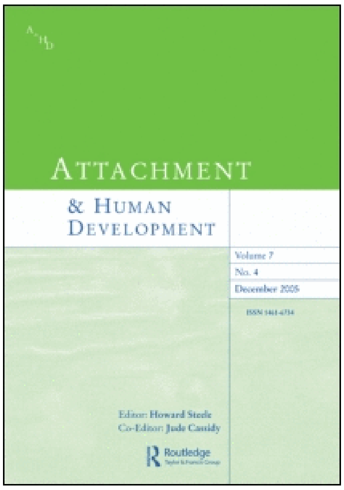

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The origins of 12-month attachment: A microanalysis of 4-month mother-infant interaction

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A microanalysis of 4-month mother-infant face-to-face communication revealed a fine-grained specification of communication processes that predicted 12-month insecure attachment outcomes, particularly resistant and disorganized classifications. An urban community sample of 84 dyads were videotaped at 4 months during a face-to-face interaction, and at 12 months during the Ainsworth Strange Situation. Four-month mother and infant communication modalities of attention, affect, touch, and spatial orientation were coded from split-screen videotape on a 1 s time base; mother and infant facial-visual "engagement" variables were constructed.

We used contingency measures (multi-level time-series modeling) to examine the dyadic temporal *process* over time, and specific rates of qualitative features of behavior to examine the *content* of behavior. Self-contingency (auto-correlation) measured the degree of stability/lability within an individual's own rhythms of behavior; interactive contingency (lagged cross-correlation) measured adjustments of the individual's behavior that were correlated with the partner's previous behavior.

We documented that both self- and interactive contingency, as well as specific qualitative features, of mother and infant behavior were mechanisms of attachment formation by 4 months, distinguishing 12-month insecure, resistant, and disorganized attachment classifications from secure; avoidant were too few to test. All communication modalities made unique contributions. The separate analysis of different communication modalities identified intermodal discrepancies or conflict, both intrapersonal and interpersonal, that characterized insecure dyads.

Contrary to dominant theories in the literature on face-to-face interaction, measures of maternal contingent coordination with infant yielded the fewest associations with 12-month attachment, whereas mother and infant self-contingency, and infant contingent coordination with mother, yielded comparable numbers of findings. Rather than the more usual hypothesis that more contingency is "better," we partially supported our hypothesis that 12-month insecurity is associated with *both higher and lower* 4-month self- and interactive contingency values than secure, as a function of mother vs. infant and communication modality. Thus, in the origins of attachment security, more contingency is not necessarily better.

A remarkable degree of differentiation was identified in the 4-month patterns of "future" C and D infants, classified as resistant and disorganized, respectively, at

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Dedication

This work is dedicated to Daniel Stern, Lotte Kohler, Ruth and Gilbert Beebe.

12 months. The central feature of future C dyads was dysregulated tactile and spatial exchanges, generating approach-withdrawal patterns. The intact maternal contingent coordination overall safeguards the future C infant's interactive agency. However, future C infants likely come to expect maternal spatial/tactile impingement, and to expect to "dodge" as mothers "chase." They managed maternal touch by tuning it out, sacrificing their ability to communicate about maternal touch. They "approached" by vigilantly coordinating their facial-visual engagement with maternal facial-visual engagement, but they "withdrew" by inhibiting their facial-visual engagement coordination with maternal touch. We proposed that future C infants will have difficulty feeling sensed and known during maternal spatial/tactile impingements.

The central feature of future D dyads is intrapersonal and interpersonal discordance or conflict in the context of intensely distressed infants. Lowered maternal contingent coordination, and failures of maternal affective correspondence, constituted maternal emotional withdrawal from distressed infants, compromising infant interactive agency and emotional coherence. The level of dysregulation in future D dyads was thus of an entirely different order than that of future C dyads. We proposed that the future D infant represents *not being sensed and known* by the mother, particularly in states of distress. We proposed that the emerging internal working model of future D infants includes confusion about their own basic emotional organization, about their mothers' emotional organization, and about their mothers' response to their distress, setting a trajectory in development which may disturb the fundamental integration of the person.

The findings have rich implications for clinical intervention, with remarkable specificity for different kinds of mother and infant distress. Heightened and lowered self- and interactive contingency, in different modalities, as well as the specific behavioral qualities identified, provide a more differentiated set of concepts to guide clinical intervention.

Keywords: mother–infant; face-to-face interaction; microanalysis; attachment

Chapter 1. Introduction

We investigated whether antecedents of 12-month attachment might be found in 4-month mother–infant face-to-face play. Infant attachment status is a critical assessment that predicts future development through early adulthood (Grossmann, Grossmann, Winter, & Zimmermann, 2002; Sroufe, Egeland, Carlson, & Collins, 2005; Waters, Merrick, Treboux, Crowell, & Albersheim, 2000). Despite considerable research, and despite important recent progress in understanding disorganized attachment, a full understanding of the mechanisms of attachment formation and transmission prior to 12 months is still lacking (De Wolff & van IJzendoorn, 1997; Fox, 1994; Hofer, 1994; Lyons-Ruth, Bronfman, & Parsons, 1999; Madigan, Bakermans-Kranenburg, van IJzendoorn, Moran, Pederson, & Benoit, 2006; Pederson & Moran, 1996; Seifer & Schiller, 1995; Tarabulsy, Tessier, & Kappas, 1996). Through a detailed microanalysis of mother–infant face-to-face communication, we take up the challenge of investigating in a more fine-grained and precise way the process of attachment transmission between mother and infant (see Peck, 2003). We propose that mother and infant self- and interactive contingency, as well as specific qualitative features of behavior (Kaitz & Maytal, 2005), are important mechanisms of attachment formation and transmission by 4 months.

The attempt to relate 4-month mother–infant face-to-face communication to 12-month attachment assessed by the Strange Situation (Ainsworth, Blehar, Waters, & Wall, 1978) combines two different research paradigms which assess different motivational systems. Ainsworth, herself, however, believed that the two research paradigms are likely to inform one another (Blehar, Lieberman, & Ainsworth, 1977). Both paradigms tap a leading edge of development: a flowering of infant social capacity at 4 months; and a spurt in locomotor capacity enabling physical separation at 12 months (Mahler, Pine, & Bergman, 1975). The 4-month face-to-face interaction task (without toys) is organized around play, with no other goal than mutual enjoyment (Stern, 1985). Nevertheless, infant distress is not uncommon, yielding opportunities to observe how mother and infant manage both distress and enjoyment. The Strange Situation examines the balance between attachment behavior and exploration of the environment in a separation-reunion paradigm (Ainsworth et al., 1978). The extent to which the infant uses the parent as a secure base from which to explore, and as a safe haven when distressed, is central to the coding. We propose that the ways in which mother and infant jointly regulate attention, affect, spatial orientation, and touch during face-to-face play at 4 months will generate a trajectory in development that is likely to affect the nature of the attachment system at 12 months. If so, we will be able to characterize the nature of the 4-month infant's procedural representations, or emerging ''internal working models'' of attachment. The contributions of infant temperament, and the regulation of sleep-wake, feeding, and alone states to the origins of attachment, important as they are, lie beyond our scope.

A new approach to the microanalysis of mother–infant communication

In this study we introduce a new approach to the behavioral microanalysis of 4-month mother–infant face-to-face communication, in relation to attachment outcomes, in a low-risk urban community sample. We integrate two types of measures: ''process'' and ''content.'' Our first focus is the *dyadic temporal process*, contingency analyses (by multilevel time-series modeling) of the moment-to-moment sequence of behaviors. Time-series methods revolutionized the study of social interaction in the 1980s, allowing an assessment of how predictably a behavior unfolds within the individual (*self-contingency*), as well as how that behavior modifies and is modified by the changing behavior of the partner (*interactive contingency*) (see Fogel, 1992). These contingency measures address self- and interactive processes across the entire segment of the face-to-face play session that is analyzed, rather than specific sequences of behaviors, such as maternal smile follows infant smile. For example, maternal facial affect interactive contingency measures how closely the mother coordinates (correlates) her entire range of facial affect changes (from positive to negative) with the infant's just prior facial affect changes. Contingency measures have received less attention than ''content'' measures of *qualitative features of behavior* per se, our second focus. Measures of qualitative features (such as percent time maternal intrusive touch) are rates of specific behaviors, taken out of time; sequence is lost.

We introduce several new features in this study:

(1) Whereas attachment research has focused on maternal antecedents of infant attachment, particularly ''sensitivity,'' we examine the dyad, analyzing both infant and mother. The infant's experience will be shaped

not only by the parent's patterns of behavior, but also by his own. Greater emphasis on the infant's active role in organizing information and behavior, and on the contributions of contingently organized infant as well as maternal coordination, is needed in the longitudinal prediction of infant attachment outcomes (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Tarabulsy et al., 1996).

(2) Whereas research on mother–infant face-to-face interaction has focused on interactive contingency (often termed ''interactive regulation'' or ''mutual regulation''), we examine contingencies which define both self- and interactive contingencies, using time-series methods. This approach is probabilistic, not causal. Time-series techniques separate the variance in each individual's behavior due to self-predictability (auto-correlation) from that due to coordination with the partner (lagged cross-correlation). Thus we are interested in whether antecedents of attachment are found in contingent processes *within* mothers and *within* infants (as they interact), that is *self-contingency*; *between* the partners, that is *interactive contingency*; or *both*. *Interactive contingency* (synonymous with contingent coordination) is defined as adjustments of one individual's behavior that are correlated with the partner's prior behavior; *self-contingency* is defined as adjustments of an individual's behavior that are correlated with his or her own prior behavior (in the context of a particular partner). It refers to the degree of predictability (stability/lability) within an individual's own rhythms of activity. Degree of self-contingency provides the individual with continuous information about the likelihood of staying in the same state.

(3) Whereas prior attachment research has focused on *content* measures of qualitative features of behavior (such as maternal intrusive touch) rather than on *temporal process* measures of contingencies, we integrate both content and process measures, as recommended by Kaitz and Maytal (2005). Whereas behavioral content is usually assessed with measures of central tendency, we explore rare behaviors and behavioral ''extremes'' as well (see Lyons-Ruth et al., 1999; Tomlinson, Cooper, & Murray, 2005).

(4) Face-to-face communication generates multiple simultaneous emotional signals which, although typically congruent, may convey conflicting information in the context of disturbance (Shackman & Pollack, 2005). Whereas parental regulation of infant emotional distress has been seen as central to attachment security, we broaden the focus to an examination of regulation through multiple communication modalities: affect (facial and vocal affect), visual attention (gaze on/off), touch (maternal touch, infant-initiated touch), spatial orientation (mother orientation from sitting upright to leaning forward to looming in; infant head orientation from vis-à-vis to arch), as well as a composite variable of facial-visual engagement, which captures a more holistic gestalt. Modalities of communication are coded separately for mother and infant to a 1 s time base, from split-screen videotapes of 4-month face-to-face interaction.

Using this approach, we investigate associations of 4-month mother and infant qualitative features of behaviors with 12-month attachment. We also predict 12-

month attachment insecurity (vs. security) from 4-month mother and infant self- and interactive contingency, investigating (a) which partner (mother or infant) may show 4-month degree of contingency that differs from that of secure dyads; (b) whether contingency is increased, or decreased, relative to secure dyads; (c) the type of contingency that is altered, self- or interactive; and (d) the communication modality in which contingency is altered. Using the ways that 4-month measures of contingency and qualitative behavioral features predict 12-month attachment, we attempt to conceptualize emerging 4-month infant "internal working models" of attachment, based on infant procedural expectancies of sequences of events.

Our central hypothesis in predicting 12-month attachment from 4-month self- and interactive contingency is that insecurity biases the system toward contingency which is *both heightened* (in some modalities) *and lowered* (in others), compared to values of secure dyads. This hypothesis stands in contrast to the usual position of the literature on mother–infant face-to-face interaction which typically postulates that "more" contingency is "better" (see for example Van Egeren, Barratt, & Roach, 2001, but see Cohn & Elmore, 1988; Jaffe et al., 2001 for critiques). Our hypothesis builds on our finding that interactive contingency of vocal rhythms in insecure dyads was both heightened and lowered, compared to secure dyads who were midrange (Jaffe et al., 2001; see also Leyendecker, Lamb, Fracasso, Scholmerich, & Larson, 1997).

Thus, as a function of partner (mother/infant) and communication modality (attention, affect, spatial orientation, and touch), we hypothesize that values of self- and interactive contingency are both heightened (in some modalities) and lowered (in others) in insecure (vs. secure) dyads. Our hypothesis builds on Jaffe et al. (2001), but within the constraints of the statistical approach we used, we did not attempt to identify a *midrange*. However, within each modality pairing, we make the assumption that contingency values of secure dyads can be considered "optimal," and we hypothesize that values of insecure dyads deviate in both directions, both higher and lower than secure.

A systems approach

We use a *dyadic systems approach*, examining contributions of both infant and mother, and of self- as well as interactive contingency, across multiple communication modalities, to the process of attachment formation (Beebe, Jaffe, & Lachmann, 1992; Beebe, Jaffe, Lachmann, Feldstein, Crown, & Jasnow, 2000; Jaffe et al., 2001; Sameroff, 1983; Sander, 1977; Tronick, 1989).

(a) In a dyadic systems view, communication is viewed as *moment-to-moment process*. Moment-to-moment variation provides an essential means of sensing the partner.
(b) Each person's behavior is created in the process of joint coordination.
(c) Elaborating joint coordination, interaction is viewed as *bi-directional*, such that contingencies flow in both directions between mother and infant. As Sander (1977) describes, both partners generate complexly organized behavior that must be interfaced or coordinated. Regulation in the system is based on the capacity for mutual modification of the partners, a bi-directional coordination. Bi-directionality does not assume symmetry; the partners need not affect each other in equal measure or like manner (Beebe &

Lachmann, 2002). The mother has greater range, control, and flexibility than the infant. Instead, bi-directional contingencies indicate that both partners actively contribute to the exchange.

(d) Interactive exchanges are seen as a product of the *integration of self- and interactive contingency processes*, which are concurrent and reciprocal, each affecting the other (Fogel, 1992; Gianino & Tronick, 1988). Thus, in the dyadic systems approach, the infant is not seen as activated by the mother; instead, each individual generates primary endogenous rhythms of activity, which must be coordinated with the partner (Sander, 1977).

