

Stability and Transitions in Mother–Infant Face-to-Face Communication During the First 6 Months: A Microhistorical Approach

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In this study the authors attempted to unravel the relational, dynamical, and historical nature of mother–infant communication during the first 6 months. Thirteen mothers and their infants were videotaped weekly from 4 to 24 weeks during face-to-face interactions. Three distinct patterns of mother–infant communication were identified: symmetrical, asymmetrical, and unilateral. Guided by a dynamic systems perspective, the authors explored the stability of and transitions between these communication patterns. Findings from event history analysis showed that (a) there are regularly recurring dyadic communication patterns in early infancy, (b) these recurring patterns show differential stabilities and likelihoods of transitions, (c) dynamic stability in dyadic communication is shaped not only by individual characteristics (e.g., infant sex and maternal parity) but also by the dyad's communication history, and (d) depending on their recency, communication histories varying in temporal proximity exert differential effects on the self-organization processes of a dyadic system.

The idea that developmental outcomes are rooted in the history of parent–child interaction is prevalent in the developmental literature. For example, the central tenet of attachment theory is that the quality of infant attachment reflects the parent–infant interaction history; individual differences in infant attachment security originate from differential histories of mother–infant interaction (Ainsworth, Blehar, Waters, & Wall, 1978). Infants experiencing synchronous interactions with their mothers develop secure attachment relationships, whereas infants engaging in interactions with their mothers characterized by asynchrony become insecurely attached (e.g., Isabella, Belsky, & von Eye, 1989). Infants with different attachment security histories differ in the growth trajectories of their expression of emotions, which suggests the importance of relational history in emotional development (Kochanska, 2001). Although studies on attachment put a special emphasis on the importance of early interactional experience, most of them acknowledge that child development is shaped by a cumulative experience of a co-constructed interactive process between parent

and child (Maccoby, 1992; Sameroff & Chandler, 1975). Recently, Landry and her colleagues (Landry, Smith, Miller-Loncar, & Swank, 1998; Landry, Smith, Swank, Assel, & Vellet, 2001) demonstrated that mothers' consistent and sustained adaptation to their children's changing needs over time, rather than an early pattern of mothering, facilitates young children's social and cognitive development. These findings not only call attention to the fact that examination of parent and infant behaviors at specific time points does not provide a full picture of development but also underscore the importance of scrutinizing historical pathways of parent–infant reciprocity over time.

Despite the developmental significance of synchrony in parent–child interaction (see Harrist & Waugh, 2002, for a review), the extent to which its establishment, maintenance, and termination are influenced by the characteristics of the individual interactants and/or by the dyadic history that emerges between them is not clear. Our overarching goal in the present study, therefore, was to examine the influence of the cumulative history of the mother–infant dyad on the stability of and transitions between patterns of ongoing mother–infant face-to-face communication. To address such a question, we need to consider a number of methodological and statistical issues. In the following sections, we discuss the dynamics and development of mother–infant face-to-face communication and address prior methodological shortcomings in the literature. Specifically, we address three issues: (a) the need for a coding system that captures the distinctive dyadic patterning of mother–infant communication and that uses the dyad (as opposed to the individual) as the unit of analysis, (b) the need for a study design that provides direct access to the dynamic process of mother–infant communication as it develops over time, and (c) the need for a statistical procedure that permits analysis of the influence of cumulative history on the currently unfolding dyadic communication.

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Dynamics of Mother–Infant Face-to-Face Communication in Early Infancy

The dynamic interdependence of mother and infant has been captured by terms such as *attunement* (Stern, Hofer, Haft, & Dore, 1985), *coordination* (Tronick & Cohn, 1989), *dialogue* (Bakeman & Brown, 1977), *interpersonal contingency* (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001), *reciprocity* (Brazelton, Koslowski, & Main, 1974), and *synchrony* (Karger, 1979). Previous studies demonstrated that rhythmic moment-to-moment changes in infants' and their mothers' behaviors are the result of bidirectional influences between the two partners (Cohn & Tronick, 1988b; Gottman & Ringland, 1981).

An individual's interactive behavior is created in the process of joint coordination with the partner. As described by Jaffe and his colleagues (2001), "Communication occurs when each affects the probability distribution of the other's behavior" (p. 21). Fogel (1993) further suggested that during the process of social communication, there is a co-regulation in which "individuals dynamically alter their actions with respect to the ongoing and anticipated actions of their partners" (p. 34). Individual differences in mother–infant communication are shaped by maternal and infant factors. In addition to maternal (e.g., depression; Field, Healy, Goldstein, & Guthertz, 1990) and infant (e.g., temperament; Feldman, Greenbaum, & Yirmiya, 1999) individuality, static demographic characteristics of mother and infant also exert an influence on mother–infant face-to-face communication. For example, mothers who are more experienced in caring for an infant are more sensitive and positive to infant signals (Belsky, Taylor, & Rovine, 1984; Freeburg & Lippman, 1986; Moore, Cohn, & Campbell, 1997). Mother–son dyads experience a higher level of coordination and matching in their interactive behaviors than do mother–daughter dyads (Malatesta & Haviland, 1982; Tronick & Cohn, 1989).

Individual differences in dyadic communication systems have been explored using two different parameters: content and timing. Dyads differ in the extent to which the behaviors of the individual partners are matched with one another in valence, intensity, and form, that is, in the degree to which the content of their individual communicative actions matches (e.g., Nicely, Tamis-LeMonda, & Bornstein, 1999; Tronick & Cohn, 1989). Dyads also vary in the ability of the individual interactants to move together over time, that is, in the synchrony in timing of the partners' behaviors (e.g., Feldman et al., 1999; Tronick & Cohn, 1989). Overall, the level of matching and synchrony between mother and infant increases with infant age (Tronick & Cohn, 1989).

In the present study, we explored another aspect of the dynamics in mother–infant face-to-face communication, namely, stability and transitions. From a dynamic systems perspective, mother–infant face-to-face communication is viewed as a dyadic system composed of multiple constituents (Fogel & Thelen, 1987). In the terms of dynamic systems theory, a sustained and recurring pattern of mother–infant communication can be considered an *attractor* state, a stable organization of behavioral actions preferred by the mother–infant dyad under certain conditions. Dynamic systems theory predicts that relative differences in the stability of attractors in a system arise from what are called *self-organizing*, or emergent, processes *within* the system. Because the constituents of a dyadic communication system constantly organize and reorganize themselves (cf. Thelen & Ulrich, 1991), two types of self-

organizing process may act on the stability of and transitions between the attractors: augmenting and suppressing processes. A *suppressing* process occurs when the system organizes itself to stay in a stable state, whereas an *augmenting* process takes place when the system reorganizes itself by shifting and leaving the current state. When the suppressing process is in effect, a communication pattern is more likely to remain stable. In contrast, when the augmenting process is in effect, the current communication pattern falters and is more likely to be involved in a transition.

To reveal the origins of individual differences in parent–child interaction, researchers have focused on identifying influential person factors such as parental (i.e., parent gender, personality) and child (e.g., child gender, temperament) characteristics as well as contextual factors beyond the dyad (e.g., parental marital quality and social support; Belsky, 1984). Little attention has been paid to factors that are within the dyad. Exploration and understanding of self-organizing processes in dyadic communication may help researchers not only further explain individual differences in developmental outcomes but also reveal the mechanisms and pathways of the development of individual differences. Therefore, our primary goal in this study was to systematically examine the contributions of emergent factors arising within the system, namely, communication history (see discussion below) relative to individual infant (e.g., age and sex) and maternal (e.g., parity) characteristics. The first step in achieving this goal was capturing the emergent dynamics of mother–infant face-to-face communication.

Most research on mother–infant communication has focused on moment-to-moment changes and emphasized the temporal sequencing of the individual behaviors of the two partners. Maternal and infant communicative actions were identified separately by using a scaling (e.g., the monadic phases coding system; Feldman et al., 1999; Tronick, Als, & Brazelton, 1980) or discrete coding strategy (Cohn & Tronick, 1988a; Fogel, 1988). The dyadic relatedness between mother and infant was then derived post hoc quantitatively (e.g., dyadic states or coherence index). As a result, dyadic communication was understood at an individual level, rather than at a dyad level. As suggested by Kenny's (e.g., Kenny, Mohr, & Levesque, 2001) social relations model of interpersonal relationship, Person A's behavior in relation to Person B is a function of three factors: (a) Person A's actor effect, (b) Person B's partner effect, and (c) a relationship effect. Within the family, the dyadic interaction of children and their parents is influenced by each family member's own characteristics, by the characteristics and behavior of his or her social partners, and by the dyadic relationship (Cook, 2001; Stevenson, Leavitt, & Thompson, 1988). During face-to-face communication, maternal and infant interactive behaviors are the product of a process of joint creation between the two partners. Signal–response, chainlike actions by the two partners cannot capture the co-regulatory effect of one partner on the other. Because of the co-constructive and co-regulatory nature of early mother–infant communication, patterns of dyadic communication are jointly defined by the behaviors of both partners. Variations in dyadic interaction are determined not only by the characteristics of the two interactants but also by the unique relationship between them. The dyad, rather than the individual interactants, should be considered as the basic unit of coding and analysis.

The dyadic pattern of communication, judged qualitatively in terms of whether and to what extent the two partners are mutually involved and co-regulated with one another as the interaction is unfolding, may be more suitable for capturing the dynamics of mother–infant communication than are dyadic states constructed from separate individual behaviors. Our initial task, then, was to devise a system that could capture the qualitatively different patterns of dynamics in mother–infant communication. For the current study, we developed a relational coding system for classifying mother–infant communication patterns that was based on the physical orientation, attentional focus, and level of mutual involvement of one partner in relation to the other.

Five distinct dyadic communication patterns were identified during the first 6 months of life: symmetrical, asymmetrical, unilateral, disruptive, and unengaged. *Symmetrical* communication reflects active, mutual engagement and shared experiences, which can be achieved by creative, collaborative activities via verbal and nonverbal behaviors such as facial expressions, visual regard, and body movement. Although mother and infant typically become more coordinated and synchronized over time, the magnitude of coordination is low (Tronick & Cohn, 1989). An *asymmetrical* pattern of communication characterizes mothers' efforts in attempting to engage their passively attentive infants in continuing interaction. Although infants are responsible for initiating and terminating mutual gaze, mothers look at, talk to, and smile at their infants significantly longer and more frequently than vice versa (Messer & Vietze, 1984). During *unilateral* communication, mothers constantly monitor and display exaggerated vocal, facial, and tactile signals to provide "frames" for their infants (Kaye & Fogel, 1980), who are interested in some activities other than social interaction. Furthermore, in some cases, mothers can be intrusive and *disruptive* (Isabella, 1993). Maternal overstimulation and interference are associated with infants' decreased smiling (Symons & Moran, 1987) and increased gaze aversion (Field, 1981). Also, on some rare occasions, both mothers and their infants attend to their separate activities and, therefore, are *unengaged* in communication. More details concerning the coding system are provided in the Method section.

The occurrence rates of these dyadic patterns in early face-to-face communication are relatively unknown, as are how these patterns maintain their stability or make transitions. Therefore, one of our goals in the present study was to investigate the temporal characteristics (e.g., mean duration and occurrence rate) and dynamic stability (i.e., the likelihood of mother–infant dyads making transitions out of communication patterns at any given moment) of the qualitatively different patterns of mother–infant communication. We expected that naturally recurring dyadic patterns in mother–infant face-to-face communication would show differential profiles of basic temporal characteristics and dynamic stability.

