (i.e., not held by the mother) than when the infant was in the mother's arms: $t(15) = -5.94$, $p < .01$ for the 2nd month; $t(15) = -5.07$, $p < .01$ for the 3rd month (see developmental trajectories in Figure 2). All of these findings consistently suggest that features of the face-to-face communication context (being held vs. not being held by the mother) interacted with the infant's age (and sex, considering the other mentioned result) in affecting the duration of both mother–infant face-to-face communication and the infant's active engagement.

Discussion

In this study we documented the process of developmental change in mother–infant face-to-face communication during the first 14 weeks of life (i.e., across the key developmental transition related to the acquisition of exogenous control) by observing the growth process within individual cases.

Curvilinear Development

The results support the hypothesis of a curvilinear developmental trajectory of early mother–infant face-to-face communication.

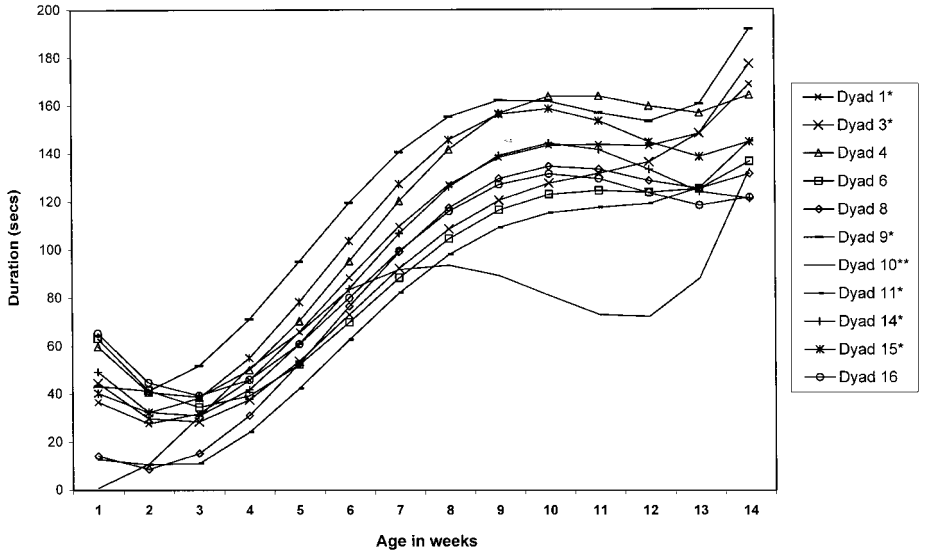

Figure 6. Group of individual developmental trajectories that increase (or increase and remain constant) in the duration of Face-to-Face Communication, Condition 2 (infant not held by mother). * Low trajectories in Condition 1. ** Low trajectories in both conditions.

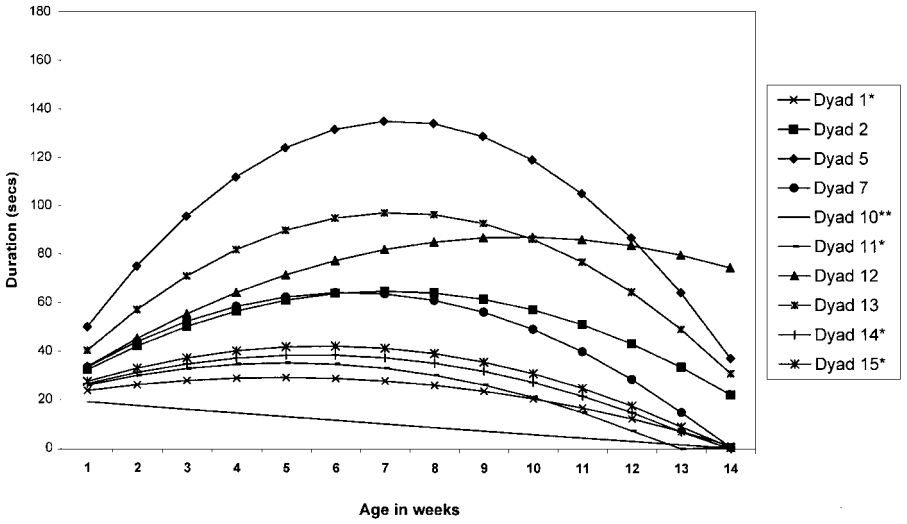

Figure 7. Group of individual developmental trajectories that peak and decrease in the duration of Face-to-Face Communication, Condition 1 (infant held by mother). * Low trajectories only in Condition 1. ** Low trajectories in both conditions.