(e) The infant has *intrinsic* motivation to detect pattern and order, to generate procedural expectancies, and to act on these expectancies (Haith, Hazan, & Goodman, 1988; Mandler, 1988). The infant is involved in an active process of ordering and re-ordering information.

Such a systems approach has not been adequately exploited in the study of the origins of attachment (Seifer & Schiller, 1995; but see Jaffe et al., 2001). Although research using the face-to-face paradigm has been strongest in advocating a mutual regulation model (Cohn & Tronick, 1988; Tronick, 1989), as Seifer and Schiller (1995) note: "In general ... the relations among assessments made in this [mutual regulation] paradigm with sensitivity and attachment assessments are as yet poorly understood" (p. 166). There is a tendency to locate the source of difficulty in one partner or the other, for example, in early infant self-regulatory difficulties, or in maternal insensitivity, rather than to evaluate the contributions of both partners, our focus.

However, Bowlby (1958, 1969, 1973) himself held a systems view in his study of the origins of attachment. Influenced by ethology, cybernetics, and evolutionary theory as well as psychoanalysis, Bowlby conceptualized patterns of behavior, their activating and terminating conditions, and their function within the social context. He described behavior patterns as "goal-corrected," open to revision as function of feedback from the environment. His theory is entirely consistent with the current "mutual regulation model" (Tronick, 1989) of empirical infant research. Both mother and child contribute in essential ways to the regulation of the attachment relationship. Bowlby (1958, p. 369, cited in Hamilton, 1985, p. 12) described five responses of the infant: sucking, clinging, following, crying, and smiling, which "serve the function of binding the child to the mother and contribute to the reciprocal dynamic of binding the mother to the child." However, Fox (1994) noted that while notions of reciprocal regulatory control were central to Bowlby's (1969) thinking, they have not been so in research on the origins of attachment.

Our dyadic systems view of face-to-face communication is consistent with broader dynamic systems views of development, which also hold that components of a system are in a continuous process of bidirectional exchange. The aspects of mother–infant exchange that we select to study are infant's self-contingency, mother's self-contingency, and each partner's interactive contingency with the other, as well as specific qualitative features of behavior. Many current versions of systems theories of development view the mechanism of development as a mutual interdependence between an actively perceiving infant and its structured environment (Gottlieb, Wahlsten, & Lickliter, 1998; Lerner, 1998; Lewkowicz, 2000; van Geert, 1998). Bidirectional reciprocal coordinations are a primary basis for promoting the system's development. Although bidirectional exchange is a major theme of research on mother–infant face-to-face exchange, its value for predicting development has not been sufficiently explored (Jaffe et al., 2001).

Contingencies

Most work on the origins of attachment uses ‘‘macroanalytic'' measures, such as global judgments or clinical rating scales (see De Wolff & van IJzendoorn, 1997, for a review). Less work uses ‘‘microanalytic'' measures of videotaped and/or audiotaped interaction, coding with units of 1 s or less. Macroanalytic as well as microanalytic measures may assess qualitative features of the *content* of behavior, such as prevalence of maternal intrusion; but microanalytic measures are necessary to construct contingency assessments of the *process* of the interaction *over time*. Using a microanalytic approach, coding videotaped behavior on a 1 s time base, we use both process (contingency) and content (behavioral quality) measures to investigate the origins of attachment. Contingency is defined as a temporal relation between the occurrence of two events (Tarabulsy et al., 1996), and operationalized with time-series methods. We do not attempt to compare our microanalytic approach with a macroanalytic measure of maternal sensitivity (Lohaus, Keller, Ball, Elben, & Voelker, 2001). Instead, our purpose was to ‘‘unpack'' the details of interactions in future secure vs. insecure dyads, with a microanalytic approach.

Contingency is a neutral term. It acquires meaning only in relation to some other outcome, such as maternal distress or attachment security. Several infant studies link temporal contingencies and the content of events (Gunnar, 1980; Haith et al., 1988; Tarabulsy et al., 1996). The nature of the behavior coded is always a critical context for an interpretation of degree of contingency. We also argue that high contingency is not necessarily better: both high and low degrees of contingency were shown to be related to insecure outcomes in our work on vocal rhythm, whereas midrange degrees were related to secure (Jaffe et al., 2001).

Infants have remarkable capacities to detect regularities in events, to perceive contingency and its degree, and to expect when events will occur. They perceive temporal relations between environmental events, and between their own behaviors and environmental consequences, by estimating probabilities of ‘‘if-then'' sequences (Saffran, Aslin, & Newport, 1996; Tarabulsy et al., 1996). They are highly sensitive to ways that their behaviors are contingently responded to (DeCasper & Carstens, 1980; Hains & Muir, 1996; Haith et al., 1988; Jaffe et al., 2001; Millar, 1988; Murray & Trevarthen, 1985; Stern, 1971, 1985; Tarabulsy et al., 1996; Watson, 1985). The partner's contingent behavior is the central cue of the partner's intentionality for the infant (Muir & Hains, 1993). The parent's contingent coordination with the infant is far more studied than that of the infant with the parent; we consider both.

DeCasper and Carstens (1980) showed that a neonate's attention, memory, and very capacity to learn are affected by whether or not the environment provides contingent stimulation. The infant's own negative affect interferes with contingency learning (Singer & Fagen, 1992). Haith et al. (1988, p. 477) showed that 3–4-month-old infants develop visual expectations rapidly and tend to organize their behavior on the basis of these expectations, arguing that ‘‘as early as 3.5 months of age, the baby can create an action-based perceptual model of the situation he or she confronts, can generate short-term expectations from this model and can support action ... This modeling, expectation and action sequence serves to maintain continuity in an ever-changing perceptual world.'' Thus infant learning of contingencies involves cognitive processes of expectation and anticipation (Tarabulsy et al., 1996).

Within naturalistic face-to-face interactions, Keller, Lohaus, Volker, Cappenberg, and Chasiotis (1999) documented that, across multiple communication modalities, mothers typically respond to infants with contingencies within short intervals of less than 1 s, using a sampling interval of 2 ms and Watson's (1985) method of contingency analysis. This split-second time-frame is similar to Stern's (1971) findings with gaze and head orientation, coded with 16 mm film, 24 frames per second. In the Keller et al. data, infants reciprocated with such rapid contingent coordination to maternal behavior only when making eye contact. Keller and colleagues argued that such maternal rapid contingency may provide the infant with the experience of causality, a form of contingent ''control'' over maternal behaviors.

Coding videotape to a 1 s time base, using an event lag contingency analysis, Malatesta and Haviland (1982) found that maternal facial expression changes were contingent on infant facial expression changes. Although contingency was operationalized with a 1 s lag, empirically maternal changes were found to occur within a fraction of a second. Mothers matched infant expressions of interest, enjoyment, surprise, sadness, anger, and eyebrow flash.

Using a sampling interval of 1 s and an odds ratio method of contingency analysis, Van Egeren, Barratt, and Roach (2001) found that mother and infant contingencies were organized within a 3 s window. Using 1/12 s sampling unit, frame-by-frame analysis of 16 mm film (24 frames per second) rather than videotape, and time-series regression techniques, Cohn and Beebe (1990) found that most mothers and infants responded to each other with contingencies of less than ½ s. Thus, as a function of technology, sampling interval, nature of coding, and statistical method of analysis, contingencies have been documented within a ½–3 s window. The most common coding unit is 1 s, but few studies systematically vary the coding unit to investigate the influence of varying temporal windows (but see Cohn & Beebe, 1990).

Variations in degrees of interactive contingencies of infants and adults during face-to-face interactions are associated with partner novelty (Bigelow, 1998; Jaffe et al., 2001), maternal depression (Beebe et al., 2008a; Cohn, Campbell, Matias, & Hopkins, 1990; Field, Healy, Goldstein, & Guthertz, 1990), and infant attachment security (Jaffe et al., 2001; Leyendecker et al., 1997; Malatesta, Culver, Tesman, & Shepard, 1989). Infants become distressed when maternal contingent stimulation is perturbed in the ''still-face'' (Tronick, Als, Adamson, Wise, & Brazelton, 1978) or ''replay'' paradigms. In the latter, using closed-circuit TV, mother's natural responsiveness is now replayed, out of ''synch'' with no contingent responsiveness to the infant's current behavior (Murray & Trevarthen, 1985).

The nature of each partner's contingent coordination with the other affects the infant's ability to attend, process information, and modulate behavior and emotional state. These reciprocal contingency processes are essential to the creation of infant and maternal social expectancies and interactive efficacy, and to infant cognitive development (Hay, 1997; Lewis & Goldberg, 1969; Murray & Cooper, 1997; Sander, 1995; Stern, 1985; Trevarthen, 1977; Tronick, 1989). Trevarthen describes the mutual regulation of joint action as a "dual prospective motor control": both partners anticipate in detail what the other will do. One translation of this concept is that the infant experiences being experienced (Beebe, Knoblauch, Rustin, & Sorter, 2005).

Contingencies and infant internal working models

Bowlby and subsequent attachment researchers have suggested that the recurrent nature of the infant's experiences leads to the development of internal representations or "working models" of self and others, generalized representations of events experienced, that influence the infant's emotional experiences and expectations throughout development (Bowlby, 1973; Bretherton, 1980; Bretherton & Munholland, 1999; Main, Kaplan, & Cassidy, 1985). Consistent with this view, a large empirical literature documents that variations in social interactions in the first months of life predict later social and cognitive outcomes (see Beebe & Lachmann, 2002, for a review). Main et al. (1985, p. 67) define internal working models as "a set of conscious or unconscious rules for the organization of information relevant to attachment ... which lead to individual differences in the mental representation of the self in relation to attachment ... [and which] direct not only feelings and behavior, but also attention, memory, and cognition" leading to differences in nonverbal behavior, and ultimately to differences in patterns of language and structures of mind. Although attachment researchers argue that internal working models provide one process by which patterns of intimate relating and attachment security are constructed, understanding of the details of these models remains rudimentary, one motivation for our study.

The concept of an internal working model is consistent with experimental literature on infant contingency and procedural representation. The perception of contingent relations allows infants to develop ongoing expectancies of sequences of events, within the self, within the partner, and between the two. This procedural form of representation is based on the predictability of events and the perception of degree of contingent control over events (Beebe & Lachmann, 1988, 2002; Jaffe et al., 2001; Stern, 1985; Tarabulsy et al., 1996).

Infant procedural representational capacities in the first 3–4 months are extensive (for reviews see Beebe, 2005; Beebe & Lachmann, 2002; Bornstein, 1985; Haith et al., 1988; Lewis & Goldberg, 1969; Lewkowicz, 2000; Mandler, 1988; Shields & Rovee-Collier, 1992; Singer & Fagen, 1992; Stern, 1985). Infants perceive time, and can estimate durations of events lasting seconds or fractions of seconds. They detect features of stimuli, such as facial shapes, temporal patterns, and spatial trajectories. They translate cross-modally, for example between visual and auditory channels, facilitating abstraction of pattern from different modalities. Infants can determine whether behavior patterns are similar or different, and can recognize recurrence, determining whether an event is likely to recur after seeing it only twice, generating rules that govern their expectancies. These generalized expectancies are based on the serial pattern in which events occur (Fagen, Morrongiello, Rovee-Collier, & Gekoski, 1984). Serial pattern information is continuously available in social interactions, on the basis of which infants detect the presence and degree of the partner's contingency. Infants remember the details of stimuli in learning experiments for at least 24 hours. However events occurring under conditions of heightened negative affect may be stored, but not easily retrieved, unless the retrieval cues are very specific (Singer & Fagen, 1992).

These processes can be described as "schema" or "model" formation, the generation of procedural models of features of stimuli, events, and action sequences, allowing the infant to recognize what is new, and to compare it with the familiar. Such model formation is an index of fundamental representational processes. Using these capacities, infants generate expectancies, procedural representations, or "internal working models" (terms which we use as synonyms) of recurrent and characteristic interaction patterns.

In describing the infant's experience of these models, we follow Sander (1977) in the view that the organization of social experience is not solely the property of the individual, but also the property of the dyadic system. Moreover, these early procedural models are inherently dyadic and cannot be described on the basis of either partner alone (Beebe & Lachmann, 1988, 1994; Beebe, Lachmann, & Jaffe, 1997; Beebe & Stern, 1977; Bowlby, 1969; Stern, 1985, 1995). The infant represents the dynamic interplay of his own actions-in-relation-to-the-actions of the other.

In creating models of social interactions, infants apprehend correspondences between body transformations they see (such as mouth opening) and their own body transformations that they do not see. Using imitation experiments in the first weeks of life, Meltzoff argues that infants are biologically prepared to perceive cross-modal correspondences of form, between what they see on the face of the partner and what they sense proprioceptively on their own faces (Meltzoff, 1985; Meltzoff & Moore, 1998). In Meltzoff's view, the infant's perception of these correspondences provides the infant with a fundamental relatedness between self and other. Meltzoff (1985) argues that, because infants use correspondences to organize their responses, infants represent these actions. This representation is not merely a visual image or iconic copy, but rather a nonmodality-specific description of the event, utilizing visual, auditory, and motor information. The representation constitutes a model against which the infant can match his own performance and guide his behavior. Through the perception of cross-modal correspondences, both infant and partner sense the state of the other, and sense whether the state is shared. In essence, the infant can determine whether *that* (perceived in the other) looks like *this feels* (perceived in the self) (Meltzoff, 2007). In Meltzoff's view, the perception and production of correspondence has a privileged position in the experience and representation of relatedness.

Trevarthen (1977, 1998) and Stern (1985, 1995) argue that infants are sensitive to correspondences not only of form, but also of time and intensity, across modalities. Stern describes correspondence as a reciprocal dyadic process across time: each *changes with* the other. Trevarthen describes mother and infant behaviors as contingently coupled in time, imitated in form, and brought into register in intensity range. This intercoordination enables each to resonate with or reflect the other. The particular temporal-spatial-intensity patterns formed by the dyad will guide action, learning, and memory. Meltzoff, Trevarthen, and Stern all agree that infant capacity to recognize cross-modal correspondences is the central mechanism allowing the infant to capture the quality of another's inner feeling state.