Relational History of Mother–Infant Communication

Studies of the temporal structure of dyadic interaction suggest that mothers and infants regulate their behaviors in relation to one another and that a transition in a dyadic state is influenced only by the dyad's current state (Cohn & Tronick, 1988b). The contribution of a partner's behavioral influence on the other's current actions beyond a few preceding seconds has rarely been considered (e.g., Keller, Lohaus, Völker, Cappenberg, & Chasiotis, 1999;

Van Egeren, Barratt, & Roach, 2001). Lollis and Kuczynski (1997) contended that moment-to-moment interactions between parents and children are the building blocks for the development of long-term enduring relationships. A relationship forms after the parent and child accumulate a history of interactions over time, and consequently, "the resulting relationship at the same time provides the dynamic context for their interactions" (Lollis & Kuczynski, 1997, p. 442). Thus, each interaction is influenced by past interactions; the shared, co-constructed history shapes the dynamics of the moment-to-moment interaction. Hinde (1979) further theorized that "at the behavioural level, each interaction may affect the course of future ones" (p. 35). In a dynamic systems framework, the process of transitions between different communication patterns in real time reflects the recurrent stabilizing and destabilizing of attractors, which may be the basis for developmental changes (cf. Thelen & Ulrich, 1991). Each time a new communication attractor forms, it is built on the previously existing communication patterns. The knowledge of the prior history of the dyadic system per se, rather than of the individuals, then, should provide further information about the likelihood of the dyad continuing the same pattern of communication or making a transition to a subsequent one.

Supporting evidence is available for the influence of relational history on dyadic interactions in early infancy. For example, when engaging in social interactions with young infants, mothers and strangers exhibit differential interactive styles. Whereas mothers are more likely to initiate interactions, strangers who share no relational history with the infants tend to respond to the infants' actions (P. M. Miller, 1993). Also, infants' contingent response to a social partner is largely determined by their past interaction experience. For example, even when mothers are less responsive than the strangers, infants are still more responsive to mothers than to responsive strangers (Bigelow, 1998). Despite the contrasting patterns in face-to-face communication between infants and mothers versus strangers, little is known about how the dynamics of mother–infant interaction are influenced by relational history. The interconnectedness between the relational history and the dynamics of social interaction has been overlooked in empirical research. As a first step toward bridging this gap, achieving an understanding of how and to what extent dyadic interactions occur and unfold in a context of relational history is pivotal.

Although research on mother–infant communication has indeed produced many dyadic systems concepts and measures, the extent to which dyadic history shapes the unfolding dyadic communication system relative to person factors remains to be tested. To our knowledge, this is the first study to systematically compare the contributions to system development of dyadic history, which is an emergent factor arising within the system, relative to person factors. We expected that cumulative dyadic history would make a contribution to the prediction of the stability of and transitions between communication patterns in real time over and above contributions from maternal and infant individual characteristics such as infant sex and age (a proxy measure of maturation) as well as maternal parity (a proxy measure of maternal experience in childcaring). Furthermore, given the dynamic reiterative and self-organizing processes within dyadic systems, we expected that cumulative experience would exert a suppressing effect, inhibiting the system from reorganizing itself and therefore increasing its stability, or tendency to stay in the current communication pattern.

In a complementary fashion, cumulative history was also expected to exert an augmenting effect, facilitating the self-organization of the system in making a transition back to a familiar pattern.

To understand whether and to what extent moment-to-moment interactions vary as a function of dyads' communication history, a process-oriented microgenetic research design and a new data analysis strategy are needed that allow for direct access to and exploration of the influence of dyadic communication history.

Microgenetic Study Design

In traditional longitudinal studies, data from large samples are collected, and target behaviors are observed infrequently and separated by lengthy time intervals. With this type of study design, only global developmental trends can be detected, and little is learned about *how* current and later development is shaped by cumulative experience. A microgenetic design is a process-oriented approach to the understanding of development (Granott & Parziale, 2002; Kuhn, 1995; P. H. Miller & Coyle, 1999) in which dense, repeated observations with a smaller number of mother–infant dyads around transitional periods permit the tracking of developmental history as it is evolving (Lavelli, Pantoja, Hsu, Messinger, & Fogel, in press).

Development is multifaceted and occurs at multiple time scales. Lewis (2000, 2002) differentiated three levels of time scale in development: a micro level (e.g., seconds and minutes), a meso level (e.g., hours and days), and a macro level (e.g., months and years). In the present study, the development of mother–infant communication was captured at two different time scales: the micro level, in which the moment-to-moment interaction between mother and infant was observed as it was unfolding second by second in real time during each observation, and the macro level, in which observations of mother–infant interaction were conducted at weekly intervals over a 6-month period. On the basis of these

two time scales, the relational history of mother–infant communication can be further classified into three different levels according to its temporal proximity to the current pattern of communication, namely long-term history, short-term history, and recent history (see Table 1 for descriptions and the *Data Analysis* section for more details). We expected that the relational history that was temporally closer to the current communication pattern would exert a stronger influence in determining the stability of and transitions from an unfolding communication pattern. Therefore, we hypothesized that the three levels of communication history would differ in their relative influence on the stability of and transitions between communication patterns and that the influence of a recently preceding history would be greater than that of a short-term history, which would be greater than that of a long-term history.

Event History Analysis

Empirical investigation of the temporal dynamics of mother–infant face-to-face communication is typically conducted by examining the sequential links (e.g., event sequential analysis) between derived dyadic states or the temporal coherence (e.g., time series analysis) between maternal and infant individual behaviors. Individual stability and developmental continuity across two or more time points are revealed by correlations and mean comparisons. To unravel the historical nature of early mother–infant face-to-face communication, one must scrutinize the stability of and transitions between dyadic communication patterns rather than the temporal sequencing of maternal and infant communicative acts. Therefore, an appropriate statistical method for analyzing duration data is necessary. Event history analysis (also known as survival analysis) is a statistical technique that provides a description of how a process evolves at every point in time.

Table 1
Classification of Dyadic Communication History

Time scale	Level of history	Description	Operational definition
Micro	Recent	Previous communication episode	Pattern (symmetrical, asymmetrical, or unilateral) and duration (in seconds) of a dyadic communication that immediately precedes the currently ongoing one
	Short-term	Past experience in dyadic communication within a given observation session	Cumulative duration (in seconds) of a communication pattern since the beginning of a given session until the onset of a current communication pattern
Macro	Long-term	Past experience in dyadic communication over weeks	Cumulative duration of a communication pattern across sessions prior to the current observation session (because of variability in session length, the cross-session cumulative duration is expressed as a percentage of total interaction time over weeks)

Event history modeling has been used to reveal time-related information about the complex and dynamic microsocial processes between the members of a dyad and within the family (e.g., Griffin, 1993b; Vuchinich, Teachman, & Crosby, 1991). Because the past, present, and future of a process of development can be considered simultaneously, event history modeling is recognized as a tool permitting the examination of stability and transitional changes (Blossfeld & Rohwer, 2002). Because of its ability to incorporate covariates, event history analysis is useful for providing conceptual and empirical information regarding the explanatory factors of the stability and transitions of a dyadic system. For example, by using this analytic strategy, one may ask questions such as the following: "What is the likelihood that mother–infant dyads will engage in a symmetrical communication for 15 seconds if they are currently engaged in one?" "What are the factors that would affect this likelihood (e.g., infant sex and maternal parity)?" and "Would other factors make additional unique contributions to increasing and decreasing this likelihood (e.g., Is the contribution of communication history over and above that of maternal and infant individual characteristics)?" Therefore, by using an event history modeling strategy, we sought not only to examine how different levels of communication history (i.e., long-term, short-term, and recent) would exert their influences on increasing or decreasing the stability of and transitions from a current communication pattern after we partialled out maternal and infant individual characteristics (see details in the *Data Analysis* section) but also to evaluate the unique contribution of each of the three levels of history.

The Present Study

Even though early mother–infant communication undergoes constant organization and reorganization resulting from the co-regulatory actions of the two partners, a limited number of stable and recurring dyadic communication patterns are expected to emerge during the first 6 months of an infant's life. By employing a microgenetic study design, a relational coding system for dyadic communication patterns, and an event history modeling statistical strategy, in this study we attempted to (a) examine similarities and differences in the basic temporal characteristics (e.g., mean duration and rate of occurrence) of recurring stable dyadic patterns in mother–infant face-to-face communication and the differential profiles in their likelihood of maintaining stability or making transitions, (b) investigate whether the influence of a dyad's communication history on the stability of and transitions from a current communication pattern is over and above the influence of individual maternal and infant characteristics, and (c) evaluate the relative significance of dyadic communication histories differing in their temporal proximity to the ongoing communication pattern (i.e., long-term, short-term, and recent histories).

Method

Participants

Thirteen mother–infant dyads were recruited to participate in a 2-year longitudinal study of the development of mother–infant communication. All infants were full-term, had no major birth complications, came from intact families, and passed a hearing test at 6 months. Twelve of these mother–infant dyads were Caucasian, and 1 was African American. Six of

the infants were firstborn, and 8 were male. Nine of the mothers had bachelor's degrees, 2 had some college education, and 2 had their high school diplomas. Seven of the mothers were employed full time, 2 were employed part time, and 4 were homemakers at the time of recruitment. All research participants were recruited from a university community in the Midwest by letters or through birth announcements published in the local newspaper.

Procedure

Thirteen infants and their mothers were videotaped weekly in a laboratory playroom beginning when the infants were between 4 and 9 weeks ($M = 5.3$ weeks) of age and continuing until 24 weeks of age. A total of 210 sessions of mother–infant unstructured play were observed across all dyads. During the first 6-month visits, in one condition mothers were seated on a straight-back chair and held their infants in their laps. Mothers were instructed to play with their infants as they normally would at home without toys. The face-to-face interaction data from this lap condition during the first 6 months were analyzed for the current study. Most of the sessions lasted approximately 5 min, except when the infant became too fussy to continue (19 sessions). The duration of the session ranged from 80 to 300 s. Ninety-one percent ($n = 191$) of the total sessions were 5 min long, and 3.8% ($n = 8$), 1.9% ($n = 4$), 1.4% ($n = 3$), and 1.9% ($n = 4$) lasted for at least 4, 3, 2, and 1 min, respectively. Three remote-controlled cameras were used to film the play sessions. One camera was focused on the mother's upper body and the side of the infant, and the other two cameras were both focused on the infant's face and body. The outputs from the two cameras that had the best views of the mother and the infant were passed through a special effects generator to produce a split-screen image with a timer superimposed on the screen.

Behavioral Coding

As suggested by Brazelton and his colleagues (Brazelton et al., 1974), during face-to-face communication, "the behavior of any one member becomes a part of a cluster of behaviors which interact with a cluster of behaviors from the other member of the dyad. No single behavior can be separated from the cluster for analysis without losing its meaning in the sequence" (pp. 55–56). The cluster, sequence, and flow of actions within a dyad, rather than the discrete interactive behaviors enacted by individuals and directed to each other, were the basic unit of coding. After repeated viewing of videotapes and discussion of them by a research team, we developed a coding system to identify the recurring and stable patterns of mother–infant communication.¹ This coding system was designed to capture the patterns of dyadic engagement varying qualitatively in their co-regulation. Five different communication patterns emerged, namely, symmetrical, asymmetrical, unilateral, disruptive, and unengaged.