A significant increase in such communication was found between Week 4 and Week 9 depending on the dyad, slightly before we expected considering the key developmental transition previously documented to occur at around 2 months. In particular, the results indicate a major developmental change in the duration of mother–infant face-to-face communication between the 1st and 2nd months. Considering that during the sessions, most of the mothers were gazing almost constantly at their infants, the significant increase in face-to-face communication seems, then, essentially due to an increase in the duration of the infant's gazing at the mother's face. These data are consistent with Wolff's (1963, 1987) earlier findings about the emergence of eye contact around 4 weeks of age as well as with data from other studies that highlight a striking increase in mother–infant visual engagement after the 1st month (Blass, 1997; Lavelli & Poli, 1998).

This study provides clear evidence that the 2nd month also marks the beginning of an active engagement in face-to-face communication on the part of the infant. In particular, in both conditions the amount of time the infant was actively engaged was significantly longer during the 2nd and 3rd months than during the 1st month. The proportions of simple gazing at the mother's face and of active engagement in communication reversed at around 7 weeks, and the infant's active engagement strongly increased until 9–10 weeks. No significant differences were found in the proportion of active engagement between the 2nd and 3rd months. Considering the scant literature on mother–infant interaction dur-

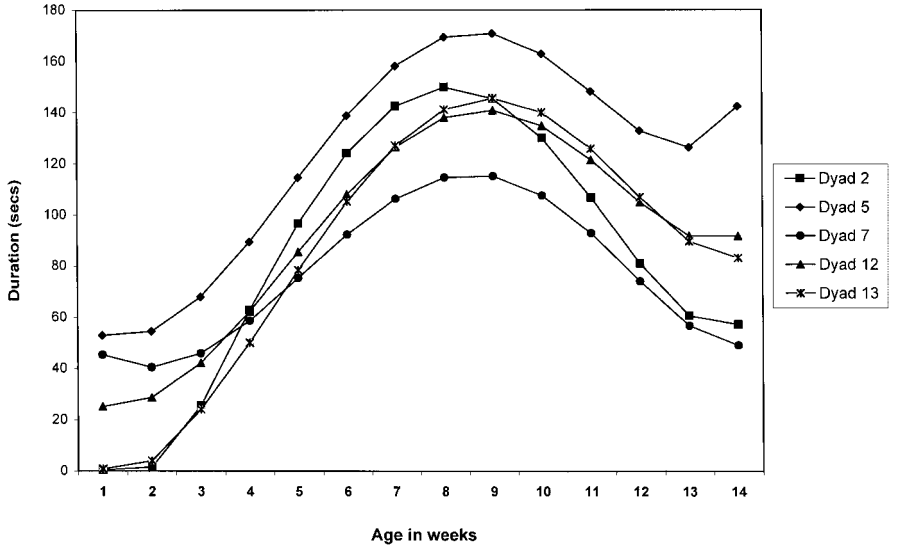

Figure 8. Group of individual developmental trajectories that peak and decrease in the duration of Face-to-Face Communication, Condition 2 (infant not held by mother).