Stern's work (1985, 1995) explicitly links cross-modal correspondences and shared states to infant attachment. Affect attunement is defined as the crossmodal matching of intensity, timing, and "shape" (such as rising and falling contours of sound) of behavior, based on dynamic micromomentary shifts over time, perceived as patterns of change that are similar in self and other (Stern, Hofer, Haft, & Dore, 1985). In this process, the infant captures the quality of another's feeling state, and discriminates whether it is shared. Stern argues that processes of affect attunement are so powerful because they contribute to attachment security and the capacity for intimacy. The individual learns that some subjective states are shareable, and some are not.

The meaning of correspondences is elaborated by Sander's (1977) concept of "matched specificities" defined as a "resonance between two systems attuned to each other by corresponding properties" (Weiss, 1970, p. 162). An example might be similar vocal rhythms in mother and infant. The presence of matched specificities yields awareness in each partner of the state of the other. This concept underlies Sander's "moment of meeting"; a match between two partners such that the way one is known by oneself is matched by the way one is known by the other. This match facilitates the development of agency, identity, and coherence in the child's experience of inner and outer (Sander, 1995).

Thus prior to the emergence of symbolic forms of representation, an early procedural representational world is being organized. To describe the organization of these representations, we suggest that infants will store models of how interactions unfold, in the dimensions of time, space, affect and arousal. (1) In time, infants will store the rate, rhythm, sequence, and tightness of contingency of the behaviors. (2) In space, infants will store patterns of mutual approach-approach or approach-avoid. (3) In affect, infants will store the positive and negative tones of faces and voices, their patterns of moving in the same affective direction or not, and whether these are shared. (4) In arousal, infants will also store an associated arousal pattern, and a proprioceptive experience of their movements over time (see Beebe & Lachmann, 1988, 1994, 2002; Beebe, Lachmann, & Jaffe, 1997; Beebe & Stern, 1977).

Based on these dimensions of time, space, affect, and arousal, Beebe and Lachmann (1988, 2002) described salient interaction patterns of infant procedural social representations: (1) facial/vocal mirroring, the expectation of matching and being matched in the direction of affective change, providing each partner with a behavioral basis for entering into the other's feeling state, and generating experiences which contribute to feeling "known," attuned to, or "on the same wave length"; (2) state transforming, the expectation of being able to transform an arousal state through the contribution of the partner (see Stern, 1985); (3) disruption and repair, the expectation of interactive repair following facial-visual mismatches; (4) "chase and dodge," the expectation of misregulation of spatial-orientation patterns, without repair, such that "As you move in, I move away; as I move away, you move in" (Beebe & Lachmann, 1988, p. 114); and (5) interpersonal timing, the expectation of degree of contingency in the self, in the partner, and between the two, generating expectancies of the degree of stability in the self's and in the partner's own behavioral rhythms, and the degree to which each partner responds to the other (see Jaffe et al., 2001). We will use these interaction patterns to guide our description of the origins of secure vs. insecure attachment.

Although the above descriptions focus on the infant's experience, the inherently dyadic nature of these representations implies that both roles are known to both people. These procedural representations are a mutually organized and mutually understood code in which any role implies its reciprocal, and neither role can be represented without the other. This may explain why infants classified as disorganized attachment at one year, who may feel controlled by the mother, may later develop a controlling style themselves (Lyons-Ruth & Jacobvitz, 2008).

Moving to a more abstract organizational level, in considering what general principles may determine the centrality of social interactions for the infant, Beebe and Lachmann (1994) proposed three "principles of salience," which constitute criteria by which interactions may be categorized and represented by infants. Is it the infant's recognition of what is regular, predictable, and "invariant" in interactions that becomes salient? This is the principle of *ongoing regulation*. Or, is it the infant's recognition that something changes, disrupts the interaction, and subsequent efforts to repair the disruption, that organizes his experience? This is the principle of *disruption and repair*, organizing expectancies of whether and how mismatches are re-righted. Or, is it the power of heightened affective moments that "colors" and organizes experience? This is the principle of *heightened affective moments*, in which a dramatic moment, positive or negative, becomes formative out of proportion to mere temporal duration, such as moments of intense negative arousal (see Pine, 1981). We will use the principles of salience to describe the origins of insecure vs. secure attachment. The principle of "ongoing regulation" will be applied to findings revealed through time-series methods, that is contingencies over time, thus "ongoing." The principle of "heightened affective" moments will be applied to findings revealed through analysis of behavioral qualities, which identifies rates of specific behaviors, taken out of time, thus "moments." The principle of disruption and repair is addressed only clinically, not through data analysis.

Lyons-Ruth (1999, 2008) argues that the organization of intimate relating is at stake as the infant develops early procedural social representations. Intimate relating entails the fundamental issue of how the infant comes to know, and be known by, another's mind. Similarly, Stern argues that processes of affect attunement are so powerful because the individual learns that some subjective states are shareable, and some are not. This learning powerfully affects attachment security and the capacity for intimacy. Learning which states are shareable, and which are not, defines the arenas in which one can, and cannot, know and be known by another's mind.

Lyons-Ruth (1999, 2008) proposes that the outcome of this process of coming to know and be known by another's mind is dependent on whether the partner is capable of a *collaborative dialogue*. Collaborative dialogue involves close attention to the other's initiatives; openness to the other's state across the entire range of positive to negative emotions; attempts to comprehend the state or subjective reality of the other; the attempt to respond in a way that acknowledges or elaborates on that state; ability to negotiate similarity and difference; and efforts to repair disruptions. Collaborative dialogues generate internal models in which both partners are represented as open to the experience of the other; each can know and be known by the partner's mind. Lyons-Ruth's position is similar to the work of Meltzoff, Trevarthen, and Stern.

Lyons-Ruth (1999) suggests that incoherent or contradictory dialogues involve a collapse of intersubjective space in which only one person's subjective reality is recognized. The partner's initiatives are ignored, over-ridden, or not acknowledged. Lyons-Ruth (1999, 2008) argues that such failures of collaborative dialogue generate contradictory internal models, in which the partner represents both roles: "I should accept your control; I should attempt to control you." Lyons-Ruth's description is consistent with our position that procedural representations are a mutually organized and mutually understood code in which any role implies its reciprocal.

To understand contradictory dialogues, Lyons-Ruth (1999) builds on the models of Fischer (1980) and Case (1991) describing how complex "control systems" for skilled actions, such as communicating, are developed by coordinating single relational procedures, such as facial affect, with other procedures, such as vocal affect, from second-to-second. Flexible integration of these procedures is essential to higher-order coordinations. However, when procedures conflict, such as simultaneous positive facial affect but negative vocal affect, the lack of integration can disturb the development of flexible control systems. This description of conflicting or unintegrated domains of knowledge is consistent with the concept of intermodal discordances, developed below (pp. 23–24), in which contradictory procedures are organized in different communication modalities at the same time. Discordant information is difficult to integrate into a coherent percept, and may remain unintegrated (Shackman & Pollack, 2005).

In summary, the following concepts will guide our understanding of variations in internal working models in future insecure infants in the Discussion.

(1) In the social sphere, a procedural, presymbolic representational world is being organized, formed in the interactive process of self-in-relation-to-other, and thus inherently dyadic.
(2) Through the perception of correspondences between one's own behavior and that of the partner, which are organized via form, time, and intensity across modalities, both infant and partner can sense the state of the other, and can sense whether the state is shared or not.
(3) Infant procedural representations of face-to-face interactions include a variety of patterns, such as (a) state-transforming, (b) facial mirroring, (c) disruption and repair, (d) mutual approach or approach/avoid spatial orientation, including spatial patterns of intrusion, and (e) degrees of self- and interactive contingency.
(4) Three principles of salience, which constitute criteria by which interactions may be categorized and represented, determine the centrality of social events for the infant: the principles of (a) ongoing regulation, (b) disruption and repair, and (c) heightened affective moments.
(5) When contradictory procedures are organized in different communication modalities, unintegrated, conflicting procedural representations are likely to develop.
(6) Collaborative vs. contradictory dialogues generate coherent vs. unintegrated infant internal working models of attachment.
(7) What is at stake in these procedural representations is the organization of intimate relating, which entails the fundamental issue of how the infant comes to know, and to be known by, another's mind.

Our view of infant procedural representations assumes the potential for reorganization and transformation (Beebe & Lachmann, 2002; Sameroff, 1983). Thelen and Smith (1994) proposed that a procedural representation is not something we "have" but something re-assembled in the moment, according to context and task. Under what conditions inner working models of 4-month infants might shift is a topic for future research.

Attachment classifications

Ainsworth et al. (1978) suggested that the developing quality of infant attachment is dependent upon the nature of maternal behaviors, particularly in response to the infant's signals and moods. Maternal sensitivity promotes a secure relationship in which the infant can use the mother as a base for protection and nurturance as well as for exploration. The insecurely attached infant spends too much or too little time in proximity to the mother or exploring the environment, upsetting an attachment-exploration balance. The Strange Situation (Ainsworth et al., 1978), conducted between 12 and 18 months, assesses the balance between attachment and exploration through a series of separations and reunions. It yields 4 categories of attachment: avoidant (A), secure (B), resistant (C), and disorganized (D). In the *secure* pattern, the mother is sensitive to the infant's needs, and the infant tends to use mother as a secure base, to engage in active proximity seeking, contact maintenance, and positive social interaction following the reunion, and to recover easily from the separation.

In the *insecure/avoidant* pattern (A), mothers are insensitive to their infants' needs, may be under-involved, and may be intrusive (Belsky, Rovine, & Taylor, 1984); infants avoid closeness with mother upon reunion. In the *insecure/resistant* pattern (C), mothers are inconsistent in their response, sometimes non-nurturant, but at times sensitive and caring (Cassidy & Berlin, 1994). They may also show direct interference, interrupting infant ongoing activity by shifting attention to mother. Their infants show limited exploration of the environment, strong proximity-seeking, and sturdy contact-maintaining, but repeated expressions of anger, crying, and petulance. They seem inconsolable in spite of efforts by mother to comfort them, and they are unable to separate from mother and resume play after the separation. A further pattern of infants who did not fit into the above patterns resulted in an additional classification, *disorganized/disoriented* (D) infants, who show incomplete movements and expressions, simultaneous displays of contradictory approach/avoidance patterns, confusion and apprehension, and momentary behavioral stilling, considered a breakdown in behavioral organization (Main & Solomon, 1990; Solomon & George, 1999).

The prediction of attachment

The focus on parental sensitivity has generated an important body of work that has generally used global (rather than microanalytic) assessments of interactions during the first year to predict 12- and 18-month attachment. Sensitivity involves alertness to infant signals, appropriateness and promptness of response, and capacity to negotiate conflicting goals (Ainsworth et al., 1978). Over 60 studies using global assessments have converged on a picture of interactions in the early months of life that predict secure vs. insecure attachment outcomes (see De Wolff & van IJzendoorn, 1997, for a review). Although a review of this literature is beyond our scope, mothers of secure infants have been described as more responsive and "sensitive," more consistent and prompt in response to infant distress, more likely to hold their infants, less intrusive, and less tense and irritable. Secure (vs. insecure) infants have been described as more responsive in face-to-face play, better able to elicit responsive caretaking, more positive, and more able to express distress (Ainsworth et al., 1978; Antonucci & Levitt, 1984; Bates, Maslin, & Frankel, 1985; Belsky et al., 1984; Blehar, Lieberman, & Ainsworth, 1977; Crockenberg, 1983;

Egeland & Farber, 1984; Grossmann, Grossmann, Spangler, Seuss, & Unzer, 1985; Isabella & Belsky, 1991; Mikaye, Chen, & Campos, 1985; Stayton, Ainsworth, & Main, 1973).

Seifer and Schiller (1995) summarized this literature with the concept that if interactions are characterized as generally sensitive, infants will come to expect that their parents will be available to help modulate states of negative arousal. They argued, however, that this concept remains too general, and that despite considerable evidence for cross-generational correspondence, there is little empirical understanding of the mechanisms by which this attachment transmission may occur. Demos (2001) also noted that Ainsworth was not sufficiently specific about the essential transactional processes involved in maternal sensitivity, with a resulting ambiguity. In their meta-analysis of this literature, De Wolff and van IJzendoorn (1997) noted that the modest size of the correlations for parental sensitivity as a predictor of attachment leaves room for additional influences. We propose that an examination of self- and interactive contingency, as well as qualitative behavioral features, using microanalytic coding of multiple communication modalities, will provide greater specificity regarding essential processes within and between the partners that predict insecure (vs. secure) outcomes.

Avoidant and resistant attachment

Avoidant infants (A) are described as minimizing response to fear by an organized shift of attention away from mother toward the inanimate environment (Cassidy, 1994; Main & Hesse, 1990), which allows self-regulation and proximity, but at a price. The state of mind of mothers of avoidant infants is one in which the importance of attachment is dismissed. In contrast, the resistant (C) infant's strategy of adaptation to maternal minimal (or inconsistent) availability is to increase bids for attention, with heightened displays of emotionality and dependence. But resistant (C) infants have difficulty using the comfort they clamor for, showing an ambivalent pattern. Cassidy and Berlin (1994) suggested that the state of mind of mothers of resistant (C) infants is one in which attachment is emphasized and autonomy minimized, and that mothers of resistant (C) infants are overly attentive to their infant's emotional response. Inconsistent or low maternal responsivity, activating greater infant bids for attention, would assure the mother of her importance to the infant. Cassidy and Berlin (1994) suggest that for avoidant (A) infants, the developing internal working model of the caregiver is one of consistent maternal rejection, whereas for resistant (C) infants, the model is one of inconsistent maternal availability.

Disorganized attachment

Traditional measures of maternal sensitivity have not been found to be associated with disorganized infant attachment. The failure of parental sensitivity to relate to disorganization is likely due to the diversity of parental profiles within the disorganized group and the lack of detailed behavioral coding (Fonagy, 2001; Lyons-Ruth & Jacobvitz, 2008). However, important progress has been made in the last decade in the understanding of the disorganized attachment. Mothers of disorganized infants are thought to be suffering from unresolved loss, abuse, or trauma, and to be in a continuing state of fear (Lyons-Ruth et al., 1999;

Main & Hesse, 1990). Maternal behavior within the Ainsworth Strange Situation has been found to be frightened and/or frightening (Jacobvitz, Hazen, & Riggs, 1997; Lyons-Ruth et al., 1999; Schuengel, Bakermans-Kranenburg, & van IJzendoorn, 1999).