When both mother and infant are mutually engaged in communication, a symmetrical pattern arises. Asymmetrical communication occurs when one partner is actively engaging the other, and the other is passively observing the first. When one partner tries to engage the other, but the other

¹ The development of the coding system was based on the qualitative analysis of videotapes collected from 13 mother–infant dyads who engaged in social interaction in different conditions between the ages of 1 and 24 months. During the first 6 months, mothers and infants engaged in face-to-face communication without objects, and these communications were the data analyzed in the current study. For 2 years, a research team comprising graduate students, postdoctoral research associates, and faculty members met regularly to discuss the theoretical issues, derive definitions for coding categories, and apply the coding system to video coding (for details of the development of the coding system, see Fogel, Walker, & Dodd, 1996).

Table 2
Definitions and Examples of Mother–Infant Communication Patterns

Pattern of dyadic communication	Definition
Symmetrical	Symmetrical communication occurs when both mother and infant are mutually engaged and co-regulating. The dyad's actions are mutually coordinated and elaborated, and there is a joint focus of attention. Spontaneity and creativity are integrated into this co-constructed interchange process. An example is a peek-a-boo game between mother and infant. Another example is when the mother performs bicycling movements with the infant's legs and the infant moves his or her arms in a rhythmical pattern.
Asymmetrical	Asymmetrical communication occurs when one partner is actively elaborating engagement while the other is attentive but more passive, and there is a joint focus of attention. An example is when a mother dances her fingers like a butterfly in front of her infant, but the infant observes the mother's movement quietly and without much enthusiasm.
Unilateral	Unilateral communication occurs when one partner tries to engage the other, who is absorbed in his or her own activity and does not attend to the partner or respond to the partner's initiations. An example is an infant engrossed in thumb sucking while the mother tries to get the infant's attention by calling and bouncing the infant and by blowing air into his or her hair.
Disruptive	Disruptive communication occurs when the actions of one partner interrupt the other. An example is when a baby is sucking on his or her thumb intently and the mother forcefully grabs and removes the baby's hand from his or her mouth. The baby protests the mother's interruption with grimacing and fussing.
Unengaged	Mother and infant are not attending to each other and are involved in separate activities. An example is an infant intently fingering the teddy bear embroidered on his or her shirt while the mother is looking out the window.

does not attend to or respond to the partner's initiations, the dyadic pattern shown is unilateral communication. Disruptive communication occurs when the actions of one partner interrupt the other. An unengaged pattern is in evidence when partners are involved in separate activities (see Table 2 for definitions and examples). Because of the low frequencies of the disruptive and unengaged communication patterns, they were excluded from data analysis (see details in the Results section).

The coders were instructed to observe the second-to-second changes in the dynamics of mother–infant interaction on the basis of their holistic and qualitative impressions of the communication. The judgment of qualitative changes in co-regulatory communication patterns is based on a continuous mutual adjustment of actions between the two participants that are exhibited in multimodal channels (Fogel, 1993). The onset of a change detected in the pattern of mother–infant communication was recorded, and the temporal sequencing of the occurrence of communication patterns was preserved. Intercoder reliability was calculated for a randomly selected 14% of the sessions. Kappa was .65, and the percentage of agreement was 85% for reliability coding.

Data Analysis

Several models are available for event history analysis (for reviews, see Allison, 1984; Blossfeld & Rohwer, 2002; Palloni & Sorensen, 1990). Cox's proportional hazards model² is particularly useful in identifying the explanatory factors when the data are collected in a continuous-time format with multiple states (e.g., three communication patterns) and repeated events (e.g., several communication episodes by the same dyad; Allison, 1984; Griffin, 1995; Singer & Willett, 1991). Cox's models can be under-

stood as an analog of multiple regression analysis for use in examining the likelihood of continuation in or transition from an ongoing communication pattern.

In the present study, dyadic patterns of mother–infant communication were identified second by second. The duration of each episode of a communication pattern (measured in seconds) served as the dependent variable in the event history analysis. The temporal sequence of change in a communication pattern within each session was preserved for the derivation of communication history indices. Models were then built to examine the influence of covariates (e.g., infant sex and recent history) on event duration (i.e., the number of seconds elapsed for a given communication pattern), and this influence is expressed as transition rate. Transition rate (also known as hazard function, risk function, or failure rate) is the likelihood of a communication pattern's making a transition at any given point in time while it is still in the process of evolving. Therefore, transition rate is an index of the "propensity" for possible future events to occur, rather than of their realization (Blossfeld & Rohwer, 2002). In this study,

² The proportional hazards assumption refers to the effect of one covariate on a dependent variable that remains the same across time, which is tested by including the interactions between the duration of communication and the covariates. Following Griffin's (1993b) procedure, in this study we tested the proportional hazards assumption by examining the interactions between covariates and the natural log of the duration of the communication pattern. Significant interactions were included in the model to correct for the violation of the proportional hazards assumption (Blossfeld & Rohwer, 2002).

transition rate is the likelihood of future change in the communication pattern, that is, that transition out of an ongoing communication pattern will occur at a particular instant given that the dyad is still engaged in it. A high transition rate indicates a faster rate of change, a quick ending, or a short duration of the communication pattern. The survival function is an estimate of the probability of a dyad's engaging in a communication pattern lasting longer than a specified time given that a transition has not yet occurred. The last episode of mother–infant communication in each session was censored given the fact that the observation was terminated before the episode ended.

Because of the mutually exclusive and exhaustive design of the coding system, when a dyad is engaged in one of the communication patterns, it can make a transition into only one of two other competing communication patterns. Thus, a pair of transition-specific models was constructed for each communication pattern in the present study. In transition-specific event history analysis, each of the subsequent communication patterns is analyzed separately in a different model, and the communication pattern not being entered into in the transition is considered censored (Griffin, 1993a, 1995; Singer & Willett, 1991). By differentiating the subsequent pattern of communication, a type-specific transition rate is generated for each type of transition, and coefficients of the covariates are also estimated separately. The sum of all the type-specific transition rates is the overall transition rate. A simplified model of communication patterns can be created by combining models with transitions to different subsequent communication patterns (Allison, 1984). The significance of the difference between the overall simplified model and the sum of transition-specific models indicates the goodness of fit of the simplified model, which we used to select between the transition-specific and simplified (or combined) models in the present study.

Three types of covariates were included in the event history models: time-constant demographic variables (e.g., infant sex and maternal parity, which was dummy coded as primiparous or multiparous), a time-varying demographic variable (i.e., infant age in weeks), and time-varying dyadic communication history variables. Following Griffin (1993b), we calculated the autocorrelation at Lag 1 of the duration of the communication pattern in each observation session as a measure of overall serial dependency reflecting the overall consistency in the duration of mother–infant communication. This autocorrelation was included in the model as a way to control for the possible inflation in the coefficient estimates.³

The relative contributions of different levels of communication history to the likelihood of transition can be determined by a model-building strategy analogous to hierarchical regression. By applying a hierarchical modeling method, we entered the covariates into the model in sets according to a specified order to examine their relative contributions to the transition rate. The order of entry was determined by the covariates' time variability (i.e., time-constant or time-varying variables), time scale (macro or micro level), and temporal proximity (long-term, short-term, or recent history) in relation to the current communication pattern. The significance of covariates is determined by testing whether the population value of the estimated coefficient is different from zero after the influences of all other covariates in the model are partialled out. In the Cox model, coefficients are estimated by maximizing the partial likelihood function, indexed by $-2 \log$ likelihood, which indicates how and how much the covariates affect the distribution of the transition rate. The improvement in the prediction of transition rate by the inclusion of covariates can be assessed by comparing the difference in the values of $-2 \log$ likelihood between two nested models, which is distributed as chi-square with the degrees of freedom equal to the differences in the parameters of the two models. A significant chi-square value suggests an improvement of the new model over the previous one through the inclusion of additional covariates. For the final model, an overall chi-square value is a separate test of whether the coefficients (B) in the model are significantly different from 0. A significant overall chi-square value indicates that at least one coefficient is significantly different from 0.

Results

Temporal Characteristics of Dyadic Communication Patterns

During the first 6 months, the active agent in all of the observed instances of asymmetrical, unilateral, and disruptive communication was the mother. Three communication patterns accounted for most of the occurrences: symmetrical, asymmetrical, and unilateral. Disruptive behaviors were observed only once (for 2 s), occurring with 1 dyad in the sampled observations. Unengaged communication between mothers and their infants was extremely rare (10 occurrences for 158 s across all dyads). Because of the rare occurrence of disruptive and unengaged communication, these patterns were excluded from further analysis. Descriptive statistics for individual dyads are reported in Table 3.⁴

To understand the basic temporal characteristics of symmetrical, asymmetrical, and unilateral communication, we compared the total duration, mean duration, and rate of occurrence of the three communication patterns. For each of the communication patterns, the total duration was calculated as a percentage of the session for each individual dyad. The mean duration and the rate of occurrence (per minute) were also calculated for each session and aggregated separately for each dyad. Separate repeated measures analyses of variance were conducted with the three communication patterns as the within-subjects factor. The dependent variables in these analyses were, respectively, the total duration, the mean duration, and the rate of occurrence.

With respect to the total duration, the three communication patterns showed significant differences, Wilks's $\Lambda = 0.04$, $F(2, 11) = 135.15$, $p < .01$, $\eta^2 = .96$. Follow-up analyses revealed that mothers and their infants spent more time overall in unilateral communication ($M = 70.32\%$, $SD = 13.16$) than in symmetrical ($M = 17.97\%$, $SD = 14.86$) or asymmetrical ($M = 11.40\%$, $SD = 5.79$) communication. In terms of mean duration, the three communication patterns also differed significantly, Wilks's $\Lambda = 0.16$, $F(2, 11) = 29.68$, $p < .01$, $\eta^2 = .84$. Again, follow-up analyses revealed that the mean duration of each episode of unilateral communication ($M = 90.11$ s, $SD = 42.58$) was significantly

³ Pooling multiple observations from the same dyad in one analysis may create the potential problem of intercorrelations between episodes known as *autocorrelation*, which violates the independence assumption. The resolution is to include covariates that tap the characteristics of a dyad's preceding event history (Allison, 1984). As a result, the autocorrelation needs to be accounted for in the model to avoid the inflation in estimating coefficients (Griffin, 1993a, 1995; Griffin & Gardner, 1989). Following Griffin's procedure, we calculated the estimates for Lag 1 autocorrelation with the correction for small samples recommended by Huitema and McKean (1991). A value of zero was assigned to the sessions in which there were only 4 or fewer episodes of mother–infant communication. The average of the Lag 1 autocorrelations was .07 (range = $-.68$ to $.45$, $SD = .19$), which suggests that the durations of mother–infant communication patterns were only nominally autocorrelated.

⁴ Although variations were observed in the frequencies and mean durations of the three communication patterns, results from growth curve modeling demonstrated that there were no significant individual differences in the developmental trajectories of the symmetrical, asymmetrical, and unilateral communication patterns over the first 6 months, $\Delta\chi^2(2) = 0.61$ – 4.67 , *ns* (Hsu, Fogel, & Messinger, 1998).