Table 5
Clusters for Estimated Parameters of the Multilevel Models for Face-to-Face Communication During the Third Month

	Condition 1 (Infant held)		Condition 2 (Infant not held)	
Dyads	Cluster	Distance	Cluster	Distance
Dyad 1[c]	2	43.63	1	23.95
Dyad 2[b]	2	14.32	2	31.67
Dyad 3[c]	2	39.85	1	31.52
Dyad 4[a]	1	74.56	1	41.71
Dyad 5[e]	2	91.53	1	14.76
Dyad 6[a]	1	16.21	1	26.32
Dyad 7[b]	2	24.67	2	43.41
Dyad 8[a]	1	94.37	1	23.41
Dyad 9[c]	2	22.96	1	54.17
Dyad 10[d]	2	58.73	2	62.22
Dyad 11[c]	2	51.18	1	30.76
Dyad 12[f]	1	71.61	2	29.74
Dyad 13[b]	2	52.04	2	31.54
Dyad 14[c]	2	40.52	1	30.96
Dyad 15[c]	2	36.25	1	16.54
Dyad 16[a]	1	6.77	1	37.04

Note. Distance between centers of final clusters = 171.07 for Condition 1 (infant held by mother), 107.68 for Condition 2 (infant not held). Cluster 1 = higher durations. Cluster 2 = lower durations.
[a] Increasing (and stable) trajectories. [b] Peaking and decreasing trajectories. [c] Low trajectories in Condition 1. [d] Low trajectories in both conditions. [e] Decreasing but still high trajectory in Condition 2. [f] Decreasing but still high trajectory in Condition 1.

ing the very first months of life, these findings are consistent with studies pointing out that the infant can play an active role in face-to-face communication with the mother beginning in the 2nd month (Kugiumutzakis, 1999; Reddy et al., 1997; Trevarthen, 1993, 1998).

The qualitative change in the infant's level of engagement in face-to-face communication—from gazing at the mother's face without expressing any other sign of active participation to showing facial actions such as brow raising or knitting, mouth opening and lip protrusion for prespeech movements, smiles, limb movements, and postural orientation toward the mother—seemed to affect the whole process of mother–infant face-to-face communication. At the emergence of the first infant facial and vocal actions clearly oriented to the mother's face—from around the beginning or the middle of the 2nd month, depending on the dyad—most of the mothers started to mark these communicative infant actions with smiles and vocalizations. Then they waited for the infant's response or accommodated to the infant's behavior with a new pattern of address and reply. Sometime during the 3rd month, depending on the dyad, mother–infant face-to-face communicative exchanges seemed to increase their mutually gratifying dimension with the addition of more playful expressions and clear initiatives by the infant.

On the whole, the 2nd month was a period of transition between the quantitatively and qualitatively different levels of mother–infant face-to-face communication observable during the 1st and 3rd months. Thus, the findings from this study suggest the importance of starting longitudinal observation of face-to-face communication before infants are 6–8 weeks old in order to study the 2nd month as a period of developmental transition.

Diverging Developmental Trajectories

Interdyad differences, especially when the infant was held by the mother, were found in terms of both the duration and the trajectory of mother–infant face-to-face communication across the age range investigated. The fact that interdyad differences were greater when the infant was held by the mother, and that in this particular condition girls spent significantly more time than boys engaged in face-to-face communication, seems to be due to the interaction of an individual variable, such as the infant's level of adaptation and pleasure in being held by the mother, that is not present in Condition 2. This interpretation is suggested by results revealing that infants who showed scant communication in the held condition spent significantly more time fussing or crying in that very condition than did their peers. Considering that 6 of the 7 infants who showed low developmental trajectories of communication in their mothers' arms were boys, these finding are consistent with the literature on gender differences documenting that male newborns and young infants display more irritability and more frequent fussing and crying states than do female infants (J. F. Feldman et al., 1980; Moss, 1967; Osofsky & O'Connell, 1977; Phillips, King, & DuBois, 1978).

However, it has also been shown that when evaluating gender differences in infant behavior, one must take into account gender-related differences in parental behavior (Weinberg, Tronick, Cohn, & Olson, 1999). With regard to this issue, some studies have reported that mothers are more likely to engage in face-to-face communication with their female infants than with their male infants. Male infants are touched and soothed for longer periods than female infants (Golombok & Fivush, 1994; Lewis, 1972; Moss, 1967). In the present study, a microanalysis of the infant's and the mother's expressive configurations and of the types of maternal stimulation will shed light on factors and processes that affected the trajectory differences.