Lyons-Ruth et al. (1999) also found that maternal frightened/frightening behavior occurs in a broader context of atypical, disrupted maternal behaviors within the Ainsworth Strange Situation. At 18 months, *degree* of infant disorganization (7-point scale) was associated with disrupted maternal behaviors: affective communication errors (such as mother positive while infant is distressed), disorientation (frightened expression or sudden loss of affect), and negative-intrusive behaviors (such as mocking or pulling infant's wrist). Of these atypical behaviors, affective communication errors were associated with the disorganized attachment category.

Lyons-Ruth (2008) suggests that research now explore whether disrupted or frightening behavior begins early in the first year. Only one such study is in the literature, that of Kelly, Ueng-McHale, Grienenberger, and Slade (2003) (but see Miller, 2010). Kelly et al. adapted the coding of 12-month maternal disrupted communication in the Strange Situation (Lyons-Ruth et al., 1999) to 4-month mother–infant face-to-face play and predicted disorganized attachment at 12 months. Miller (2010) adapted the coding of maternal disrupted communication to 4-month face-to-face play and predicted disorganized attachment from maternal lack of response to infant affect (positive and negative), discrepant or aggressive response to infant distress, interference with infant self-regulation, and over-riding infant affective cues with her own agenda.

Madigan et al. (2006) performed a meta-analysis of 12 studies, based on 851 families, on the strength of associations between anomalous parenting (assessed at 12 and 18 months) and D attachment. Anomalous parenting included behaviors such as frightening, threatening (loom), dissociative (haunted voice; deferential/timid), and disrupted (failure to repair, lack of response, insensitive/communication error). They found that a child who does (vs. does not) experience anomalous parenting is 4 times as likely to be classified as D attachment ($r = .34$). However, they argue that much of the variance remains to be explained, and that further exploration of infant, parent, ecological, and genetic factors are warranted. They specifically suggest that future research should attempt to identify the details of the elusive behaviors of anomalous parenting directly implicated in the development of D attachment, one of the goals of the current study. Lyons-Ruth et al. (1999, p. 69) suggested that the degree of derailment of communication seen in disorganized dyads "should be fear-arousing in itself because the infant will have little sense of influence over the caregiver at times of heightened fear or stress" (see also Koos & Gergely, 2001). This concept is pursued in our current analyses, where little infant sense of influence can be translated into lowered maternal contingent coordination with infant behavior.

The prediction of attachment from microanalytic contingency approaches

In contrast to macroanalytic approaches, few studies have predicted 12-month attachment using detailed coding of videotapes and contingency assessments. Such a microanalytic look was advocated by Peck (2003), who argued that more fine-grained and precise investigation might elucidate the process of attachment transmission. The studies reviewed below coded videotaped behavior on a 1 s time base, or with rating scales that nevertheless captured details of behavior.

Langhorst and Fogel (1982) coded 4-month face-to-face interaction on a 1 s time base. Mother "reserving" stimulation for periods of infant looking at her was negatively correlated with avoidance in the Strange Situation. The proportion of time infants spent in gaze "avert" and postural "avoid" was positively correlated with avoidance. Maternal tendency to increase stimulation following negative infant cues was positively correlated with infant avoidance, and negatively correlated with proximity-seeking. Lewis and Feiring (1989) predicted B attachment from midrange values of 3-month infant object/toy play and sociability, and mother respond and proximal stimulation; future insecure dyads received scores higher or lower than secures. Future A infants received the most stimulation, B infants a moderate level, and C infants the least.

Malatesta et al. (1989) coded behavior on a 1 s time base and analyzed maternal facial changes contingent (within 1 s) on infant facial changes (but not infant contingent on mother) in dyads at 2.5, 5, and 7.5 months. Mothers of future B infants showed moderate, whereas those of future A infants showed higher, levels of contingency. Mothers of future A infants were more variable in their display of negative affect. Tobias (1995; Slade et al., 1995) used contingency measurements of 4-month mother–infant face-to-face engagement changes, with findings similar to those of Malatesta et al. (1989). Tobias (1995) used the Adult Attachment Interview (AAI) administered in the last trimester of the mother's pregnancy to predict 4-month mother–infant interaction, coded on a 1 s time base. She found that future B mothers and infants showed moderate degrees of contingency, whereas C mothers and infants showed higher degrees.

Koulomzin, Beebe, Anderson, Jaffe, Feldstein, and Crown (2002) predicted 12-month B vs. A attachment from 4-month infant gaze, head orientation, facial expression, and self-touch/mouthing behavior during face-to-face interaction, coded on a 1 s time base. Mother behavior was not coded. Future B (vs. A) infants looked at mother more, with a more stable pattern. Future B infants were able to sustain gaze, as well as coordinated gaze/head orientation, yielding a stable focus of attention to mother's face, regardless of self-touch/mouthing. Future A infants maintained a level of stable gaze at mother equal to those of future B infants only if involved in self-touch/mouthing.

Kiser, Bates, Maslin, and Bayles (1986) documented that mothers of 6-month infants later classified as secure ("future B") had longer bouts of play than those of future C infants, in the baseline face-to-face play of the "Still-Face" paradigm (Tronick et al., 1978). Future B (vs. C) infants showed less distress in the still-face segment, but future B (vs. C) infants fussed more in the resumption of normal play. Future A infants (vs. B or C) displayed less positive mutuality and sustained shorter bouts of play in the baseline segment, but more positive expressiveness in the resumption of play. Tronick (1989) found that infants who experienced more repairs of mismatches in an ongoing interaction, and who used more adaptive methods of coping with the still-face experiment (such as continuing to signal the mother), were more likely to have secure attachments. Using the Still-Face paradigm, Cohn, Campbell, and Ross (1991) showed that 6-month future B, but not A, infants displayed positive eliciting behaviors while mother maintained a still face. Kogan and Carter (1996) analyzed resumption of play following the still-face and found that infants who cried more and were more difficult to soothe ("resistant"), and infants who were more likely to avert gaze and turn away (''avoidant''), showed less contact-maintaining behavior during the reunion episodes of the Strange Situation.

Also using the still-face paradigm and detailed video coding, Braungart-Rieker, Garwood, Powers, and Wang (2001) predicted 12-month infant attachment outcomes from measures of 4-month infant facial/vocal affect and self-regulation (self-touch/focus on something other than mother) during the still-face episode, and maternal sensitivity (coded on 5-point scale every 10 s epoch) during free-play. Greater 4-month maternal sensitivity predicted 12-month security. However, the specific attachment classification (avoidant, B1-B2 secure, or B3-B4 secure and resistant) was also a function of infant 4-month infant affect and self-regulation. Although future secure and future resistant infants were equally affectively distressed during the still-face episode, mothers of future secure infants were more sensitive.

Tomlinson et al. (2005) predicted 18-month attachment outcomes from videotaped 2-month mother–infant face-to-face interaction, coded using 5-point rating scales (maternal sensitivity, coercive-intrusive, and remote-disengaged behavior). Using multi-variate analyses, 2-month maternal depression, intrusiveness, and remoteness all predicted 18-month insecurity. Multivariate analyses of 2-month maternal measures predicting disorganized attachment identified maternal frightened/frightening behavior and depression.

The role of interpersonal contingent coordination in infant development has been unclear (Cohn & Elmore, 1988; Jaffe et al., 2001; Keller et al., 1999; Tarabulsy et al., 1996). High coordination (interactive contingency) has been seen as more optimal for development (Chapple, 1970) or, in contrast, as an index of stress (Gottman, 1979). An optimal midrange model of coordination has also been proposed (Cohn & Elmore, 1988; Jaffe et al., 2001; Warner, Malloy, Schneider, Knoth, & Wilder, 1987). Most infant literature currently considers higher contingent coordination a more optimal pattern (see Cohn & Elmore, 1988; Dunham & Dunham, 1994; Tarabulsy et al., 1996; Van Egeren et al., 2001).

A number of macro- and microanalytic studies now converge on an ''optimum midrange model'' of interactive contingency for attachment and social outcomes, in which both higher and lower degrees of contingent coordination are problematic. Maternal overstimulation, intrusiveness, inconsistency, and particularly high *or* low levels of maternal stimulation and/or infant and mother responsiveness are associated with insecure outcomes (Belsky et al., 1984; Hane, Feldstein, & Durnetz, 2003; Isabella & Belsky, 1991; Jaffe et al., 2001; Lewis & Feiring, 1989; Leyendecker et al., 1997; Malatesta et al., 1989; Tobias, 1995; Warner, 1992).

Our prior work documented that midrange degree of 4-month mother–infant and stranger–infant interactive contingency of vocal rhythms (coded on a ¼ s time base) predicted 12-month infant security, whereas higher and lower degrees predicted disorganized/anxious-resistant and avoidant attachment, respectively (Jaffe et al., 2001). Higher contingent coordination increases the predictability of the interaction. We interpreted high coordination as excessive monitoring, or ''vigilance,'' a dyadic effort to create more moment-to-moment predictability. We construed it as a coping strategy elicited by novelty, interactive challenge, or threat. We interpreted low coordination as inhibition of monitoring, or withdrawal. Midrange coordination leaves more ''space,'' more room for uncertainty, initiative, and flexibility within the experience of correspondence and contingency: optimal for secure attachment.

A follow-up study showed that a similar optimum midrange model characterized the association of 12-month mother–infant (but not stranger–infant) vocal rhythm coordination and secure attachment (Beebe, Hane, Feldstein, Jaffe, Crown, & Markese, 2008c). A second follow-up study predicted 4-year attachment representations (Bretherton story stems) from 4- and 12-month stranger–infant vocal rhythm coordination, with support for the midrange model (Markese, Beebe, Feldstein, & Jaffe, 2008).

An entirely different approach to the role of contingency in the origins of infant attachment has been taken by Gergely and colleagues (Gergely & Watson, 1996; Koos & Gergely, 2001). In Gergely's paradigm, the "mirror interaction situation," infant and mother are seated next to each other, but they are separated by a barrier. Thus direct mother–infant face-to-face communication is prevented. Instead, both partners view a mirror in which both are visible, so that they may interact through the mirror. In the first 2–3 months of life, infants prefer to interact with their own image in the mirror, a "perfectly" contingent stimulus; thereafter they prefer to interact with the mother's image in the mirror, an "imperfectly" contingent stimulus (see also Bahrick & Watson, 1985). Koos and Gergely (2001) hypothesize that the origins of disorganized attachment can be found in a "deviant contingency environment" in which infants experience periods of being in contingent "control" (where mothers provide high levels of contingency), followed by periods of sudden loss of such contingent control (where mothers provide very low levels of contingency). During such periods of loss of control, Koos and Gergely propose that the ensuing feelings of helplessness may trigger the infant to switch back to a preference for perfect contingency. They tested this idea in their "mirror interaction situation" with a modified still-face procedure of 2 min in which mother is instructed to interact naturally (in the mirror), followed by 2 min of "still-face," and 2 min in which mother resumes natural interaction (in the mirror). Six-month infants who will later be classified disorganized (vs. secure) attachment showed more "self-testing movement," looking at the visual consequences of testing out their own movement in the mirror, in all 3 phases of the experiment. Koos and Gergely suggest that perfectly contingent simulation is more attractive to future disorganized infants. We note that this experiment using the mirror interaction situation does not explicitly address their idea of a deviant contingency environment in which mothers of future disorganized infants provide both very high, and also very low, contingency, during ongoing interactions. In contrast, the study we describe below explicitly tests whether mothers of future disorganized (vs. secure) infants provide higher, or lower, levels of contingency during face-to-face interactions.

In their experimental paradigm of interacting through the reflections in a mirror, Gergely and colleagues study the role of 3 types of contingency: (1) perfect contingency (specifying self), (2) high but imperfect contingency (in maternal responsivity, through the mirror), and (3) absence of contingency (in the still-face condition). Instead, in our paradigm of face-to-face communication, we study a *range of degrees* of contingency generated as mothers are responsive to infants (and vice-versa). Our approach is parallel to Gergely's contingency type (2), but at the same time very different, because we examine direct face-to-face interaction, and because we examine the reciprocal range of degrees of contingency generated as infants are responsive to mothers. However, because the paradigms are profoundly different, their results are not comparable.

Self- and interactive contingency

The current study refines the study of attachment by examining forms of contingency both within and between the partners. Within a face-to-face encounter, each person has the dual task of regulating one's own state and interacting with the partner (Gianino & Tronick, 1988; Sander, 1977). Each person's behavior is affected both by one's own prior behavior (self-contingency) and by that of the partner (interactive contingency) (Thomas & Malone, 1979; Thomas & Martin, 1976). Time-series methods are designed to partition these two sources of variance. Because any behavior in a face-to-face encounter may participate simultaneously in self- *and* interactive contingency functions, every behavior must be assessed for both functions.

Self- and interactive contingency are defined, using lag correlations, as predictability within (autocorrelation) and between (lagged cross-correlation) two partners' behavioral streams over time. Interactive contingency refers to moment-to-moment adjustments of each individual that are correlated with changes in the partner's prior behavior. It does not imply conscious intention or causality; the definition is probabilistic. Focusing on dynamic temporal movement, this definition measures an interpersonal match in direction of behavioral change over time (see Beebe & Lachmann, 1988; Feldman, 2006). For example, bi-directional interactive contingency of facial affect in our data refers to each person's tendency to go in the same affective direction, becoming more (and less) positive as the partner does, a "facial mirroring" process.