Table 3
Frequency and Duration (in Seconds) of Symmetrical, Asymmetrical, and Unilateral Communication Patterns

Dyad	Total no. of sessions	Duration of session						Symmetrical						Asymmetrical						Unilateral											
		M		SD		n		M		SD		n		M		SD		n		M		SD		n		M		SD		n	
1	20	296.25	14.50	51	24.67	30.81	22.61	22.99	10.11	12.22	10.11	8.16	12.83	36.82	37.20	69.12	25.22	73	12.83	10.11	12.22	10.11	8.16	12.83	36.82	37.20	69.12	25.22	73		
2	18	295.44	18.12	25	16.16	21.31	8.22	13.41	7.22	10.50	7.22	9.40	10.64	38.89	33.70	82.27	15.55	64	10.64	10.50	10.50	9.40	10.64	38.89	33.70	82.27	15.55	64			
3	15	284.67	55.37	27	15.44	16.02	11.35	13.29	18.38	19.22	18.38	14.37	26.17	39.08	45.96	74.28	29.67	40	26.17	19.22	19.22	14.37	26.17	39.08	45.96	74.28	29.67	40			
4	16	295.63	17.50	16	21.88	20.97	8.57	13.28	12.46	16.00	12.46	8.71	15.01	67.63	67.23	82.72	24.04	30	15.01	16.00	16.00	8.71	15.01	67.63	67.23	82.72	24.04	30			
5	14	289.64	38.75	71	19.55	28.90	39.73	20.91	12.25	13.39	12.25	7.57	14.15	30.58	34.03	52.70	21.29	66	14.15	13.39	13.39	7.57	14.15	30.58	34.03	52.70	21.29	66			
6	19	300.00	0.00	18	10.50	5.08	3.60	3.87	40.64	28.49	40.64	19.86	28.95	63.76	59.58	75.02	28.31	41	28.95	28.49	28.49	19.86	28.95	63.76	59.58	75.02	28.31	41			
7	18	291.94	32.95	17	12.71	11.36	4.00	5.81	69.11	50.71	69.11	17.96	28.28	86.44	89.13	77.81	30.91	18	28.28	50.71	50.71	17.96	28.28	86.44	89.13	77.81	30.91	18			
8	16	288.44	46.25	63	22.32	2.09	34.73	29.87	9.61	10.31	9.61	12.33	13.97	28.59	34.63	52.94	34.76	56	13.97	10.31	10.31	12.33	13.97	28.59	34.63	52.94	34.76	56			
9	19	273.21	68.69	10	17.90	13.51	3.47	7.60	31.56	25.45	31.56	22.17	28.84	52.11	62.59	72.72	29.36	35	28.84	25.45	25.45	22.17	28.84	52.11	62.59	72.72	29.36	35			
10	15	299.47	2.07	43	14.37	13.94	15.44	15.41	16.96	15.63	16.96	11.22	13.31	46.00	49.69	73.29	18.20	50	13.31	15.63	15.63	11.22	13.31	46.00	49.69	73.29	18.20	50			
11	17	299.41	2.43	57	29.02	48.05	45.95	34.60	21.92	21.88	21.92	8.27	14.31	29.64	39.61	45.70	35.50	58	14.31	21.88	21.88	8.27	14.31	29.64	39.61	45.70	35.50	58			
12	14	285.71	43.27	64	16.50	16.08	29.07	24.27	16.35	13.61	16.35	6.22	13.98	27.09	27.85	64.71	23.47	67	13.98	13.61	13.61	6.22	13.98	27.09	27.85	64.71	23.47	67			
13	9	300.00	0.00	13	14.23	8.94	6.85	11.63	3.05	7.57	3.05	1.96	3.85	29.38	22.54	90.85	13.33	16	3.85	7.57	7.57	1.96	3.85	29.38	22.54	90.85	13.33	16			
M	16.15	292.29		36.54	18.10		17.97			18.84		11.40		44.59		70.32		47.23		18.84		11.40		44.59		70.32		47.23			
SD	2.91	7.88		22.25	5.21		14.86			11.37		5.79		18.14		13.16		18.83		11.37		5.79		18.14		13.16		18.83			

Note. The percentages of the sessions for communication patterns may not sum to 100 because of averaging, rounding, and the exclusion of the disruptive and unengaged communication patterns.

longer than those of either symmetrical ($M = 17.13$ s, $SD = 17.59$) or asymmetrical ($M = 12.07$ s, $SD = 9.02$) communication. The three communication patterns were also different in their occurrence rate, Wilks's $\Lambda = 0.11$, $F(2, 11) = 46.82$, $p < .01$, $\eta^2 = .90$. Follow-up analyses further showed that mothers and their infants engaged in more frequent unilateral ($M = 0.76$, $SD = 0.21$) communication per minute than symmetrical ($M = 0.52$, $SD = 0.34$) or asymmetrical ($M = 0.36$, $SD = 0.15$) communication. Taken together, these results suggest that the three naturally occurring communication patterns have different temporal characteristics, with unilateral communication occurring the most frequently and lasting the longest compared with symmetrical and asymmetrical communication.

To further illustrate the differences among symmetrical, asymmetrical, and unilateral communication, we performed an event history analysis with communication pattern as the covariate. It also revealed that mothers and their infants did not engage in symmetrical and asymmetrical communication as long as they engaged in unilateral communication ($Bs = .79$ and $.88$ for symmetrical and asymmetrical communication, respectively, $ps < .01$). The unilateral pattern of communication had a higher survival probability (see Figure 1A) and a lower transition rate (see Figure 1B) than those of symmetrical and asymmetrical communication.

Together, these findings demonstrate that the three communication patterns not only have different basic temporal properties in

terms of mean duration, occurrence rate, and total duration but also show distinctive profiles of development at a real-time level.

Influences of Person and History Variables on the Stability of and Transitions Between Communication Patterns

To understand the contributions of maternal and infant demographic variables to the development of an ongoing communication pattern, and the relative significance of each of the three levels of communication history in predicting the likelihood of transition and stability, we conducted a hierarchical event history analysis. For each of the three communication patterns, a separate transition-specific model was generated for each of the two possible subsequent communication patterns. For example, for symmetrical communication, two transition-specific models were constructed—one for a transition to asymmetrical communication and the other for a transition to unilateral communication. Hierarchical models were then built to investigate the contributions of each set of covariates.

Three pairs of hierarchical models were built. In each hierarchical model, the entry order of the covariates was as follows: (Step 1) time-constant person variables (i.e., infant sex and maternal parity) and time-varying variables (i.e., infant age and autocorrelation), (Step 2) a long-term history variable, (Step 3) short-term history variables, and (Step 4) recent history variables. All three pairs of transition-specific models were significant, overall $\chi^2s(10 \text{ or } 13, Ns = 77\text{--}353) = 42.66\text{--}134.58$, $ps < .01$, suggesting that the covariates made significant contributions in predicting transition rates. Details about findings from these models are presented in the following sections separately for symmetrical, asymmetrical, and unilateral communication.

Stability of and Transitions From Symmetrical Communication

Separate hierarchical event history models were constructed to reveal the transitional dynamics of shifting from a symmetrical communication pattern to an asymmetrical communication pattern and to a unilateral communication pattern.

Transitioning From Symmetrical to Asymmetrical Communication

Contributions of person and other variables. Results from the hierarchical event history modeling revealed that the likelihood of mother–infant dyads who were engaging in symmetrical communication transitioning to a subsequent asymmetrical communication was influenced by the characteristics of mother and infant (see Table 4). Specifically, the transition rate was reduced about 8.7% as the infant's age increased by 1 week, suggesting that as the infants got older, the dyads were more likely to maintain symmetrical communication for a longer period of time. Multiparous mothers and their infants were about 2.1 times more likely than first-time mothers and their infants to make a transition, which suggests that first-time mothers and their infants tended to maintain symmetrical communication for a longer period of time before exiting to asymmetrical communication (see Figure 2A1). Infant

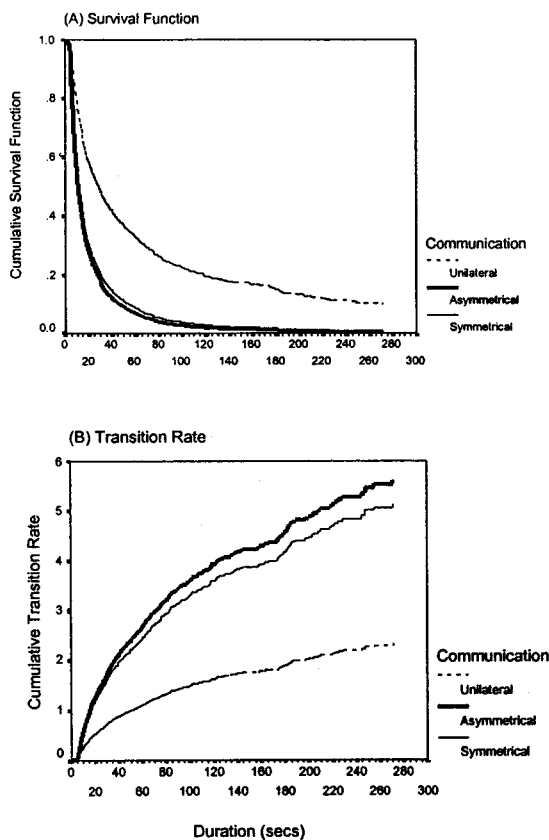


Figure 1. Profiles of cumulative transition rate and survival function for different communication patterns.

Table 4
Competing Transition-Specific Models of Transition Rate for Symmetrical Communication

Covariate	Subsequent communication pattern					
	Asymmetrical			Unilateral		
	<i>B</i> ^a	Exp(<i>B</i>) ^b	% of change ^c	<i>B</i>	Exp(<i>B</i>)	% of change
Step 1: Person and other variables						
Infant sex	.547	1.727	+172.7	-.298*	.742	+74.2
Infant age (in weeks)	-.091**	.913	-8.7	.056**	1.058	+5.8
Maternal parity	.719**	2.053	+205.3	-.217	.805	+80.5
Autocorrelation at Lag 1	.485	1.624	+62.4	-.535**	.586	-41.4
$\Delta\chi^2(4)$		27.239**			38.665**	
-2 log likelihood		728.285			3,604.465	
Step 2: Long-term history variable						
Cumulative symmetrical communication (% of cumulated total)	-.018*	.982	-1.8	.001	1.001	+0.1
$\Delta\chi^2(1)$		5.548*			0.082	
-2 log likelihood		722.737			3,604.382	
Step 3: Short-term history variables						
Cumulative duration of symmetrical communication	.002	1.002	+0.2	-.003	.997	-0.3
Cumulative duration of asymmetrical communication	.015**	1.015	+1.5	-.010**	.990	-1.0
Cumulative duration of unilateral communication	-.001	.999	-0.1	.004**	1.004	+0.4
$\Delta\chi^2(3)$		29.129**			33.180**	
-2 log likelihood		693.608			3,571.202	
Step 4: Recent history variables						
Pattern of immediately preceding communication	-1.071**	.343	+34.3	.509**	1.663	+166.3
Duration of immediately preceding communication	-.006	.994	-0.6	.003*	1.003	+0.3
$\Delta\chi^2(2)$		19.164**			15.511**	
-2 log likelihood		674.444			3,555.692	
Overall $\chi^2(10)$		106.029**			82.985**	
<i>n</i>		77			353	

Note. All durations were in seconds.