Nevertheless, considering that in the condition in which infants were held, a positive correlation was found between mutual gazing in the 1st month and active engagement in face-to-face communication in the 2nd and 3rd months, it might be that small individual differences between girls and boys in interacting with their mothers while being held by them in the neonatal period were then amplified into different developmental trajectories by the mothers' responses to these slight differences. Intrinsic factors such as sex may account for some part of the explanation of the formation of individual differences, but these factors do not operate alone. Intrinsic factors themselves develop in the context of prenatal and early developmental epigenesis and the microsystem of the mother–infant dyad and the exosystem of the culture (Gottlieb, 1991; Oyama, 1985). Finally, regardless of sex differences, the fact that interdyad differences were greater when the infant was held by the mother may have been due to the condition itself, which compared with Condition 2 (mutual frontal position), presents more possibility of variance in mutual postural orientation for face-to-face communication.

The hypothesis that interdyad differences are more likely to emerge in a crucial developmental transition period—in this case, at around 2 months—is supported by the results. In fact, in both conditions, individual trajectories of mother–infant face-to-face communication were similar and increasing across the early weeks of observation but diverged at around 2 months. After this age, we

can distinguish two different groups of infants on the basis of their developmental trajectories: one group with trajectories in the duration of face-to-face communication with the mother that continue to increase or that reach high levels and then tend to stabilize at those levels and another group with trajectories that peak around the transition period and then begin to decrease. From a methodological point of view, this finding suggests that differences between infants can be profitably studied by comparing the overall patterns of their individual developmental trajectories on a variable of interest, in addition to the usual way of studying them by comparing the levels of a variable reached by different infants at a few age points. This finding also supports the method of making weekly observations across a key developmental transition period (Fogel, 1990; Thelen, 1990).

A clear-cut developmental transition is visible in the peak-and-decrease group in both conditions and in most dyads of the increase-and-stabilization group in Condition 2, that is, when there was a marked increase in the duration of mother–infant face-to-face communication. This means that for the majority of dyads and for the classical facing condition, the developmental change in mother–infant face-to-face communication fits the transitional model proposed by the dynamic systems perspective. Thus, if we use this perspective as a metatheoretical framework to shed light on the developmental change, we can consider the trajectories' divergence as an example of what dynamic systems theorists (Kellert, 1993; Prigogine & Stengers, 1984) refer to as a *bifurcation*. Further research should explore the combination of system factors that may contribute to this bifurcation at this age.

However, for some dyads, especially in the condition in which infants were held, the developmental changes do not conform to the propositions of dynamic systems theory. This last result (a) suggests that the particular model of change proposed by dynamic systems theorists might be too narrow for describing all kinds of developmental changes in the domain of early communication and (b) indicates a context specificity of early mother–infant face-to-face communication (see next section). Further research on the microprocesses of changes within frames can lead to a clearer understanding of the conditions under which we see different kinds of developmental trajectories.

Effect of Context: Being Held Versus Not Being Held by the Mother

After the 1st month, the duration of mother–infant face-to-face communication was significantly longer when the infant was semi-reclined on the sofa, not held or in physical contact with the mother's body. These findings support the hypothesis that features of the face-to-face communication context, such as being held versus not being held by the mother, interact with the infant's age (and sex; see previous section) in affecting the duration of mother–infant face-to-face communication.

In particular, the fact that no significant differences between conditions were found during the 1st month may be related to the infant's motor development, because the possibility of movement is more limited when the infant is being held than when the infant is not being held. Especially during the 3rd month, many infants faced with motor constraint in the being-held condition showed signs of fussing that might have interfered with the maintenance of visual contact with the mother. On the contrary, in the not-being-held condition, most of the infants appeared more relaxed and enjoyed moving their limbs during face-to-face communicative exchanges with their mothers. Moreover, the first improvements in the development of postural control of the head occurred during the 2nd month, allowing infants to maintain a frontal orientation also in the semi-reclined position on the sofa; that is, in the condition in which during the first weeks they showed more difficulties in maintaining face-to-face postural orientations because they were not held by their mothers.