Self-contingency (auto-correlation) refers to the degree to which a prior state predicts the next observed state within an individual. It refers, for example, to the degree to which an individual's facial affect is predictable or stable over time. It provides the individual with a continuous procedural assessment of the likelihood of staying in the same state. Self-contingency is measured in relation to a particular partner; it does not refer to something that either partner "brings" to the interaction. Whereas other work ignores auto-correlation (Stern, Jaffe, Beebe, & Bennett, 1975) or removes it statistically (Cohn & Tronick, 1988; Jaffe et al., 2001), we treat it as a variable in its own right (McCleary & Hay, 1980; Thomas & Malone, 1979; Warner, 1992). Both forms of contingency are associated with infant and maternal distress (Beebe, Jaffe, Buck, Chen, Cohen, Blatt, et al., 2007; Beebe, Jaffe, Buck, Chen, Cohen, Feldstein, et al., 2008a; Cohn et al., 1990; Feldman, 1997; Field et al., 1990). Using transition probabilities rather than time-series analysis, our prior work (Koulomzin et al., 2002) showed that degree of predictability or stability of infant behavior was associated with attachment outcomes. Defining transitions from any state to itself as "stable" vs. transitions from one state to another as "labile" we showed that 4-month future avoidant (vs. secure) infants were characterized both by *less stable* processes of gaze on-off, and self-touch/mouthing behaviors, but by *more stable* processes of facial behaviors (less varied facial signaling).

A contingency approach to regulation

The concept of regulation has many definitions within varying research traditions (Campos, Frankel, & Camras, 2004; Cole, Martin, & Dennis, 2004; Davidson, Jackson, & Kalin, 2000). Contingency, or predictability of behavior over time, is ours (Cohn & Tronick, 1988; Sander, 1977). Of Cole et al.' s (2004) review of definitions of regulation, our approach fits their "analysis of temporal relations" using time-based methods, which they illustrated with the work of Cohn and Tronick (1988). Cole et al. (2004) note that these time-based methods are "well-suited to inferring that each person's behavior regulates that of the partner" (p. 324).

We adopt the terms self- and interactive contingency to avoid confusion over the many different meanings of the term "regulation." We nevertheless construe our self- and interactive contingency measures as *forms* of self- and interactive regulation. The advantage of framing our contingency measures as "regulation" is that our findings can then be related to a large literature on self- and interactive regulation (see Beebe & Lachmann, 2002; Beebe et al., 2007, 2008a; Cohn & Tronick, 1988; Sander, 1977; Tronick, 1989).

Although our approach is familiar for interactive regulation, it is less so for self-regulation (but see McCleary & Hay, 1980; Thomas & Malone, 1979; Warner, 1992). There is little agreement on the definition and mechanism of self-regulation (Fox, 1994). One frequent definition of self-regulation is the activation/dampening of arousal and capacity to down-regulate negative affect. Kopp (1989) suggests that self-regulation in infancy includes both affect tolerance of positive states as well as the management of distress (expressed through such behaviors as head aversion, non-nutritive sucking, body rubbing, and object focus).

One difficulty is that any of these behaviors can be viewed simultaneously as self-regulatory *and* as aspects of interactive regulation. Thus these very behaviors may operate as interactive influences as well. For this reason we use time-series techniques which are designed to disembed the two processes. We do not decide in advance the function of a behavior (self-regulation or interactive regulation), and instead hold open the possibility that both functions may be operative. Thus behaviors considered self-regulatory, such as self-touch, or looking away, can be examined for self-predictability, as well as for ways in which self-touch or looking away behaviors may be interpersonally coordinated.

Predictability of behavior is the most general and abstract of the above concepts of self-regulation, and is the most fundamental principle of brain/behavior organization. The brain continuously anticipates changes in the environment and within the organism, on the basis of incoming information (Kandel, 1999; Llinas, 2001; Pally, 2000). The autocorrelation measure of self-predictability of an individual's behavior from moment-to-moment taps *one* essential feature of self-regulation (Beebe, Hane, Margolis, Markese, Jaffe, Chavarga, et al., 2010), but omits others.

Our approach to self- and interactive contingency can be construed as an examination of the contingencies of *intra*personal and *inter*personal *rhythms* within a face-to-face encounter. Social behavior unfolds in time in an ongoing patterned format, loosely rhythmic. Although the simplest rhythms are strictly regular (periodic), the rhythms of human communicative behavior are irregular (non-periodic), based on a recurrent non-random temporal patterning (Cohn & Tronick, 1988; Feldman, Greenbaum, Yirmiya, & Mayes, 1996; Jaffe et al., 2001; Lashley, 1954). Mother–infant interaction, in particular, is organized through loosely organized repeating rhythmic cycles (Beebe, 1982; Stern, 1974; Feldman, 2006). Self-contingency measures the predictability of loose behavioral rhythms within an individual. Behavioral forms of self-regulation are originally grounded in basic biological rhythms, such as those of breathing (Feldman, 2006). Interactive contingency measures the degree to which the loose rhythms within an individual can be predicted from those of the partner. In social interactions, *both* intrapersonal and interpersonal rhythms provide ongoing temporal information necessary to predict and coordinate with one's partner, so that each can anticipate how the other will proceed (Warner, 1992). Models for these definitions of self- and interactive contingency are considered "stochastic": both self and partner behaviors can be predicted from immediately prior behaviors, but the series as a whole does not follow a pre-determined regularity, so that each individual is open to the changing behavior of self and partner (Cohn & Tronick, 1988; Feldman, 2006; Gottman, 1981).

The meaning of higher and lower degrees of contingency

Varying degrees of *self-contingency* generate moment-to-moment expectancies regarding the predictability of one's own behavior. In relation to attachment insecurity, either heightened or lowered self-contingency could be problematic (see Koulomzin et al., 2002). Lowered gaze self-contingency in insecure (vs. secure) infants indexes a more varying process of infant gaze on/off patterns, from moment-to-moment. For example, infants of depressed mothers showed lowered gaze self-contingency, a less predictable pattern of looking and looking away from mother's face (Beebe et al., 2008a). Such lowered infant self-contingency may make it harder for mothers to anticipate the infant's ongoing behavioral stream, and for infants to anticipate their own behaviors. We translated lowered self-contingency into the metaphor of "self-destabilization." Heightened self-contingency indicates behavior tending toward an overly steady state, non-varying at the extreme, translated into the metaphor of "self-stabilization." Heightened touch self-contingency in insecure (vs. secure) infants, for example, would index a more stable, predictable process of touch (from none, to one, to more than one form of touch, per second). In a prior study we found that infants of more dependent (empty, needy) mothers heightened their gaze self-contingency (Beebe et al., 2007), indicating that infants were more likely to stay in the same gaze state, a more slowly-moving process between gaze on and off.

Varying degrees of *interactive contingency* generate expectancies of how predictably the partner changes in relation to the individual's own behavior, and vice-versa: metaphorically, expectancies of "how I affect you" and "how you affect me." Interactive contingency can be both heightened, and lowered, as a function of distress in either partner. Hay (1997) suggests that social experiences that force the infant to pay too much attention to the partner, *a heightened coordination*, or reciprocally to pay too little attention, *a lowered coordination*, are likely to interfere with the infant's developing ability to attend to the environment, disturbing social and cognitive development. Either heightened or lowered infant contingent coordination may disturb the infant's ability to modulate his own emotional state while processing information.

Heightened interactive contingency increases the predictability of the interaction. For example, heightened facial coordination with maternal facial changes in insecure (vs. secure) infants would index a more tightly correlated process in which infant facial changes are more contingent on prior maternal facial changes, translated into the metaphor of "activation" or "vigilance." In prior work we interpreted heightened interactive coordination as efforts to create more predictability in contexts of novelty, challenge, or threat (Jaffe et al., 2001). Vigilance for social signals is an important aspect of social intelligence, likely an evolutionary advantage with uncertainty or threat, and accompanied by heightened arousal (Ohman, 2002).

Lowered interactive coordination indicates interpersonal inhibition, or withdrawal from coordinating with the partner (Jaffe et al., 2001). For example, lowered facial coordination with maternal facial changes in insecure (vs. secure) infants would index a less tightly correlated process in which infant facial changes are less contingent on prior maternal facial changes, translated into the metaphor of withdrawal or inhibition. The partner's lowered interactive coordination compromises the individual's ability to anticipate the consequences of his own actions: lowered interactive efficacy or agency. In the context of insecure attachment we construe heightened or lowered values of contingency (relative to those of secure dyads) as *loss of flexibility, or dysregulation*.

Our approach identifies complex patterns of *interactive contingency*. With insecurity, as a function of modality, mother and infant may show: (a) reciprocally heightened contingent coordination (mutual "approach" or "vigilance"), (b) reciprocally lowered contingent coordination (mutual "withdrawal"), (c) *opposite directions of coordination within the same modality* (dyadic "approach-withdraw"), and (d) intermodal discordant coordinations, such as heightened infant facial but lowered infant gaze coordination, documented in our study of infants of depressed mothers (Beebe et al., 2008a). Patterns (c) and (d) are confusing communications.

Alterations in self-contingency may or may not be accompanied by alterations in interactive contingency (and vice-versa). In instances where both forms of 4-month contingency are altered in relation to 12-month insecure attachment, there are four possible patterns within an individual, two symmetrical (both heightened, both lowered), and two asymmetrical (one heightened, one lowered). The asymmetrical patterns define imbalances between the two forms of contingency. The asymmetrical pattern of self-contingency heightened, but interactive contingency lowered, is interpreted metaphorically as a retreat from the partner into one's own "program," similar to Tronick's (1989) description of infants of depressed mothers as preoccupied with self-regulation at the expense of engagement with the partner. The asymmetrical pattern of self-contingency lowered, but interactive contingency heightened, is interpreted metaphorically as overly involved with the partner at the expense of self-stability.

Modalities of communication

We refine the study of the origins of attachment by examining separate modalities of communication: attention, affect, orientation, and touch. Face-to-face communication generates multiple simultaneous emotional signals in numerous modalities. Infants are sensitive to all modalities and are capable of coordinating them to apprehend affective states (Murray & Cooper, 1997; Stern, 1985; Trevarthen, 1977; Tronick, 1989). Multiple modalities typically convey temporally coordinated, congruent information (Bahrick & Lickliter, 2002; Lickliter & Bahrick, 2001). Redundancy and overlap facilitate selective attention, learning, and memory.

However, with disturbed communication, different modalities can convey discordant information, difficult to integrate into a coherent percept (Shackman & Pollack, 2005). Composite multimodal measures of "engagement," which combine infant orientation to the partner (from en face to arch), visual attention (gaze on/off mother's face), and positive to negative facial and vocal affect (such as Cohn & Tronick's [1988] "monadic phases" or Beebe and Gerstman's [1980] "facial-visual engagement") are often used in research on mother–infant face-to-face communication. However, such composite measures risk neglecting the unique contributions of different modalities. Only examination of separate modalities can identify potential discordant communication, as well as specify exactly which modalities of communication may be involved in the development of insecure attachment (Bahrick, in press; Van Egeren et al., 2001; Weinberg & Tronick, 1996). For example, depressed mothers and their infants showed a discordant pattern of lowered coordination of gaze (on/off partner's face), but heightened facial/vocal affect coordination, a result not detectable if gaze and affect were assessed as a composite (Beebe et al., 2008a). On the other hand, only a composite measure provides a holistic, gestalt approach to capturing the quality of the interaction. In this study we employ both separate modalities and a composite measure, facial-visual engagement.

If attachment insecurity shows different associations with various modalities of the exchange, (1) clinically, it is easier to observe specific modalities than a composite variable; and (2) we will have a more refined view of communication disturbances. The separate modalities that we code encompass most of what can occur in a face-to-face interaction between mothers and infants at 4 months, when infants are in an infant seat, and no toys are provided. We code mother and infant gaze, facial affect, touch, and spatial orientation. For infants we also code vocal affect. The one salient modality omitted in this study is maternal vocalization (vocal rhythm data is reserved for a future report). In our prior work, the communication modalities coded here, and their degrees of self- and interactive contingency, were sensitive to maternal depressive symptoms, self-criticism, and dependency (Beebe et al., 2007, 2008a).

Direction of gaze

Gaze at the partner's face signals the possibility of an interaction and is thus the foundation of the face-to-face encounter. Infants and mothers are sensitive to the partner's direction of gaze, and by 3 to 4 months the visual system, along with head movement, approaches adult efficiency (Stern, 1974). As Stern (1971, p. 502) documented, infant control over gazing at and away from mother's face, in conjunction with head turning away, allows the infant "subtle instant-by-instant regulation of contact." Mothers tend to gaze at infants a larger proportion of the time than infants gaze at mothers (Kaye & Fogel, 1980; Stern, 1974), in part because infant gaze aversion functions to regulate arousal (Field, 1981).

Much work documents that high infant gaze aversion is problematic (Field, 1995; Stern, 1971, 1985). However, Beebe et al. (2008a) found that depressed mothers and their infants looked more at each other's faces than control dyads. Stechler and Latz (1966) documented a pattern of infant difficulty in looking away, "obligatory attention." Colombo et al. (2001) found that infants who are "longer lookers" have less efficient information-processing. Thus both extremes of high and low infant gaze away may be problematic. Similarly, either excessive or insufficient contingent coordination with partner gaze patterns may be problematic, consistent with an "optimum midrange model." In our prior work, depressed (vs. control) mothers and their infants lowered their gaze coordination, a form of withdrawal (Beebe et al., 2008a), whereas more (vs. less) "dependent" mothers heightened their gaze coordination, a form of vigilance (Beebe et al., 2007).

Facial and vocal affect

Infant perception and expression of facial and vocal affect are remarkably sophisticated. By 7 months in utero, facial innervation is almost fully myelinated (Oster, 2005). At birth, infants make nearly all the facial muscle movements of adults. The full range of display of infant facial expressions flowers by 4 months and is a central feature of these early interactions (Stern, 1985; Tronick, 1989; Weinberg & Tronick, 1994).

Whereas the study of naturalistic mother–infant interaction of necessity examines the entire ''package'' of multimodal communication, experimental methods can examine infant perception of multimodal vs. unimodal emotion. Sensitivity and discrimination of emotion emerges first in multimodal stimulation, where infants can detect redundant information common across modalities, and later in unimodal stimulation. Different methods, examining infants at different ages, give rise to slightly different estimates of the timetable of infant ability to discriminate, categorize, and understand the meaning of emotional expressions. Infants begin to differentiate and recognize social signals within the first few months of life by abstracting information that is invariant across multimodal information (Walker-Andrews, 1997). For example, 5–7-month-old infants can differentiate facial and vocal expressions (happy, sad, angry) of an unfamiliar person. Later in development, infants discriminate affect in unimodal stimulation. For example, using habituation techniques, Flom and Bahrick (2007) found that, in unfamiliar persons, infant detection of multimodal affect emerged first, at 4 months, followed by discrimination of vocal affect at 5 months, and by discrimination of facial affect by 7 months. By other methods, even neonates appear to discriminate among surprise, fear, and sadness in an adult model; they express this discrimination through corresponding expressions of their own (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977). Walker-Andrews (1997) concludes that young infants discriminate facial and vocal communication, especially in the context of a dynamic, multimodal, interactive process, but that more experimental research is needed on exactly how infants respond to their partners' facial and vocal expressions.