^a *B* is the estimated coefficient, which is interpreted as the predicted change in transition rate for a unit increase in the predictor. A positive sign with the coefficient indicates an increased likelihood of transition or a shortened duration of the communication pattern, whereas a negative sign represents a decreased likelihood of transition or a prolonged duration of the communication pattern. ^b Exp(*B*) indicates the influence of the predictor on the transition rate. ^c For continuous covariates, Exp(*B*) estimates the percentage change in likelihood with each unit change in the covariate by using the conversion formula $\text{Exp}(B) - 1 \times 100$. For dichotomous covariates, Exp(*B*) is a ratio of the likelihood of two variables, where the denominator is the reference category. Female, primiparous, and asymmetrical communication were the reference categories for infant sex, maternal parity, and pattern of immediately preceding communication, respectively.

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

sex and autocorrelation at Lag 1 did not exert significant influences on the likelihood of transitioning.

Contributions of communication history variables. After we controlled for the demographic variables and the autocorrelation, the inclusion of history variables in the order of long-term, short-term, and recent history improved the fit of the model (see Table 4).

With respect to long-term history, as the cumulative total duration of symmetrical communication across sessions increased by 1%, the transition rate was reduced about 1.8%, indicating that a suppressing effect was in process. As mother-infant dyads experienced more symmetrical communication over weeks, they were more likely to maintain the currently ongoing symmetrical communication. With respect to short-term history, whereas a 1-s

increase in the cumulative duration of asymmetrical communication within a session increased the transition rate by 1.5%, the cumulative durations of symmetrical and unilateral communication within a session had no significant effects on the transition rate. Thus, when dyads experienced more asymmetrical communication within a session prior to the onset of a currently ongoing symmetrical communication, they were more likely to make a transition back to an asymmetrical pattern of communication. With respect to recent history, the likelihood of mother-infant dyads transitioning from symmetrical to asymmetrical communication after having been engaged in unilateral communication was 34.3% of that after having been engaged in asymmetrical communication. In other words, when symmetrical communication was preceded by asymmetrical communication, mother-infant dyads were more

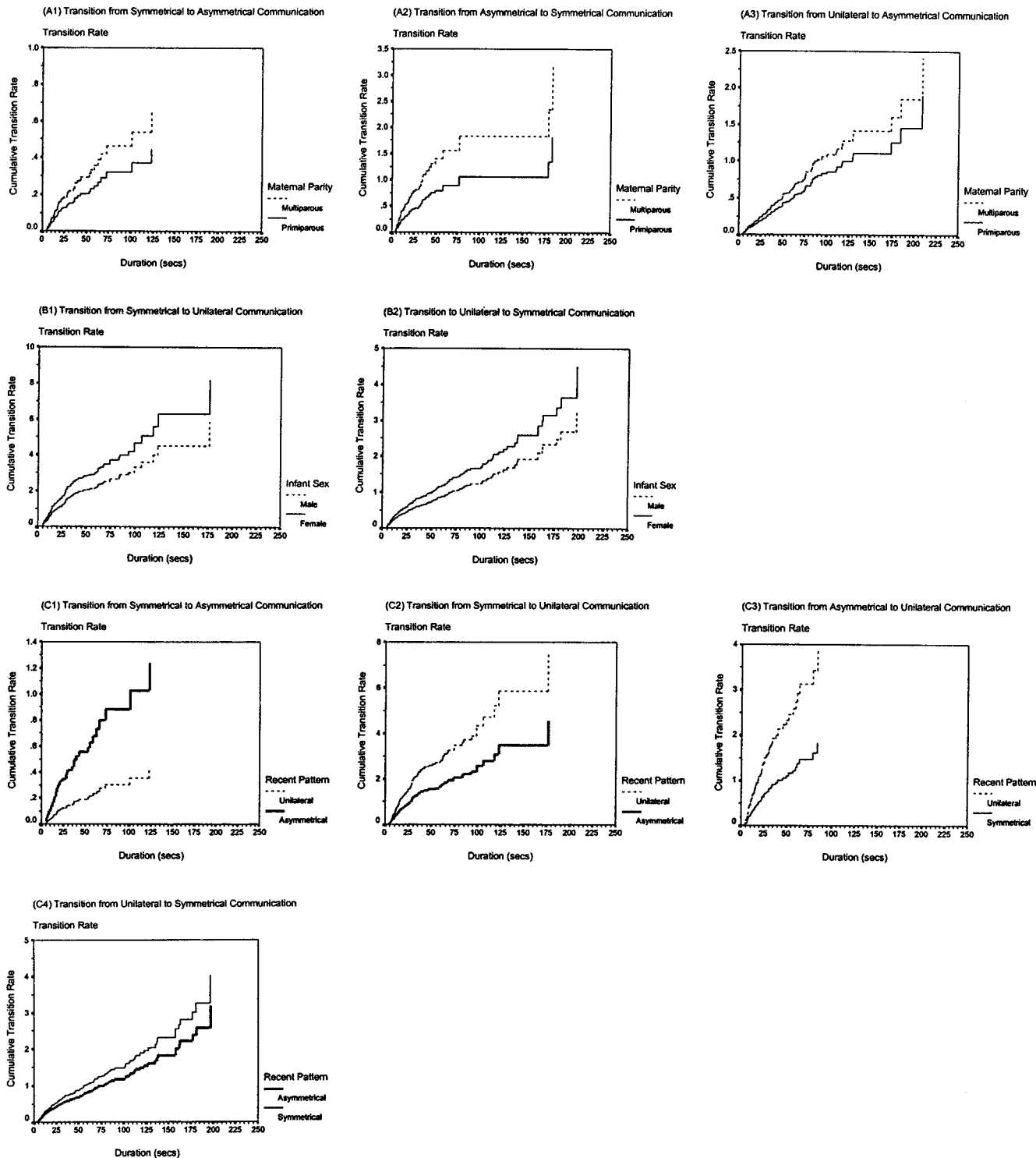


Figure 2. Profiles of cumulative transition rates for different communication patterns with transitions to different subsequent patterns, as influenced by maternal parity (Graphs A1 to A3), infant sex (Graphs B1 to B2), and the pattern of an immediately preceding communication episode (Graphs C1 to C4).

likely to make a transition back to asymmetrical communication than they were when symmetrical communication was preceded by unilateral communication (see Figure 2C1). However, the duration of the preceding communication pattern had no significant effect on the stability of the symmetrical communication pattern and the transition from the symmetrical to the asymmetrical communication pattern.

Relative contributions of history variables. The fact that the fit of the model improved significantly as each of the history variables was added to the model in the order of their temporal recency suggested that the influence of the more recent history was over and above that of the more distant history. Specifically, recent history variables made a significant contribution in predicting the likelihood of transition from a symmetrical to a subsequent asymmetrical communication pattern, a contribution greater than both that of the short-term history variables and that of the long-term history variable (see Tables 4 and 8). Therefore, the salience of the recency of the communication history in the stability of and transition from symmetrical communication was supported.

Transitioning From Symmetrical to Unilateral Communication

Contributions of person and other variables. Hierarchical event history analysis revealed that the likelihood of mother–infant dyads engaged in symmetrical communication making a transition to a subsequent unilateral communication was influenced by infant sex and age as well as by the autocorrelation at Lag 1 (see Table 4). Relative to mother–son dyads, mother–daughter dyads tended to stay in symmetrical communication for a longer period of time before transitioning to unilateral communication (see Figure 2B1). As the infants became older, the dyads were more likely to end symmetrical communication more quickly. Also, the consistency in the duration of symmetrical communication within a session decreased the likelihood of the dyads' exiting symmetrical communication. In other words, the variability in the duration of symmetrical communication within a session was associated with the continued progression of an ongoing symmetrical communication.

Contributions of communication history variables. After the demographic variables and the autocorrelation were controlled for, the inclusion of short-term and recent history variables, but not the long-term history variable, improved the fit of the model (see Table 4). With respect to the short-term history variables, the propensity of the dyads to maintain an ongoing symmetrical communication was likely to be increased by their experience with unilateral communication but decreased by their experience with asymmetrical communication. With regard to the recent history variables, similar patterns were found. It appeared that a preceding unilateral communication increased the likelihood of mother–infant dyads making a transition back to unilateral communication, whereas a preceding asymmetrical communication decreased this likelihood (see Figure 2C2).

Relative contributions of history variables. The addition of a long-term history variable of cumulative symmetrical communication across sessions did not improve the model in predicting the likelihood of transition from symmetrical communication. However, the fit of the model improved significantly as recent history variables were included in the model after the inclusion of short-

term history variables (see Tables 4 and 8). Thus, the salience of the recency of the communication history in the stability of and transition from symmetrical communication was supported.

Furthermore, to determine whether the two transition-specific models—namely, the transition from symmetrical to asymmetrical communication and the transition from symmetrical to unilateral communication—could be combined, and therefore whether a simplified model could be constructed, we performed a comparison analysis. Following the methods outlined by Allison (1984), we tested a model without the distinction between the subsequent communication patterns. The difference between the sum of the two log-likelihood values from the transition-specific models ($-2 \log \text{likelihood} = 4,230.14$) and the log-likelihood value from the simplified model ($-2 \log \text{likelihood} = 4,481.76$) was significant, $\Delta\chi^2(10) = 251.62$, $p < .01$. Therefore, the profiles of transition rate for the two transition-specific models were different, and the simplified model was not accepted.

Stability of and Transitions From Asymmetrical Communication

A second pair of hierarchical event history models was tested to reveal how and to what extent the stability of asymmetrical communication and the likelihood of transitioning from an asymmetrical communication pattern to symmetrical and unilateral communication patterns would be predicted by person variables and different levels of the history variables.

Transitioning From Asymmetrical to Symmetrical Communication

Contributions of person and other variables. Analysis revealed that even though the addition of demographic variables and the autocorrelation at Lag 1 did not jointly improve the model, maternal parity exerted a significant influence on the likelihood of mother–infant dyads transitioning from asymmetrical communication to symmetrical communication (see Table 5). Compared with first-time mothers and their infants, experienced mothers and their infants were 1.8 times more likely to make this transition (see Figure 2A2).

Contributions of communication history variables. After we controlled for demographic variables and the autocorrelation, the inclusion of the short-term and recent history variables, but not the long-term history variable, improved the fit of the model (see Table 5). With regard to short-term history, the propensity for the dyads to exit asymmetrical communication and transition to symmetrical communication was decreased by their experience with asymmetrical communication within a session but was increased by their experience with symmetrical communication. Even though the inclusion of recent history variables improved the fit of the model, none of the estimates for the individual variables was significant.