However, the proximity to the mother's body may have played a central role in affecting not only the duration but also the quality of mother–infant face-to-face communication, maintaining the level of positive arousal lower than that in the not-being-held condition. In other words, the physical contact with the mother's body and the tactile contact elicited when the infant was in the mother's arms may have acted as a sort of soothing mechanism for many infants, as well as a less comfortable condition for some of them, mostly boys. This interpretation is supported by results showing that in the being-held condition, the duration of active engagement in face-to-face communication on the part of the infants, especially male infants, was lower and later than that in the not-being-held condition. Moreover, the positive correlation between simple gazing in the 1st month and active engagement in the 2nd and 3rd months in the being-held condition, but not in the other condition, suggests a context specificity of early mother–infant face-to-face communication.

This context specificity also seems to be supported by the role that the tactile contact elicited in the being-held condition may have played in directing the infant's attention from the mother's face toward the mother's hands, as suggested by studies on the impact of adult touching on infant attention and affect (Stack & Arnold, 1998; Stack & Muir, 1990, 1992). However, these studies were conducted on 3- and 5-month-old infants, and in our study only during the 3rd month did infants begin to shift their attention to the mother's hands and body. Thus, this factor might only partially explain the significantly lower duration of face-to-face communication observed when the infant was in the mother's arms.

Finally, a further possible interpretation of the results that does not exclude the previous ones and that might explain the differences found between conditions since the beginning of the 2nd month is that the absence of contact with the mother's body in the sofa condition might have stimulated the infants to have another form of communication with their mothers. This explanation was also suggested by Papousek and Papousek (1977), who pointed out that for the infant, it is so important to maintain some kind of contact with the mother that the frequency of mother–infant visual contact tends to increase when the baby is not held by the mother. On the whole, our findings suggest the importance of considering contextual features, such as being held by the mother and the closeness to the mother's body, in studying early mother–infant face-to-face communication.

Conclusion

This study provides new data on developmental changes and individual differences in mother–infant face-to-face communication from the relatively little explored period of the very first weeks of life through the 3rd month. Face-to-face communication

was observed in a naturally occurring context in the participants' homes, satisfying criteria of ecological validity. Intensive observations across the 2-month developmental transition period and data analysis with a multilevel modeling technique allowed us to model individual and average developmental trajectories of early mother–infant communication, that is, to visualize the form of developmental change across a key developmental transition within individual cases. This method for longitudinal studies makes it possible to go profitably beyond the traditional comparison between relatively few group outcomes over the age range investigated. Moreover, it also provides a new approach to the study of individual differences, suggesting that differences between infants can be analyzed in terms of the overall pattern of their developmental trajectories. In this study, the comparison of individual developmental trajectories of face-to-face communication showed a divergence of trajectories coincident with the 2-month transition. After this age, two different patterns of trajectories emerged. The characteristics of the developmental trajectory are unexplored and potentially interesting individual-differences variables (Fogel, 1990; Thelen, 1990). There are two possible uses of such variables: (a) for understanding the dynamics of the bifurcation process that *creates* individual difference and (b) for understanding the developmental outcomes that *result* from this difference. Further research should continue the exploration of system factors that may contribute to this divergence in order to shed light on factors and processes that most affect early mother–infant face-to-face communication. The relatively small sample size, which was due to both the choice of a multiple-case design based on weekly observations and the practical difficulties of data collection with newborn infants, is counterbalanced by an elevated number of videotaped sessions ($N = 446$). Nevertheless, the sample size clearly needs to be enlarged to assess the consistency of our findings. In addition, the extension of this longitudinal design beyond the 14th week of life will enable us to address the issue of between-groups developmental outcomes. However, because the present findings indicate that interdyad differences in mother–infant communication emerge very early in the infant's life, they highlight the importance of studying mother–infant face-to-face communication beginning in the 2nd month, a period of significant developmental change.