In the multimodal context of naturalistic face-to-face interactions with familiar adults, infants are sensitive to changes in adult facial and vocal expressions by 3 months, if not earlier (Gusella, Muir, & Tronick 1988; Haviland & Lewica, 1987; Montague & Walker-Andrews, 2002; Muir & Hains, 1993; Papousek, 1992). Infants perceive variations in the form and intensity of communicative behaviors in facial and vocal modalities (Jasnow & Feldstein, 1986; Messinger, 2002; Trevarthen, 1977; Stern, 1985). By 6 months, the basic emotions of interest, joy, disgust, surprise, distress, sadness, and anger are present, as demonstrated in cross-cultural studies (Ekman, Levenson, & Friesen, 1983; Izard, 1979). Many studies converge on the central conclusion that the infant's perception of the partner's facial affect is sufficiently accurate that the partner's emotion is of fundamental importance to the infant's own emotional state (Tronick, 1989). Studies using sophisticated contingency analyses also converge on the conclusion that, within the multimodal naturalistic face-to-face encounter, mothers and infants by 4 months do contingently coordinate the channels of facial affect, vocal affect, and vocal rhythm (Bigelow, 1998; Cohn & Tronick, 1988; Feldman, 2006; Field et al., 1990; Jaffe et al., 2001; Malatesta et al., 1989).

Infant touch

Infant-initiated touch is coded by relatively few researchers, although self touch and oral/mouthing behaviors are important means of self-comfort. Infants use more self touch during the still-face experiment (Weinberg & Tronick, 1996), when mother leaves the room, or when a stranger enters (Trevarthen, 1977). Examining infants in the "replay" experiment, where infants are subjected to a noncontingent replay of the mother's behavior from a prior normal interaction, Murray and Trevarthen (1985) found that infants turn away from mother, and show more negative expressiveness and more self touch. Koulomzin et al. (2002) found that 4-month future A (vs. B) infants showed more self touch, and the necessity to self touch in order to look at mother for durations comparable to those of future B infants, during face-to-face interaction.

Infant touch and infant vocal affect together form an emotion regulation constellation. In the across-group analysis of the current data set (Beebe et al., 2008b), we documented that infant-initiated touch functions to modulate infant vocal distress: the more touch, the less likely vocal affect was negative. Reciprocally infant vocal affect activated touch: the more positive vocal affect, the more likely was infant touch. The presence of infant touch is a coping mechanism that facilitates positive vocal affect.

Maternal touch

Although most research focuses on visual, vocal, and facial communication, maternal touch is embedded in the face-to-face exchange. Maternal touch can compensate when facial or vocal communication is not available, as in the still-face experiment (Pelaez-Nogueras, Field, Hossain, & Pickens, 1996; Stack & Arnold, 1998). Less affectionate maternal touch is associated with maternal depression (Beebe et al., 2008a; Cohn et al., 1990; Feldman & Eidelman, 2003; Tronick,1989; Weinberg & Tronick, 1996).

Spatial orientation

Infants have excellent spatial perception from birth. Neonatal auditory-visual coordination permits localization of sound in visual space. In response to a stimulus looming into the face on a collision course, infants duck their heads and put up their hands in a defensive reflex (Bower, Broughton, & Moore, 1970). Mandler (1988) documents that infants form image-schemes of the trajectories of objects and their interactions in space. Infant head orientation is a central means of regulating proximity and attention. Infants can visually monitor the mother's face peripherally from a variety of head positions. Peripheral monitoring is lost with more extreme head aversions (90° angle away; arching/twisting the body away) (Beebe, 2003; Beebe & Stern, 1977; Stern, 1971; Tronick, 1989).

In face-to-face interactions mothers may sit upright, lean forward, or "loom" into the infant's face. Demetriades (2003) found that abrupt maternal transitions from upright to loom were more likely with higher maternal anxiety. Weinberg and Tronick (1998) found more use of the upright spatial position when strangers played with infants of psychiatrically disturbed mothers. The dyadic spatial pattern of mother "chase" infant "dodge" (Beebe & Stern, 1977; Stern, 1971) is a form of maternal spatial intrusion, interfering with infant looking away: as infants "dodge" by turning away with head and body, mothers "chase" by following the direction of the infant's movement with their own head and body movements; and vice-versa. Kushnick (2002) found that chase and dodge interactions, and oscillations between loom and upright positions, were more likely in mothers with elevated dependency.

Conflicting emotional signals

Young infants perceive, and express, conflicting signals. Ten-month infants respond with ambivalence (positive and negative emotion simultaneously or in rapid succession) when an experimenter shows simultaneous conflicting angry and happy communications about a toy; infants hesitate (prolonged visual fixation on experimenter and/or reluctance to approach toy) when an experimenter shows sequential conflicting communication about the toy; and infants show most uncertainty when an experimenter shows an angry communication about the toy (Barrett, Campos, & Emde, 1996). Montague and Walker-Andrews (2002) presented 3.5-month infants with paired happy and sad, and happy and angry, expressions of their mothers, while the soundtrack for one of the two facial expressions was played from a centrally located speaker. Infants looked longer at mothers' concordant expressions when happy and sad were paired, but at mothers' discordant expressions when happy and angry were paired. Happy and angry are conflicting signals, whereas happy and sad are common blends of emotion in adults.

Weinberg and Tronick (1996) found conflicting emotional responses in 4–6-month infants during the reunion episode following the still-face: more infant joyful faces and increased looking at mother in the reunion episode compared to baseline play, but a continuation in the reunion episode of the increased infant sadness and anger shown during the still-face. Intermodal discrepancy, intra-individual or dyadic, is a particularly confusing form of communication.

Mechanisms of sensing the state of the other

Facial communication is used by a variety of researchers to explicate adult mechanisms of sensing the state of the other at the procedural level. Ekman, Levenson, and Friesen (1983; Levenson, Ekman, & Friesen, 1990) found that a particular facial expression is associated with a particular pattern of physiological arousal. Matching the expression of the partner therefore produces a similar physiological state in the onlooker. As partners match each other's affective patterns, each recreates a psychophysiological state in himself similar to the partner, thus participating in the subjective state of the other (Beebe & Lachmann, 1988, 2002). The individual's pattern of arousal provides an additional avenue of knowledge about the partner's emotional state (Levenson & Ruef, 1997). Dimberg, Thunberg, and Elmehed (2000) exposed adult subjects to 30 ms of happy, angry, and neutral target faces through a masking technique (a 5 s exposure to a neutral face before and after the target face); subjects could not consciously perceive the target face. Facial electromyographic activity (via miniature electrodes) revealed that subjects displayed distinct facial muscle reactions corresponding to the happy and angry target faces. Thus positive and negative facial reactions are evoked out of awareness, another way of participating in the state of the other. Infants also sense the state of the other at the procedural level, reviewed above (Meltzoff, 1985; Trevarthen, 1998; Stern, 1985, 1995).

Mirror neurons provide another mechanism for sensing the state of the other. Rizzolatti found that the same neurons activated as a monkey *reaches* for an ice-cream cone are also active when the monkey simply *observes* this action in the researcher. Mirror neurons provide an ''action-recognition'' mechanism: the actor's actions are reproduced in the premotor cortex of the observer (Iacoboni, Molnar-Szakacs, Gallese, Buccino, Mazziotta, & Rizzolatti, 2005; Rizzolatti, Fadiga, Fogassi, & Gallese, 1996). Through mirror neurons, the observer has an enhanced capacity to recognize the intention of the actor (Wolf, Gales, Shane, & Shane, 2001). Pally (2000) suggested that mirror neurons can be seen this way: I understand your intention by understanding (in a procedural format) what my own intention would be, if I were doing what you are doing.

Approach of the study

The modalities of communication chosen for analysis can be conceptualized as *attention* (mother and infant gaze on/off the partner's face); *affect* (mother and infant facial affect, infant vocal affect, and mother and infant composite facial-visual engagement); *touch* (maternal affectionate to intrusive touch, and presence/absence of infant-initiated touch, as well as specific types of infant touch [touch own skin, object, mother]); and *spatial orientation* (maternal sitting upright, leaning forward, looming in; infant head orientation from *vis a vis* to 60–90° aversion and arch). For each modality, we created an ordinalized behavioral scale (see Method) (with the exception of gaze on/off). Whereas the preceding modalities were analyzed for both contingencies and behavioral qualities, in addition we examined two dyadic codes, ''mother chase and infant dodge,'' and ''mother positive while infant distressed,'' for behavioral qualities only.

Within the face-to-face exchange, gaze and facial affect are central modalities of communication (Stern, 1985; Tronick, 1989; Weinberg & Tronick, 1994); infant vocal affect is an important means of communication of emotion, particularly of distress (Mumme, Fernald, & Herrera, 1996); infant-initiated touch is a salient but not well-studied behavior (Tronick, 1989; Weinberg & Tronick, 1994); affectionate to intrusive patterns of maternal touch are a central but less studied modality (Field, 1995; Stack, 2001; Stepakoff, Beebe, & Jaffe, 2000, 2008); and maternal spatial orientation and infant head orientation are not well-studied (see Beebe & Gerstman, 1980; Beebe & Stern, 1977; Stern, 1971; Weinberg & Tronick, 1998).

Among the modalities coded by our ordinalized scales, many possible pairs of infant–mother modality could be made. We chose to generate eight mother–infant ''modality-pairings'' for examination of 4-month self- and interactive contingency in relation to 12-month attachment, as listed below:

(1) infant gaze–mother gaze,
(2) infant facial affect–mother facial affect,
(3) infant vocal affect–mother facial affect,
(4) infant engagement–mother engagement,
(5) infant engagement–mother touch,

(6) infant vocal affect–mother touch,
(7) infant-initiated touch–mother touch,
(8) infant head orientation–mother spatial orientation.

Our criterion was the same modality for both partners where possible (pairings 1, 2, 4, 7, 8). In pairing (3) we examined infant vocal affect as a second way of exploring the infant's emotional response to the mother's face (see Hsu & Fogel, 2003, who found correlations between mother facial affect and infant vocalization). We explored maternal touch in relation to infant vocal affect, infant touch, and infant engagement, reasoning that infants may respond to more intrusive forms of maternal touch with vocal distress, increased touch efforts, or with changes in facial-visual engagement (see Van Egeren et al., 2001, who found bi-lateral contingencies between mother touch and infant vocalization). Because maternal touch was the most exploratory of our variables, we examined it in more pairings than the other variables.

We also explored a ninth intrapersonal pairing *within* the infant: (9) infant touch–vocal affect. This analysis constitutes an alternative approach to infant self-regulation (emotion regulation) consistent with traditional definitions as activation/dampening of emotion/arousal. Following Tronick's (1989) view that infant self touch has a self-comforting function, inhibiting negative infant affect, in our across-group analysis of these infants we demonstrated that more infant-initiated touch predicts less infant vocal distress, and more positive infant vocal affect predicts more infant touch (Beebe et al., 2008b). In the current study we test whether these 4-month patterns differ in relation to 12-month attachment security/insecurity.

We adopt the terminology of "future" secure or insecure infants to refer to 4-month patterns of infants who will be so classified at 12 months. Figure 1 shows the design of the study.

Hypotheses

We use the modalities of behavior defined above to address associations of 12-month attachment with 4-month behaviors, examining (1) the temporal process of behaviors over time through contingency analyses, and (2) qualitative features of the form and intensity of behaviors. Using the nine modality-pairings, we analyzed the origins of 12-month attachment in 4-month contingencies by the following dimensions: (a) which partner shows altered 4-month contingency with insecurity, mother or infant; (b) the type of contingency which is altered, self- or interactive; (c) whether the altered contingency is higher, or lower, relative to secure dyads; and (d) the modality of contingency altered. Using qualitative features of behaviors, we used the ordinalized mother and infant behavioral scales of each modality to examine associations with 12-month attachment. Table 1 summarizes the hypotheses.

(1) Hypotheses examining the contingency process of 4-month behaviors over time

(a) Rather than positing that higher contingency values are more optimal, we build on our prior study where both higher and lower values of vocal rhythm coordination predicted insecure attachment (Jaffe et al., 2001). We

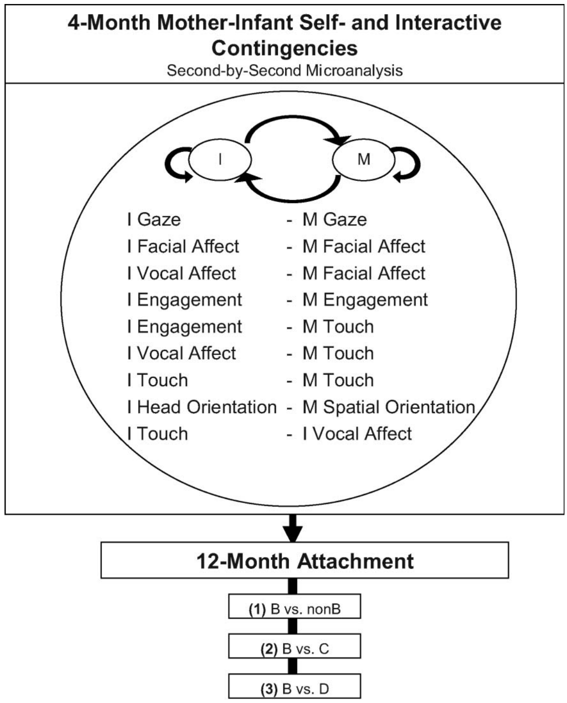

Figure 1. Design of study.

hypothesize that *12-month insecurity is associated with both heightened and lowered contingency in 4-month mother–infant face-to-face communication*: across the system of both partners and all communication modalities, *both* higher values of 4-month self- and interactive contingency (in some modalities), and lower (in other modalities), are associated with 12-month insecure (vs. secure) attachment.