Relative contributions of history variables. The addition of a long-term history variable did not improve the model, whereas the addition of short-term and recent history variables did. However, the fact that the coefficients of the recent history variables were not significant suggested that the pattern and duration of a preceding mother–infant communication episode were not influential in prediction. It appeared that short-term history made the largest rela-

Table 5
Competing Transition-Specific Models of Transition Rate for Asymmetrical Communication

Covariate	Subsequent communication pattern					
	Symmetrical			Unilateral		
	<i>B</i> ^a	Exp(<i>B</i>) ^b	% of change ^c	<i>B</i>	Exp(<i>B</i>)	% of change
Step 1: Person and other variables						
Infant sex	.261	1.298	+129.8	.187	1.206	+120.6
Infant age (in weeks)	.018	1.018	+1.8	.033*	1.033	+3.3
Maternal parity	.604*	1.829	+182.9	-.122	.885	+88.5
Autocorrelation at Lag 1	-.133	.876	-12.4	-.728	.483	-51.7
$\Delta\chi^2(4)$		7.515			11.630*	
-2 log likelihood		1,075.256			1,591.599	
Step 2: Long-term history variable						
Cumulative asymmetrical communication (% of cumulated total)	.006	1.006	+0.6	-.023**	.977	-2.3
$\Delta\chi^2(1)$		0.327			6.836**	
-2 log likelihood		1,074.929			1,584.763	
Step 3: Short-term history variables						
Cumulative duration of symmetrical communication	.008**	1.008	+0.8	-.007**	.993	-0.7
Cumulative duration of asymmetrical communication	-.011**	.989	-1.1	.001	1.001	+0.1
Cumulative duration of unilateral communication	.001	1.001	+0.1	.004**	1.004	+0.4
$\Delta\chi^2(3)$		36.190**			18.685**	
-2 log likelihood		1,038.739			1,566.078	
Step 4: Recent history variables						
Pattern of immediately preceding communication	-.346	.707	+70.7	.754**	2.126	+212.6
Duration of immediately preceding communication	-.005	.995	-0.5	-.001	.999	-0.1
$\Delta\chi^2(2)$		6.780*			9.449**	
-2 log likelihood		1,031.959			1,556.629	
Overall $\chi^2(10)$		52.647**			42.664**	
<i>n</i>		113			172	

Note. All durations were in seconds.

^a *B* is the estimated coefficient, which is interpreted as the predicted change in transition rate for a unit increase in the predictor. A positive sign with the coefficient indicates an increased likelihood of transition or a shortened duration of the communication pattern, whereas a negative sign represents a decreased likelihood of transition or a prolonged duration of the communication pattern. ^b Exp(*B*) indicates the influence of the predictor on the transition rate. ^c For continuous covariates, Exp(*B*) estimates the percentage change in likelihood with each unit change in the covariate by using the conversion formula $\text{Exp}(B) - 1 \times 100$. For dichotomous covariates, Exp(*B*) is a ratio of the likelihood of two variables, where the denominator is the reference category. Female, primiparous, and symmetrical communication were the reference categories for infant sex, maternal parity, and pattern of immediately preceding communication, respectively.

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

tive contribution to the stability of asymmetrical communication and the likelihood of a mother–infant dyad making a transition from asymmetrical to symmetrical communication (see Tables 5 and 8).

Transitioning From Asymmetrical to Unilateral Communication

Contributions of person and other variables. Results revealed that demographic variables and the autocorrelation at Lag 1 influenced the likelihood of a mother–infant dyad engaged in asymmetrical communication transitioning to unilateral communication (see Table 5). As the infants grew older, the dyads were less likely to stay in an asymmetrical pattern of communication before exiting to unilateral communication.

Contributions of communication history variables. After we controlled for person variables and the autocorrelation, the inclusion of history variables at all three levels improved the fit of the model (see Table 5). With respect to long-term history, the more experience the dyads had with asymmetrical communication across sessions, the more likely they were to stay in asymmetrical communication before transitioning into unilateral communication. In terms of short-term history, the likelihood of the dyads exiting asymmetrical communication was decreased by their prior experience with symmetrical communication within a session but was increased by their experience with unilateral communication. Similar patterns were found with respect to recent history. Whereas a preceding unilateral communication increased the likelihood of a transition, a preceding symmetrical communication

decreased this likelihood (see Figure 2C3). Nevertheless, the duration of the preceding communication pattern had no significant effect on the transition rate.

Relative contributions of history variables. The addition of the long-term history variable improved the prediction of the stability of and transition from asymmetrical communication. The inclusion of the short-term history variables showed further improvement of the prediction, indicating that short-term history was more influential than long-term history. Furthermore, the influence of the pattern and duration of an immediately preceding mother–infant communication episode was over and above the influence of short-term history in prediction (see Table 5). Together, these findings demonstrate the importance of the recency of the communication history in determining the stability of asymmetrical communication and the likelihood of a transition from it to unilateral communication.

Finally, using the same procedure outlined previously, we made a comparison to determine whether a simplified model was sufficient. The sum of the log likelihood values from the two transition-specific models ($-2 \log \text{likelihood} = 2,588.59$) was compared with the log likelihood value from the combined model ($-2 \log \text{likelihood} = 2,743.18$). A significant difference was found, $\Delta\chi^2(10) = 154.59, p < .01$. Therefore, the combined model was rejected, indicating that the profiles of the transition rates for the two transition-specific models were different.

Stability of and Transitions From Unilateral Communication

Results from the analysis of the proportional hazards assumption revealed that the covariates of maternal parity, within-session cumulative duration of unilateral communication, and pattern of immediately preceding communication did not continue to have the same influence on the transition rate of unilateral communication as its duration increased. Therefore, the interactions between the duration of unilateral communication and each of these variables were included in the model to correct for the violation of the assumption.

Transitioning From Unilateral to Symmetrical Communication

Contributions of person and other variables. Analysis demonstrated that the likelihood of mother–infant dyads engaged in unilateral communication making a transition to symmetrical communication was significantly influenced by infant sex and age as well as by the autocorrelation at Lag 1 (see Table 6). Specifically, the likelihood of the mother–daughter dyads transitioning from unilateral to symmetrical communication was about 1.5 times that of the mother–son dyads, which suggests that mother–son dyads tended to stay in unilateral communication longer than mothers and their baby girls (see Figure 2B2). As the infants grew older, the dyads ended unilateral communication faster. The consistency in the duration of unilateral communication within a session enhanced the likelihood of the dyads shifting from unilateral to symmetrical communication. Stated differently, the variability in the duration of unilateral communication was associated with a quicker ending of unilateral communication.

Contributions of communication history variables. After we controlled for person variables and the autocorrelation, both short- and long-term communication history variables, but not recent history variables, improved the fit of the model (see Table 6). With respect to long-term history, the likelihood of the dyads making a transition from unilateral to symmetrical communication was decreased by their experience with unilateral communication across sessions. With regard to short-term history, the likelihood of the dyads making a transition was increased by their experience with symmetrical communication but was decreased by their experience with asymmetrical communication. Furthermore, the increase in the interaction between the duration of current unilateral communication and the cumulative duration of unilateral communication increased the transition rate, demonstrating a greater influence of the cumulative duration of unilateral communication on the likelihood of transition from the current communication pattern as its duration increased. With regard to recent history, a preceding symmetrical communication increased the likelihood of mother–infant dyads moving from unilateral to symmetrical communication, whereas a preceding asymmetrical communication decreased it. In other words, as was the case with short-term history, the dyads tended to shift back to symmetrical communication faster when unilateral communication was preceded by symmetrical communication than when it was preceded by asymmetrical communication (see Figure 2C4). An increase in the interaction between the duration of unilateral communication and the pattern of the immediately preceding communication increased the transition rate, demonstrating that the influence of the immediately preceding pattern of communication on the probability of transitioning from unilateral communication increased as the duration of unilateral communication increased. Nevertheless, although the estimates for the pattern of the immediately preceding communication and its product with the duration of unilateral communication were significant, they did not improve the fit of the model.

Relative contributions of history variables. Results showed that long-term history contributed significantly to the prediction of transition rate, and the addition of short-term history variables further improved this prediction. However, the knowledge about recent history did not make a further contribution to the prediction of the likelihood of transition (see Table 6). Therefore, the role of the recency of the dyad's communication history in the stability of and transition from unilateral communication was partially supported.

Transitioning From Unilateral to Asymmetrical Communication

Contributions of person and other variables. Analysis showed that person variables and the autocorrelation at Lag 1 made significant contributions to the likelihood of a transition from unilateral to asymmetrical communication (see Table 6). Specifically, as the infants became older, the dyads were more likely to remain in unilateral communication before exiting to asymmetrical communication. Multiparous mothers and their infants were 6.4 times more likely than primiparous mothers and their infants to make such a transition (see Figure 2A3). Also, an increase in the interaction between the duration of unilateral communication and maternal parity reduced the transition rate, indicating that the influence of maternal parity on the likelihood of transition increased as

Table 6
Competing Transition-Specific Models of Transition Rate for Unilateral Communication

Covariate	Subsequent communication pattern					
	Symmetrical			Asymmetrical		
	<i>B</i> ^a	Exp(<i>B</i>) ^b	% of change ^c	<i>B</i>	Exp(<i>B</i>)	% of change
Step 1: Person and other variables						
Infant sex	-.372*	.689	+68.9	.272	1.312	+131.2
Infant age (in weeks)	.063**	1.065	+6.5	-.070**	.932	-6.8
Maternal parity	.164	1.179	+117.9	1.863**	6.441	+644.1
Ln(Duration) × Maternal Parity ^d	-.095	.910	-0.9	-.500**	.606	-39.4
Autocorrelation at Lag 1	.932**	2.539	+153.9	1.026**	2.789	+178.9
Δχ ² (5)		55.503**			51.804**	
-2 log likelihood		2,942.052			1,598.419	
Step 2: Long-term history variable						
Cumulative unilateral communication (% of cumulated total)	-.018**	.982	-1.8	.027**	1.028	+2.8
Δχ ² (1)		31.046**			29.096**	
-2 log likelihood		2,911.007			1,569.223	
Step 3: Short-term history variables						
Cumulative duration of symmetrical communication	.004**	1.005	+0.5	.002	1.002	+0.2
Cumulative duration of asymmetrical communication	-.014**	.986	-1.4	.009**	1.009	+0.9
Cumulative duration of unilateral communication	.005	.995	+0.5	-.008	.992	-0.8
Ln(Duration) × Cumulative Duration of Unilateral Communication ^d	.003*	1.003	+0.3	.002	1.002	+0.2
Δχ ² (4)		27.572**			21.156**	
-2 log likelihood		2,883.435			1,548.167	
Step 4: Recent history variables						
Pattern of immediately preceding communication	-1.365*	.255	+25.5	.598	1.818	+181.8
Duration of immediately preceding communication	-.002	.998	-.02	-.001	.999	-.01
Ln(Duration) × Pattern of Immediately Preceding Communication ^d	.351*	1.421	+42.1	-.081	.922	-7.8
Δχ ² (3)		6.557			2.879	
-2 log likelihood		2,876.877			1,545.288	
Overall χ ² (13)		107.255**			134.576**	
<i>n</i>		289			163	

Note. All durations were in seconds.

^a *B* is the estimated coefficient, which is interpreted as the predicted change in transition rate for a unit increase in the predictor. A positive sign with the coefficient indicates an increased likelihood of transition or a shortened duration of the communication pattern, whereas a negative sign represents a decreased likelihood of transition or a prolonged duration of the communication pattern. ^b Exp(*B*) indicates the influence of the predictor on the transition rate. ^c For continuous covariates, Exp(*B*) estimates the percentage change in likelihood with each unit change in the covariate by using the conversion formula Exp(*B*) - 1 * 100. For dichotomous covariates, Exp(*B*) is a ratio of the likelihood of two variables, where the denominator is the reference category. Female, primiparous, and symmetrical communication were the reference categories for infant sex, maternal parity, and pattern of immediately preceding communication, respectively. ^d These interactions were included in the model because they did not meet the proportional hazards assumption described in Footnote 2.