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Appendix

Categories of Mother–Infant Communication Frames

Attention Getting

The infant is gazing away from the mother's face, and the infant's head is also turned away, while the mother is attempting to capture the infant's attention in different ways (e.g., by repeated calling of the infant's name, simple questions asked in a soft tone of voice, vocalizations, head movements to get closer to the infant's face, hand movements, or also, when the mother is holding the infant, gentle tactile stimulation or adjustments of the infant's position to facilitate eye contact). Alternatively (but infrequently), maybe the infant is half-closing his or her eyes. More frequently, maybe the mother is simply softly talking to the infant or caressing him or her without showing clear intentions of getting the infant's attention.

Onset: When the infant shifts his or her gaze away from the mother's face without turning it again to the mother within 3 s, and the mother stops talking to the infant in the tone of the previous frame and assumes a more neutral facial expression while following the infant's gazing direction.

Face-to-Face Communication

Mother and infant are engaged in face-to-face communication, defined by mutual gaze focused on the partner's face or, in case the infant is not gazing continuously at the mother's face, by clear vocal or gestural actions directed to the mother.

Simple Gazing

Mother is talking with a soft, high-pitched voice and/or smiling or showing exaggerated facial expressions to the infant or sometimes touching the infant (e.g., caressing and playing with the infant's hands and fingers, walking her fingers on the infant's tummy). The infant is gazing at the mother's face without expressing any other sign of active engagement in face-to-face communication.

Onset: When the infant raises his or her lids and shifts his or her gaze to the mother's face and the mother tends to highlight the establishing of visual contact with a smile or exclamation such as "Here you are!" Alternatively, in case the mother and the infant were already engaged in face-to-face communication, when the infant stops showing signs of active engagement but maintains visual fixation at the mother's face while she is addressing the infant.

Active Engagement

Mother and infant are both actively engaged in face-to-face communication in a way that resembles a "protoconversation." The infant is gazing at the mother's face and showing facial actions of high-arousal attention such as brow raising or knitting and widening of the eyes while the mother is talking in a gentle and playful high-pitched voice, smiling at the infant and mirroring his or her facial actions with enhanced mimicry. When the infant smiles or emits pleasure vocalizations, the mother immediately marks these infant actions with a gaping smile, imitates the infant's vocalization, and then waits for another infant response. The same sequence occurs when the infant, with approaching postural orientation, shows mouth opening and lip protrusion for coos or prespeech movements, often with arm raising and waving and open-handed movements: The mother pauses and waits for the infant's emission of vocalizations and then answers with smiles and imitative sounds, and the infant reacts again with smiles and coos in a sequence of increasing playful turn taking. When not held by the mother, especially during moments of high-arousal attention to the mother's playful actions, the infant may show motor excitement (e.g., open the arms in up-and-down movements, leg kicking). Maybe the mother laughs at an infant's gaping smile or at a particular facial expression or vocalization.

Onset: When, during visual fixation of the mother's face, the infant shows a facial and/or vocal action clearly addressed to the mother, and the mother marks it by smiling—often imitating the infant's action or expressing a positive comment—and raising the level of positive arousal within the communication. Alternatively, (but infrequently) if the infant is not gazing at the mother's face, when he or she smiles (or vocalizes or shows particular facial actions) and turns his or her gaze to the mother.

Calming

Mother is attempting to soothe or calm the infant, who is showing signs of discomfort or is fussing or crying. The infant's fussiness may range from merely producing a few fussylike sounds or movements to (infrequently) stiffening his or her body and/or arms and legs, as well as from simple signs of a precry face to audible crying. The mother's soothing actions may range from simple getting closer to the infant (when the infant is not being held by mother) and holding his or her hand or caressing and kissing him or her while talking in a whispered tone of voice, to cradling or gently bouncing the infant when the infant is in the mother's arms.

Onset: When the mother promptly changes her facial and vocal expression and her ongoing action becomes a soothing action upon noticing sudden signs of a precry face or any other sign of discomfort on the part of the infant.

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