(b) Based on Tronick's (1989) findings of "preoccupation" with self-regulation in infants of depressed mothers, we hypothesize that insecure infants manifest higher self-contingency of self-initiated self touch.

(c) Future anxious-resistant (C) dyads show 4-month "ambivalence": dyadic "approach-withdraw" (one partner heightened, and the other lowered, coordination within the same modality-pairing), and/or individual approach-withdraw (coordinations within a modality altered in opposite directions). This hypothesis is based on the ambivalent pattern of C infants in the Ainsworth Strange Situation: increased bids for attention, but difficulty using comfort.

(d) Mothers of future disorganized (D) infants lower their emotional (facial, engagement) coordination with infant facial/vocal/engagement changes. This hypothesis integrates Lyons-Ruth et al.' s (1999) proposal that mothers of D infants are unpredictable, so that the infants have difficulty influencing maternal behavior, as well as the finding that these mothers are less likely to acknowledge infant distress, by remaining positive when infants are distressed.

Table 1. Hypotheses.

Hypothesis	Partner	Contingency Type	Higher/lower relative to secure	Modality	Hypothesis upheld
Contingency					
(a) 12-month insecurity will be associated with both heightened and lowered contingency in 4-month M-I face-to-face communication	M, I	both	both	all	See Table 9
(b) Insecure infants manifest higher self-contingency of self-initiated touch	I	self	higher	touch	D
(c) Future C dyads show a 4-month ambivalence: dyadic approach-withdraw and/or individual approach-withdraw	M, I	both	both: opposing directions	all	C infants
(d) Mothers of future D infants lower their emotional (facial, engagement) coordination with infant facial/vocal, affect/engagement	M	interactive	lower	face, engagement	Yes (engagement)

	Partner	Higher/lower relative to secure	Quality	Hypothesis upheld
Infant qualitative behavioral features				
(a) Low and high infant gaze aversion characterize insecure infants	I	both	gaze away	No
(b) Future insecure infants show more negative facial affect	I	higher	neg facial affect	No
(c) Future insecure infants show more negative vocal affect	I	higher	vocal distress	D
(d) Future insecure infants show more facial/vocal distress	I	higher	neg fac/voc affect	D
(e) Future disorganized infants use more discrepant affect	I	higher	discrepant affect	D
(f) Insecure infants use more self-initiated touch	I	higher	self-initiated touch	No (less touch)
(g) More infant spatial aversion characterizes insecure infants	I	higher	60–90 head avert/arch	No

(*continued*)

Table 1. (*Continued*).

Hypothesis	Partner	Higher/lower relative to secure	Quality	Hypothesis upheld
Mother qualitative behavioral features				
(a) Mothers of insecure infants gaze away more than mothers of secures	M	higher	gaze away	D
(b) Mothers of disorganized infants show greater prevalence of negative facial expressiveness	M	higher	negative facial affect	No
(c) Mothers of insecure infants use less positive facial expressiveness	M	lower	positive facial affect	No
(d) Mothers of future resistant infants use touch that interrupts the infant's ongoing activity	M	higher	interruptive touch	No
(e) Mothers of future insecure infants show more intrusive touch	M	higher	intrusive touch	nonB, C
(f) Mothers of future insecure infants will show more spatial intrusion (maternal "loom" and "chase and dodge")	M	higher	spatial intrusion	C (chase and dodge) D (loom)
(g) Mothers of future disorganized infants show positive facial expressiveness while infants show distress	M	higher	facial expressiveness	D

Note: M = mother, I = infant.

(2) Hypotheses examining qualitative features of 4-month behaviors

To examine associations between 4-month qualitative features of behavior and 12-month attachment, we use two approaches. (1) The means of the ordinalized behavioral scales, which represent the full range of behaviors coded, were examined. Because the means yielded little, and because it is likely that differences may appear in rare behaviors, or "extremes" of behaviors (Lyons-Ruth et al., 1999; Tomlinson et al., 2005), we also explored (2) rare behaviors or behavioral "extremes," based on precedent in the literature or conjectures specified in advance.

Infant

(a) Infant gaze away. Most of the literature considers extensive infant gaze aversion as problematic (see Field, 1995; Stern, 1985). But infants of depressed mothers showed elevated looking at mother (Beebe et al., 2008a), and earlier work documented infant "obligatory attention," a form of gaze vigilance (Stechler & Latz, 1966). Thus we conjecture that both extremes of infant gaze aversion, very low, as well as very high, characterize insecure infants.

Based on findings that toddler negative affect predicts social and cognitive difficulties in development, and that toddler negative affect is associated with insecure attachment (NICHD Early Child Care Research Network, 2004), we made the following hypotheses:

(b) Infant negative facial affect. We hypothesize that future insecure (vs. secure) infants show more negative facial affect.

(c) Infant negative vocal affect. We hypothesize that future insecure (vs. secure) infants show higher vocal distress.

(d) Infant facial/vocal distress. We hypothesize that future insecure (vs. secure) infants show more overall affective distress (facial/vocal affect).

(e) Infant discrepant facial/vocal affect. We hypothesize that future disorganized (vs. secure) infants use more discrepant affect (simultaneous positive and negative facial and vocal affect). This hypothesis is based on the definition of 12-month disorganized behavior within the Strange Situation as involving simultaneous approach and avoidance behavior, and on clinical observation by the first author of videotapes of the Jaffe et al. (2001) data set.

(f) Infant touch. We hypothesize that insecure infants are "preoccupied" with touch, as manifested by more use of infant-initiated touch, based on Tronick (1989), who found that infants of depressed mothers were preoccupied with self-regulation efforts, including self touch.

(g) Infant 60–90° head avert/arch. We hypothesize that more infant spatial aversion (60–90° head aversions, or head/body arching away from mother), characterizes insecure infants. This conjecture is based on Stern (1971) and Beebe and Stern (1977), who described the clinical significance of this pattern.

Mother

(a) Mother gaze away. We hypothesize that mothers of insecure (vs. secure) infants gaze away more than mothers of secures, conjecturing that these mothers have more difficulty with visual intimacy.

(b) Mother negative facial affect. We hypothesize that mothers of disorganized (vs. secure) infants show greater prevalence of negative facial expressiveness, a parallel to the finding of greater frightened/frightening faces in D mothers (Main & Hesse, 1990).

(c) Mother positive facial affect. We hypothesize that mothers of insecure (vs. secure) infants use less positive facial expressiveness.

(d) Mother interruptive touch. We hypothesize that mothers of future resistant (vs. secure) infants use touch that interrupts the infant's ongoing activity (see Cassidy & Berlin, 1994).

(e) Mother intrusive touch. We hypothesize that mothers of future insecure (vs. secure) infants show extremes of intrusive touch, based on findings of more intrusive maternal behavior by mothers of insecure infants (Belsky, 1999; Tomlinson et al., 2005; Vondra, Shaw, & Kevenides, 1995).

(f) Mother spatial intrusion ("loom" and "chase and dodge"). We hypothesize that mothers of future insecure infants will show more spatial intrusion, measured by maternal "loom" and dyadic maternal "chase" and infant "dodge" behavior, based on Stern (1971) and Beebe and Stern (1977). In addition, Demetriades (2003) found more loom behavior in anxious mothers; Kushnick (2002) found more "chase and dodge" in dependent mothers.

(g) Mother affective error. We hypothesize that mothers of future disorganized infants show positive facial expressiveness while infants show distress, based on Lyons-Ruth et al. (1999).

Chapter 2. Method

Participants

Recruitment

Within 24 hours of delivering a healthy first-born infant, 152 mothers were recruited from Children's Hospital, Columbia University Medical Center, for a study of "infant social development" involving 4- and 12-month lab visits for videotaping (1992–1998).[1] Subjects were primiparous women delivering full-term, healthy, singleton infants without major complications. Mothers were at least 18 years old, married or living with partner, with home telephone. At 4 months, 132 mothers and infants came to the lab for videotaping. No significant differences were found in ethnicity, education, or infant gender between the 132 participants at 4 months and the 152 recruited at birth. At 12 months, 84 mother–infant pairs returned for assessment of attachment (Strange Situation). The 84 with attachment classifications did not differ from the 48 without, in age, ethnicity, infant gender, or a global code of mothering style.[2] Many efforts were made to retain subjects for the 12-month follow-up. The main reason given by mothers for not attending was that they had returned to work. The high attrition is also likely influenced by high rates of urban mobility in New York City. The attrition rate is similar to that of Jaffe et al. (2001), for a sample collected in the same hospital, with the same criteria, a half decade earlier.

Demographic description

Of the 84 dyads who returned at 12 months, mothers had a mean age of 29 (SD = 6.4, range 18–43), with ethnicity 51.2% White, 29.8% Hispanic, 16.7% Black, 2.4% Asian. Completion of some college or more characterized 87.4% of mothers (3.6% without High School diploma, 4.8% without college, 26.2% some college, 34.5% college degree, 31.0% post college education). Obvious risk factors were absent. Of the 84 dyads, 37 infants (44%) were female.

Procedure

Scheduling of 4- and 12-month lab videotaping took into account infants' eating/sleeping patterns. At 4 months, mothers (seated opposite the infant) were instructed to play with their infants (in an infant seat on a table) as they would at home, but without the use of toys, for 10 min (necessary to obtain vocal rhythm data for a separate report). Two video cameras generated a split-screen view of the interaction. At 12 months, consistent with our prior procedure (Jaffe et al., 2001), following a face-to-face interaction (reported separately), a break and a snack, mothers and infants participated in the Ainsworth Strange Situation.

Measurement of infant attachment at 12 months

This laboratory test of infant attachment at 12 months followed the separation-reunion paradigm known as the Strange Situation (Ainsworth et al., 1978). The standard 4 infant categories avoidant (A), secure (B), anxious-resistant (C), and disorganized (D) were coded by Dr. Elizabeth Carlson. The percent of B infants was 56% ($N = 47$), of A was 5% ($N = 4$), of C was 19% ($N = 16$), and of D was 20% ($N = 17$). Of the 17 D infants, 3 were D/B, 4 D/A, 6 D/C, and 4 D/cannot classify. Of the 84 infants, 37 were insecure (nonB). Of 47 male infants, 24 were nonB; of 37 female infants, 13 were nonB. A second rater performed reliability coding for A, B, and C on a subset of 32 randomly selected dyads (40% of the sample). Using Cohen's Kappa, a measure of inter-rater agreement (1 = perfect agreement, 0 = no agreement), Kappa = .55, $p < .001$. Regarding reliability for the D classification, within this same subset of 32, there were 7 D infants, and reliability coding yielded 88% agreement (6/7) for these cases. We also classified infants using the 7-point degree of disorganization scale. Table 2 shows that all D infants had scores of 5–7; three C infants had scores of 5; one B had a score of 5; no A's had a score over 4.

Behavioral coding of mother–infant interaction at 4 months

The first 2½ uninterrupted continuous play minutes of videotaped mother–infant interaction were coded on a 1 s time base (see Cohn & Tronick, 1988;

Table 2. Percent of A, B, C and D infants with degrees of disorganization 1 to 7.

Degree of disorganization scale	Attachment classifications Degree of disorganization within each classification				
	A (N = 4)	B (N = 47)	C (N = 17)	D (N = 18)	Total
1	0.0	27.7	31.3		21.4
2	50.0	12.8	6.3		10.7
3	25.0	34.0	18.8		23.8
4	25.0	23.4	25.0		19.0
5		2.1	18.8	29.4	10.7
6				41.2	8.3
7				29.4	6.0

Field et al., 1990) by coders blind to attachment status, using Tronick and Weinberg (1990) timing rules (see Appendix A, note). Ambady and Rosenthal (1992) showed that accuracy in predicting interpersonal consequences did not differ among observations varying from 30 s to 5 min; samples <5 min did not differ from those based on longer samples; the effect size was higher than most effect sizes in social psychology. Samples of face-to-face interaction of 2–3 min are stable, generating robust session-to-session reliability (Cohn & Tronick, 1989; Moore, Cohn, & Cambell, 1997; Weinberg & Tronick, 1991; Zelner, Beebe, & Jaffe, 1982).

Mothers and infants were coded independently. Communication modalities coded were mother gaze, facial affect, touch, and spatial orientation; infant gaze, facial affect, vocal affect, touch, and head orientation. Behavioral codes were used to create *ordinalized scales* for data analysis (required by time-series techniques). Appendix A defines the behavioral coding schemes and the ordinalized behavioral scales. *Mother facial affect* was ordinalized from a high of "mock surprise" to a low of "negative face"; *infant facial affect* was ordinalized from a high of "high/medium positive" to a low of "negative"; *gaze* was coded on-off partner's face; *infant vocal affect* was ordinalized from "positive/neutral" to "angry protest/cry"; *infant-initiated touch* was ordinalized as two or more touch behaviors (touch own skin, clothing/object, mother), one, or none; *infant head orientation* was ordinalized from "en face" to "arch"; *mother spatial orientation* was ordinalized as "sitting upright," "leaning forward," and "looming in." Web Appendix 1 (http://nyspi.org/Communication_Sciences/index.html) lists the 21 mother touch behaviors coded (Stepakoff, 1999; Stepakoff et al., 2000). Appendix B defines the mother touch scale, ordinalized from a high of "affectionate" to a low of "high intensity/intrusive."

Reliability estimates (Cohen's Kappa) were computed per dyad, for 30 randomly selected dyads (tested in three waves to prevent coder "drift"), for ordinalized scales (with the exception of mother touch, where kappas were computed for the 21 behaviors). The mean Kappas (and range per dyad) for the 30 dyads follow. Infants: gaze. 80 (.63–.95), facial affect. 78 (.53–1.00), touch. 75 (.60–.98), vocal affect. 89 (.72–1.00), head orientation. 71 (.61–1.00). Mothers: gaze. 83 (.68–.97), facial affect. 68 (.45–.84), touch. 90 (.62–.99), spatial orientation. 89 (.57–1.00), dyadic chase and dodge. 89 (.59–.99). Mother facial affect (nine degrees) was difficult to code; one dyad with poor video quality was difficult to code for chase and dodge.