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

unilateral communication was unfolding. An increase in the autocorrelation of the duration of unilateral communication at Lag 1 increased the likelihood of transition, suggesting that the consistency in the duration of unilateral communication enhanced the likelihood of the dyads exiting unilateral communication and entering asymmetrical communication. In other words, the variability in the duration of unilateral communication was associated with its continuation.

Contributions of communication history variables. After the contributions by person variables and the autocorrelation were

partialled out, the inclusion of variables reflecting both long- and short-term history, but not recent history, improved the fit of the model (see Table 6). With regard to long-term history, the more time the dyads spent in unilateral communication across sessions, the more likely it was that they would make a faster transition from unilateral to asymmetrical communication. With respect to short-term history, the more prior experience the dyads had with asymmetrical communication within a session, the more quickly they transitioned back to asymmetrical communication.

Relative contributions of history variables. Examination of changes in the fit of the model after the addition of each level of the history variables showed that long-term history contributed significantly to the prediction of the likelihood of transition. The contribution of short-term history variables was over and above the contribution of long-term history. However, the recent variables did not make an additional contribution to prediction (see Tables 6 and 8). Therefore, the role of the recency of the communication history in the stability of and transition from unilateral communication was partially supported.

Finally, we also made a comparison to determine whether the two transition-specific models could be combined. Using the same procedure outlined previously, we summed the log likelihood values from the two competing risks models ($-2 \log \text{likelihood} = 4,422.17$) and compared them with that for the combined model ($-2 \log \text{likelihood} = 4,970.67$). A significant difference was found, $\Delta\chi^2(13) = 548.50, p < .01$. The two transition-specific models were judged to be distinctively different, and thus the simplified model was not accepted.

Summary of Findings on Influence of Communication History

To summarize the findings on the different levels of communication history, we inspected the overall patterns in the results from the three pairs of transition-specific models. First, the pattern, rather than the duration, of the recent communication history made a significant contribution to the stability of a communication pattern and the likelihood of a transition from it. The three levels of history variables made unique contributions to the prediction of

the likelihood of a mother–infant dyad transitioning out of a current communication pattern. Specifically, the contribution of recent history was greater than the contribution of short-term history variables, which was greater than the contribution of the long-term history variable (see Table 7).

Close inspection of the patterning in the direction of the prediction made by recent history showed that recent history had both augmenting and suppressing effects on the self-organization of the dyadic communication system. When the current communication pattern was preceded by a pattern that was the same as the subsequent pattern, the likelihood of a transition from the current pattern was increased. Thus, a faster transition from the current pattern to a subsequent communication pattern was observed. In contrast, when the current communication pattern was preceded by a pattern that was different from the subsequent pattern, the likelihood of a transition from the current pattern was suppressed. As a result, the current communication pattern was more stable, lasted longer, and made a slower transition to the subsequent communication pattern (see Table 7). A similar trend was also observed in the influence of short-term history on the stability of and transition from the communication patterns—both an augmenting effect and a suppressing effect were found. Experience with a communication pattern prior to the onset of the current communication pattern consistently increased the likelihood of transition to the prior pattern of communication but decreased the dyad’s chances of moving to a different pattern of communication (see Table 7). With respect to long-term history, a suppressing effect on the self-organization of the dyadic system prevailed. It appears that as dyads became more experienced with a communication pattern over weeks, the lower the likelihood was that mothers and their

Table 7
Summary of Findings: Influence of Communication History on the Transition Rate of Current Communication Pattern

Level of history	Communication pattern		Communication history		
	Current	Subsequent	Symmetrical	Asymmetrical	Unilateral
Long term	Symmetrical	Asymmetrical	↓	—	—
		Unilateral	<i>ns</i>	—	—
	Asymmetrical	Symmetrical	—	<i>ns</i>	—
		Unilateral	—	↓	—
	Unilateral	Symmetrical	—	—	↓
		Asymmetrical	—	—	↑
Short term	Symmetrical	Asymmetrical	<i>ns</i>	↑	<i>ns</i>
		Unilateral	<i>ns</i>	↓	↑
	Asymmetrical	Symmetrical	↑	↓	<i>ns</i>
		Unilateral	↓	<i>ns</i>	↑
	Unilateral	Symmetrical	↑	↓	<i>ns</i>
		Asymmetrical	<i>ns</i>	↑	<i>ns</i>
Recent	Symmetrical	Asymmetrical	—	↑	↓
		Unilateral	—	↓	↑
	Asymmetrical	Symmetrical	<i>ns</i>	—	<i>ns</i>
		Unilateral	↓	—	↑
	Unilateral	Symmetrical	↑	↓	—
		Asymmetrical	<i>ns</i>	<i>ns</i>	—

Note. ↑ represents an augmenting effect or a significant positive influence of communication history on the transition rate of the current communication pattern, whereas ↓ represents a suppressing effect or a significant negative influence; *ns* indicates that the improvement was not statistically significant, whereas a dash indicates that analysis was not available.

infants would make a transition out of an ongoing communication with the same pattern (see Table 7).

Summary of Findings on Relative Contributions of Different Levels of Communication History

To provide a better picture of the contribution of each level of communication history to the prediction of the stability of and likelihood of transition from a current communication pattern, we have summarized the relative significance of each of the levels of communication history in Table 8. Overall, all three levels of communication history shaped the stability of communication patterns and the likelihood of transition from those patterns, with the communication history that was temporally closer to the current pattern exerting more influence. However, there were a few exceptions. The recent history did not exert a greater influence on the likelihood of transition from unilateral communication, which suggests that the recency principle of communication history did not always apply to unilateral communication. Furthermore, the long-term history did not exert a significant effect on the likelihood of transition from symmetrical to unilateral communication and from asymmetrical to symmetrical communication.

Discussion

Our purpose in this study was to unravel the relational, dynamical, and historical nature of mother–infant face-to-face communication during the first 6 months by examining the stability of and transitions between mother–infant face-to-face communication patterns at both a real-time (i.e., moment to moment) and a developmental-time (i.e., from one week to the next) level. Results from the present study extended the research on early mother–infant communication in three main ways. First, distinct patterns of dyadic relational communication were directly evaluated on the basis of observers' qualitative judgments of the level of mother and infant co-regulation in real time. This coding strategy appears to be ecologically valid in terms of its superiority in detecting behavioral configurations and tracking interaction flows. Concepts such as attunement (Stern, 1984) and contour vitality (Stern, 1999), which delineate the intersubjectivity and the qualitative aspect of mother–infant social experience, are more likely to be captured by a coding system that uses the dyad as the basic unit of

analysis. Second, an event history modeling of the transitional dynamics of communication patterns adds to our understanding about the stability of and transitions between mother–infant communication patterns in early infancy by taking account of the duration of communication. This statistical analysis goes beyond the mere sequencing of dyadic states and simultaneously considers information from the past, the present, and the future, which provides a systematic way of examining the dynamic self-organization of mother–infant communication. Finally, the contribution of the three different levels of communication history, varying in temporal proximity to the currently evolving communication pattern, to the augmenting and suppressing effects on the self-organization of communication patterns was assessed directly. The relative significance of communication history in determining the stability of communication patterns and the likelihood of transitions between them was evaluated systematically and in depth. This microhistorical analysis helps to extend our understanding of the development of a communication system by connecting its evolving process at a real-time level with its change at a developmental-time level.

Early Communication Patterns Show Differential Stability and Transitions

We found that mothers and infants spent their time in three distinct and regularly recurring communication patterns during the first 6 months of the infants' lives, namely, symmetrical, asymmetrical, and unilateral communication. Trained observers reliably detected these communication patterns, which varied qualitatively in whether and how the mother and infant co-regulated each other from a continuous flow of face-to-face interaction. In a dynamic systems conceptualization, these communication patterns appear to reflect three "attractors" (cf. Fogel & Thelen, 1987; Thelen & Smith, 1994) of a face-to-face communication system in early infancy.

Mothers and their infants spent more time in a unilateral pattern of communication, during which mothers actively engaged their inattentive infants. Once they were in this communication pattern, they stayed in it for a relatively longer period of time, indicating a higher level of stability of this attractor. In contrast, symmetrical and asymmetrical patterns of communication tended to be short-

Table 8

Summary of Findings: Unique Contribution of Communication History to the Transition Rate of Current Communication Pattern

Communication pattern		Level of communication history		
Current	Subsequent	Long-term	Short-term	Recent
Symmetrical	Asymmetrical	+	+	+
	Unilateral	<i>ns</i>	+	+
Asymmetrical	Symmetrical	<i>ns</i>	+	+
	Unilateral	+	+	+
Unilateral	Symmetrical	+	+	<i>ns</i>
	Asymmetrical	+	+	<i>ns</i>

Note. + represents a significant improvement of the nested model over the previous one, indicating that a specific level of communication history made an additional contribution to the prediction of transition rate that was over and above that of the previous level; *ns* indicates that the improvement was not statistically significant.

lived and had a higher chance of being transitioned from, which suggests that they may be less stable attractors during the first 6 months of an infant's life. Our finding that mothers and their infants under 6 months of age spent about 18% of the time in symmetrical communication is within the range from 15% to 24% reported by Silvén (2001) and is consistent with Tronick and Cohn's (1989) report that even though mother and infant are co-regulated during face-to-face communication, the proportion of time the mother and infant are coordinated during face-to-face interaction in the first 6 months is small (30% of the time in their study). Also, the finding that mothers were the active agents in asymmetrical and unilateral communication is consistent with results from Cohn and Tronick's (1988b) study showing that before 9 months of age, mothers, not infants, initiate face-to-face interaction.

Each of the three co-regulatory communication patterns showed a distinct profile of stability and likelihood of transition. Results from the event history analysis revealed that there was a 50% chance of mothers and their infants making a transition once they had engaged in a symmetrical communication for about 12 s ($M = 18$ s, $SE = 0.58$, range = 3–255 s), in an asymmetrical communication for about 10 s ($M = 11$ s, $SE = 0.65$, range = 1–229 s), and in a unilateral communication for about 31 s ($M = 70$ s, $SE = 2.26$, range = 2–271 s), indicating that communication attractors varied in their dynamic stability. These results are also consistent with Tronick and Cohn's (1989) finding that during early face-to-face communication, mothers and their infants shift between matching and nonmatching states. However, the transition rate between matching and nonmatching states in their study was once every 3–5 s. This difference could be due to the coding method (dyadic coding vs. scaling approach) and experimental condition (baby in mother's lap vs. in an infant seat).

Although symmetrical communication cannot be sustained for long, the coordinated and co-regulated involvement between mother and infant has implications for infant development in various domains. For example, infants are more likely to utter speechlike vocalizations during symmetrical communication than during asymmetrical and unilateral communication in the first 6 months (Hsu & Fogel, 2001). Despite the asymmetry and unidirectionality of these latter patterns, infants' experience with them may also serve critical developmental functions. For example, Silvén (2001) found that in a mother–infant–object triadic interaction context, longer durations of infant-initiated unilateral communication at 6 months predicted higher levels of infant vocabulary comprehension at 12 months. Taken together, the available evidence suggests that different co-regulatory communication patterns appear to be differentially associated with different domains of infant development. Future research is needed to discern the role and significance of the temporal characteristics and transitional dynamics of mother–infant communication patterns in later development.

Furthermore, the variability (or consistency) in the length of the communication episodes within a session is indicated by the Lag 1 autocorrelation of the duration of the communication pattern, which reflects a global history of the dyadic communication. We found that the variability/consistency in the duration of asymmetrical communication makes no significant contribution to the likelihood of transition from asymmetrical communication. However, the variability/consistency in the duration of symmetrical and

unilateral communication has differential effects on their transition dynamics. Whereas the consistency in the duration of symmetrical communication facilitates its stability before a transition to unilateral communication, the consistency in the duration of unilateral communication heightens its likelihood for transition. It appears that the consistency in the duration of symmetrical and unilateral communication exerts a stabilizing effect and a destabilizing effect, respectively, on their stability.

Finally, caution needs to be exercised with regard to the issue of statistical nonindependence resulting from multiple observations of the same dyad. In the present study, by including the Lag 1 autocorrelation within a session in the modeling, we attempted to control for the inflation in estimates. However, several different strategies have also been employed to address the nonindependence issue in repeated measures designs. Space limitations prevent us from discussing these alternatives here. Interested readers are referred to works by Allison (1984) and Singer and Willett (1991).

Stability of and Transitions Between Early Communication Patterns Are Influenced by Person Variables

In the present study, we replicated previous research showing that characteristics of the mother (i.e., parity) and the infant (i.e., sex and age) influenced the stability of and transitions between communication patterns during the first 6 months. Each of these factors is discussed separately in the following sections.

Maternal Parity

In contrast to first-time mothers and their infants, experienced mothers and their infants were less likely to remain in an attractor state and showed a heightened propensity to transition between symmetrical and asymmetrical communication and from unilateral to asymmetrical communication. It appears that mothers with more child-caring experience and their infants are likely to end a communication attractor more quickly. Mothers with more caregiving experience feel not only efficacious in parenting (Fish & Stifter, 1993) but also more positive and sensitive to their infants' signals (Freeburg & Lippman, 1986; Moore et al., 1997). Therefore, multiparous mothers may employ more frequent and different strategies for regulating infants' attention and affect, which, in turn, result in the shorter bouts of interaction between communication patterns. This hypothesis, nevertheless, needs to be empirically tested.

Infant Sex

Mother–son and mother–daughter dyads demonstrated significantly different propensities toward stability and transitions in communication patterns. Compared with mother–daughter dyads, mothers and their sons found it difficult to exit a unilateral pattern of communication, but once they achieved a symmetrical pattern of communication, they tended to remain in this attractor state for a longer period of time. These findings are consistent with the literature showing that coordination and matching of interactive behaviors is greater between mothers and their male infants (Malatesta & Haviland, 1982; Tronick & Cohn, 1989) even though it is

more difficult for mother–son dyads than for mother–daughter dyads to achieve such a coordinative state (Weinberg, Tronick, Cohn, & Olson, 1999). It has been suggested by Weinberg and her colleagues (1999) that boys experience greater difficulty than girls in self-regulation and that, therefore, it takes longer for them to get to a mutually engaged state (i.e., they remain longer in unilateral communication).

Infant Age

Age is not only an index of infant cognitive and physical maturity but also a crude indicator of communication history between mother and infant. As the infants grew older, the mother–infant dyads were more likely to stay longer in a symmetrical communication attractor before transitioning to asymmetrical communication, whereas the dyads were less likely to stay in this attractor before transitioning to unilateral communication. Similarly, although infant age increases the likelihood of transition from asymmetrical to unilateral communication and from unilateral to symmetrical communication, it reduces the likelihood of transition from unilateral to asymmetrical communication. Together, these findings suggest that with age, mother–infant dyads are less likely to engage in asymmetrical communication, tend to stay in unilateral communication only briefly, and show a propensity to return to symmetrical communication. This emergent pattern suggests that with age, symmetrical communication becomes a more stable and deeper communication attractor in the developmental landscape.

Transformations in dyadic communication with age may be due to developmental changes in infants. For example, during asymmetrical communication, infants gaze at their mothers and show reduced or no movements in their extremities. A young infant who is attentive but unengaged suggests a pattern of obligatory looking, an inability to self-regulate attention (Ruff & Rothbart, 1996). Attention without active participation may also reflect an older infant's emotional states of boredom or interest (Izard, 1977). Undoubtedly, maternal interactive behaviors would be altered differently by an infant experiencing boredom, looking obligatorily, or displaying a covert expression of interest. Alternatively, developmental change in dyadic communication with age may be an outcome of repeated experience with previous communication. From a dynamic systems perspective, the explanation for a particular pattern of dyadic communication cannot rest entirely on a description of individual developmental changes and individual characteristics. Additional critical information is provided by the emergent history arising from self-organizing processes within the system—they exist by virtue of the system's intrinsic dynamics (Fogel, 1993; Thelen & Smith, 1994). Dynamic systems of interpersonal relationships, in other words, form their own history of what occurs between two people, a history that is unique to that relationship and that acts as a constraint on the future unfolding of that relationship. We discuss this alternative interpretation of the dyadic communication history in the following section.

Stability of and Transitions Between Early Communication Patterns Are Also Influenced by Dyadic History

Our findings clearly demonstrated that the dyadic communication history exerted an influence on the stability of and the tran-

sitions between mother–infant communication patterns in early infancy even after we controlled for the contributions of maternal (e.g., experience in child care as indexed by parity) and infant (e.g., age and sex) characteristics. The influence of dyadic history on the stability of and transitions between mother–infant face-to-face communication patterns is over and above the influence of infant age, a marker for biological maturation, which demonstrates that the dynamics of self-organization of face-to-face communication in early infancy is not simply driven by maturation. That some of the observed effects are relatively small may be because the second was used as the scaling unit in measuring the duration of communication patterns. Evidently, a first-order Markov model, in which the influence on the changes in dyadic communication is limited to the immediately previous state (often a 0.25- or 1-s interval; see Cohn & Tronick, 1988b), is not sufficient to account for the temporal dynamics in mother–infant communication.

Inspection of the effects of different levels of communication history on the stability of and transitions from a currently evolving communication pattern shows a consistent pattern of suppression and augmentation. With respect to recent history, it appears that previous experience in a communication attractor exerts a “pull” effect, resettling the system back into a familiar pattern. A similar trend was also observed in the influence of short-term history on the self-organization of the dyadic system. The accumulated duration of a communication pattern shortens the duration of the ongoing communication pattern and pulls the attractor back into the same communication pattern as before. This phenomenon of moving back to a historically existing communication pattern suggests a consolidation effect of mother–infant dyads' repeated experience within a communication attractor. This consolidation effect also occurs by suppressing transition when the ongoing communication shifts to a pattern that is different from the earlier one experienced by the dyad. The influence of long-term history on the self-organization of the communication system is primarily through the effect of suppression. In other words, repeated experience in a communication attractor over developmental time (e.g., weeks) facilitates its stability in real time (i.e., moment to moment) by reducing the likelihood of transition. These findings demonstrate that dynamic self-organization processes emerge within the dyad from the interactions between mother and infant.

Narrative descriptions of maternal and infant behavior during early communication delineate a gradual build-up process of initiation, acceleration, peak, deceleration, and withdrawal within an episode of dyadic communication (Brazelton et al., 1974; Trevarthen, 1977). In this study, the stability of and transitions within early dyadic communication were scrutinized in its flow over time as it unfolded from one moment to the next across weekly sessions. Our findings suggest that dyadic communication attractors are also maintained and routinized by previous experience. However, just as the history of individuals or societies can never repeat itself exactly, the knowledge of the prior history of mother–infant communication can only inform but not completely predict the dynamic stability of the current pattern of mother–infant communication. Because there is always ongoing creativity, elaboration, extension, and new emergence during co-regulatory processes in dyadic communication, the transformed communication pattern further serves as a dynamic context for the development of an enduring relationship between the parent and child (Lollis & Kuczynski, 1997).

Relative Influence of Communication History on Early Communication Is Determined by Its Recency

Communication histories varying in temporal proximity to the ongoing communication pattern further showed differential effects on the self-organization of dyadic systems. Overall, the recency of the communication history determines the relative significance of its effect. Recent history (i.e., the preceding communication episode) made a greater contribution to the stability of and transitions from a communication pattern than did short-term history (i.e., past experience within a session). The effect of short-term history was also greater than that of long-term history (i.e., past experience over weeks). However, exceptions were observed with unilateral communication. Recent history was not more influential than short-term and long-term history on the stability of and transitions from unilateral communication. Furthermore, long-term history accumulated over weeks also exerts a significant influence on the self-organization dynamics of a dyadic system except when the dyads transition from symmetrical to unilateral communication and from asymmetrical to symmetrical communication.

How does past interpersonal experience exert an influence on current interaction? One explanation involves the social cognition of infants and mothers. Attachment theory postulates that parents and infants construct mental representations or internal working models about each other and their relationship on the basis of repeated interactional experience (e.g., Pederson, Gleason, Moran, & Bento, 1998; Slade, Belsky, Aber, & Phelps, 1998; van IJzendoorn, 1995). In conceptualizing the development of close relationships, Baldwin (1992, 1995) also proposed that individuals develop cognitive structures reflecting regularities in interpersonal encounters, which are termed *relational schemas*. A sensorimotor form of such relational schemas may be available to infants before the formation of an attachment relationship during the second half of the 1st year of life.

One can also speculate that repeated and shared positive emotions between the mother and infant may exert both momentary and enduring influences on their flexibility and creativity, which, in turn, may facilitate the proliferation of symmetrical communication. In contrast, recurring nonshared emotions or shared negative emotions may destabilize a symmetrical communication attractor so that the dyad moves back to and stays in a unilateral communication attractor. Compared with symmetrical and asymmetrical communication, dyads engaged in unilateral communication are less likely to make a transition and to be affected by recent history. A synergetic relation between emotions and communication—specifically, a tight coupling between nonshared emotions and interaction—may be the explanation for unilateral communication as a stable attractor.

In conclusion, results from the current study provide a foundation for at least five avenues of future research. First, it is unknown whether the relational, dynamical, and historical nature of mother–infant communication revealed in the current study would be replicated for communications between mothers and their children beyond the first 6 months and between infants and other familiar adults with whom infants have an extensive history of social interactions, such as fathers, grandparents, and child-care providers. Second, it is of theoretical and clinical interest in unraveling the nature of face-to-face communication to go beyond the parent and child to dyadic communications between peers, between

spouses, as well as between therapists and clients. Studies using similar designs with intensive weekly observations need to be conducted within different relationships to determine the generalizability of the current findings. Third, future studies should attempt to determine which of the intrapersonal and interpersonal processes are responsible for the historical influence on early communication. Examination of intrapersonal factors such as social cognition, memory, and physiological responses as well as interpersonal processes such as shared emotions that have been linked to communication may provide valuable insights into the specific underlying processes of historical influence on the transitional dynamics of early communication. Fourth, because this study was based on only one context—face-to-face communication—the nature of early communication may have been partially a function of social context. Future studies including other social contexts, for example, a triadic mother–infant–object context, need to be conducted to determine the effects of context on the transitional dynamics of early communication. Finally, cross-cultural research has demonstrated that in addition to culture-general patterns, there is also cultural specificity in individual maternal and infant behaviors during dyadic exchanges (Bornstein et al., 1992). Whether and to what extent cultural contexts affect the stability of and transitions between early face-to-face communication patterns deserve research attention.

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