Appendix C presents the mother and infant engagement scales, generated with algorithms (obviating reliability testing). A composite ordinalization of the behaviors was created, one for mother and one for infant, based on a combination of Tronick's (1989) "monadic phases" and Beebe and Gerstman's (1980) mother and infant engagement scales. Infant engagement is a composite of gaze (on/off mother's face), head orientation (from en face to arch), and facial affect and vocal affect (from positive to negative), ordinalized from a high infant score of "high positive engagement" to a low of "cry." All component variables are correlated with infant engagement: head orientation ($r = .454$), vocal affect ($r = .479$), facial affect ($r = .515$), and gaze ($r = .664$), (all $p < .001$). Mother engagement is a composite of gaze and facial affect, ordinalized from a high score of "mock surprise" to a low of "neutral/negative off." Mother engagement is correlated with gaze ($r = .671$) and facial affect ($r = .783$), (all $p < .0001$).

Using our ordinalized scales, we generated eight mother–infant "*modality-pairings*," and a ninth *intrapersonal* infant pairing, for data analysis, as noted above. The associations of 4-month behavior with 12-month attachment were analyzed in 3 contrasts: secure (B) vs. (a) insecure (nonB: A, C, D), (b) resistant (C), and (c) disorganized (D); avoidant (A) were too few to test. We analyzed the insecure (nonB) group to be comparable to much of the literature.

Data analysis

Bivariate analyses of qualitative features of behavior

One central goal of the study was the investigation of differences in qualitative features of 4-month behavior in relation to 12-month attachment classifications. We tested direct associations between means of 4-month ordinalized behavior scales (e.g. mothers' mean facial affect, infants' mean facial affect) and future infant attachment status (contrasts of B vs. nonB, B vs. C, and B vs. D), using traditional bivariate analyses. Although main effects of the multi-level models could be interpreted for these associations, we chose to test for effects without having controlled for the various other variables in our models.[3] Our bivariate analyses, conducted at the dyad level, are thus more comparable to those in the literature.

Lack of findings when testing means of the ordinalized behavioral scales (see below, p. 43) prompted an exploratory approach, labeled the analysis of "behavioral extremes," following Lyons-Ruth et al. (1999), and Tomlinson et al. (2005). We conjectured that the specific way that we operationalized the behavior in question would matter in identifying associations with attachment. The measurement of behavioral extremes was by definition exploratory, because there is no precedent in data coded to a 1 s time base in multiple separate modalities. In our behavioral extremes approach, attachment was tested for association with mean percent of time per individual of *specific behaviors* considered clinically relevant (such as maternal intrusive touch), rather than the mean of the ordinalized scale. In addition we identified which mothers or infants had "ever" used these extreme behaviors, and those that had used them to an "excessive" degree (20% or more of 150 s). Using maternal touch as an example, we first tested for the mean of the scale; then we tested for a clinically relevant behavioral extreme, "intrusive touch," which could be examined as (a) the percent of time in intrusive touch, (b) whether intrusive touch was ever used, or (c) whether intrusive touch was used an excessive amount of time.

These three measures of "behavioral extremes," (1) percent time, (2) "ever" used, and (3) excessive use, allowed us to evaluate whether precursors of insecure attachment could be found in the mere existence of a particular behavior, the percentage of time it was used, or in its excessive use. Behaviors assessed are defined in Table 3. Distributions of the behavioral extremes across the group can be found in Web Appendix 2, and descriptive statistics for the behavioral extremes by attachment classification can be found in Web Appendix 3, both of which are posted on our website (http://nyspi.org/Communication_Sciences/index.html).

Analyses were tailored to each measure. All three behavioral extremes measures were not always appropriate. We used parametric and/or nonparametric tests as

Table 3. Definitions of behavioral extremes (derived from ordinalized behavioral scales).

Ordinalized behavioral scale	Definitions of behavioral extremes	
INFANT		
Gaze	Gaze away	Look away from mother's face
Facial affect	Negative facial affect	Frown, grimace, pre-cry, and cry face
Vocal affect	Negative vocal affect	Fuss, whimper, angry protest, cry
	Distress (facial or vocal)	Either negative facial affect or negative vocal affect
	Discrepant affect	Simultaneous (within the same sec) positive affect in one modality (either facial or vocal) and negative affect in the other
Touch	No touch	No infant-initiated touch
	Touch own skin	Touch/suck own skin
Head orientation	60°–90° avert	Avert head 60°–90°
	arch	Arching back
	% Avert or Arch	Either 60°–90°avert or arch
MOTHER		
Gaze	Gaze away	Look away from infant's face
Facial affect	Positive facial affect	Smile 2, smile 3, mock surprise; (see Appendix A)
	Negative facial affect	Frown and/or grimace and/or compressed lips
Touch	Intrusive touch	Rough (scratch, push, pinch)/ high intensity aggressive touch
	Interruptive touch	Maternal touch "push, constrain movement, force or control infant movement" (e.g., force of infant's hand down)
Spatial orientation	Loom	Mother head "loom" in toward infant's face
DYADIC		
Infant facial/ Vocal affect, M facial affect	M Positive facial affect while I distressed	Infant distress episodes initiated by sec in which infants showed negative vocal/facial affect; Mother positive face smile 2 or higher
	Chase & Dodge[a]	2 consecutive sec in which mother moves head toward infant's face while infant (in same or following sec) orients head away

Note: See Appendix A for all definitions with the exception of Mother Touch, WEB Appendix 1.
[a]Chase and dodge was not constructed from the separate ordinalized behavior scales but rather was coded as a dyadic variable.

appropriate, since many distributions were heavily skewed. We tested associations with attachment categories as well as the degree of disorganization scale (tested across the group). This exploratory approach to behavioral extremes yielded far more than means of the ordinalized scales. We note that results were very sensitive to the particular way of measuring the behavior. Because behaviors were at times tested multiple ways, these analyses must be taken with caution and require replication.

Self- and interactive contingency analyses

The SAS PROC MIXED program (Littell, Miliken, Stoup, & Wolfinger, 1996; McArdle & Bell, 2000; Singer, 1998) was used to estimate random (individual differences) and fixed (common model) effects on patterns of self- and interactive behavior over 150 s. Modeling the complexity of real-time interactions remains difficult. Whereas time-series analysis has been considered state-of-the-art, the multilevel time-series models used in this study have many advantages. They are designed to address patterns over time, translated here into the course of behavior second-by-second, either within the individual (self-contingency), or between two individuals (interactive contingency).

To analyze interactive contingency, traditional time-series techniques first create two separate estimates per dyad of the magnitude of the effect of partner's prior behavior on the individual (infant behavior predicts that of mother: I $\rightarrow$ M; mother behavior predicts that of infant: M $\rightarrow$ I), controlling for the individual's prior behavior (autocorrelation). These estimates are then entered into regression equations to relate them to some other variable (e.g. attachment); the error of the individual scores is lost. These Ordinary Least Squares (OLS) estimates for each partner make the invalid assumption that the model predictors are fixed: that they represent investigator-selected, e.g., maternal behaviors. This assumption ignores a source of error when the predictor (such as, which infants are insecure) is not selected or manipulated by the investigator. In contrast, this source of error is taken into account in the multilevel time-series models, producing more accurate estimates. Multilevel models (Singer & Willett, 2003) have more power, take into account error structures, and estimate individual effects with empirical Bayesian (maximum likelihood) techniques (rather than OLS), which take into account prior distributions. Because the prior probability of error is greatest for the extreme parameters, this method tends to "pull in" such extremes. Additional advantages of this approach include: (a) multiple time-series (in our case, self- and interactive contingency) can be modeled simultaneously, (b) an average effect of key parameters (e.g. I $\rightarrow$ M contingency) is estimated for the group and allows the investigator to ask how that group mean changes in the context of other factors such as attachment security, (c) control variables and their conditional effects can be included as necessary, (d) an increased information payload results, and (e) more appropriate statistical model assumptions are made.

The models developed here examined nine modality-pairings, including one, mother gaze – infant gaze (on/off gaze), in which the dependent variable is dichotomous and therefore analyzed by the SAS GLIMMIX program (Cohen, Chen, Hamgiami, Gordon, & McArdle, 2000; Littell et al., 1996). Analyses used all 150 s coded from videotape for each individual. In these models, repeated observations of individuals are the basic "random" data, just as in cross-sectional data single individual variables are the basic units of analyses. "Fixed" effects, however, indicate average effects over the full sample, so that it is possible to estimate the extent to which a single overall model accounts for the individual differences reflected in the "random" model.[4]

Preliminary analyses estimated the number of seconds over which lagged effects were statistically significant and their magnitude for the pairs as a whole (fixed model estimates). For each dependent variable, measures of prior self or partner behavior, termed "lagged variables," were computed as a weighted average of the recent prior second, based on these analyses. Typically the prior 3 s sufficed to account for these lagged effects on the subsequent behavior.[5] This analysis is illustrated in Figure 2. The estimated coefficient for the effects of these lagged variables upon current behavior over the subsequent 147 s of interaction indicates the level of self- (M → M, I → I) or interactive (M → I, I → M) contingency: the larger the coefficient, the stronger the contingency. Each subsequent analysis included both sources of contingency; thus estimated coefficients of one form of contingency control for the other.

Tests of hypotheses used fixed rather than random effects. For each model, second-by-second data on individuals is considered the basic random model. Thus the first step in these analyses examined the between-subject differences ("random effects") in mean level, linear slope over time, mean by time, and autoregressive error. We found substantial random variance (individual differences) in means, in linear changes over time, and in mean by linear change interactions. In addition we found that residuals were not independent over adjacent seconds; we therefore included autocorrelation in random models. In predicting gaze we ran models of random intercept only, using the SAS macro GLIMMIX program. These random models were the basis for examination of the fixed effects. Significant random effects were thus removed from the fixed effects models.

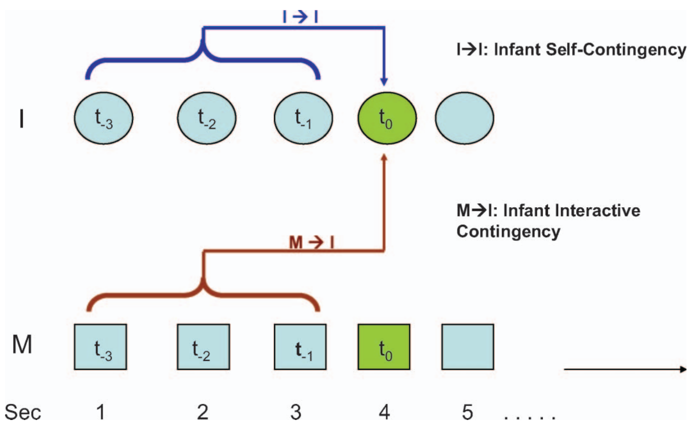

Figure 2. Illustrations of infant self- and interactive contingencies defined by time-series analysis.
Note: To calculate infant self-contingency, second 4 in the infant's stream of behavior identifies t_0, the predicted second. A weighted average of seconds t_{-1}, t_{-2}, and t_{-3} in the infant's behavioral stream identify the "weighted lag," which is used to predict t_0. To calculate infant interactive contingency, a weighted average of seconds t_{-1}, t_{-2}, and t_{-3} in the mother's behavioral stream is used to predict t_0 in the infant's behavioral stream. For both self- and interactive contingency, this is an iterative process in which second 5 will then identify the new t_0, and seconds 2, 3, and 4 will identify the new "weighted lag." A parallel diagram would depict mother self- and interactive contingency.

Prior to testing associations with attachment, a *basic model* of fixed (‘‘average’’) effects was produced for each behavioral dependent variable. The modeling process for predicting the time-varying behavioral variable in question (e.g. mother facial affect) considered time (potential linear change over time), all demographic variables, effects of lagged variables as described above, and all possible 2-way interactions between control variables and self- and interactive contingency. Effects of lagged variables represent the average self- and interactive contingency across the subjects. Therefore, when testing associations with attachment, any differences in the magnitude of estimated coefficients reflected in the fixed effects reflect influences of attachment on self- and interactive contingency.

Variables in the multilevel basic models were added in the following steps following the mean value of the dependent variable: (1) time (sequence of observation, second-by-second), (2) self- and partner lagged variables, (3) demographic variables, (4) conditional effects between demographic variables, and (5) conditional effects of demographic variables with lagged self and lagged partner behavior. Because effects of demographic variables and their conditional effects were included as a check on the assumption that these would not alter the basic findings, when these effects were not significant they were dropped from subsequent and final models.

To illustrate our equation, for the predicted value of mother behavior from mother and infant behavior, the ‘‘basic model’’ equation for fixed effects was

$$\mathrm{M} = \mathrm{M}_{\mathrm{lagged}} + \mathrm{I}_{\mathrm{lagged}} + \mathrm{attach} + \mathrm{demographics} + \mathrm{M}_{\mathrm{lagged}} * \mathrm{attach} + \mathrm{I}_{\mathrm{lagged}} * \mathrm{attach}$$

Where

$\mathrm{M}_{\mathrm{lagged}}$ – represents a weighted mean of mother’s lagged behavior,
$\mathrm{I}_{\mathrm{lagged}}$ – represents a weighted mean of infant’s lagged behavior,
attach – represents attachment (B vs. nonB, B vs. C, B vs. D),
demographics – represents all demographic variables retained from earlier steps.

Coefficients in the fixed effects model for $\mathrm{M}_{\mathrm{lagged}}$ and for $\mathrm{I}_{\mathrm{lagged}}$ represent mother self-contingency and mother interactive contingency, respectively. For details of computation see Chen and Cohen (2006). Because our goal was an examination of self- and interactive contingency in relation to attachment, we refer the reader to Website Appendix 4 for ‘‘basic model’’ tables (http://nyspi.org/Communication_Sciences/index.html), three for each of the nine modality-pairings, a total of 27 tables. Prior across-group analyses using these basic models on the current data set showed significant coefficients with positive signs for self- and interactive contingency in all modality pairings (see Beebe et al., 2003, 2008b), with one exception, infant head orientation predicting mother spatial orientation, significant with a negative sign.[6]

In a traditional study design, 12-month attachment would be the dependent variable, and 4-month behavior the independent. Our use of multilevel models to assess self- and interactive contingency requires that 4-month second-by-second behavior be the dependent variable, with self and partner lagged behavior the independent variables, and attachment as an additional independent variable. The central hypotheses involved the associations of infant attachment classifications with the lagged effects that reflect self- and partner contingency. Following each basic model, we examined statistical interactions of attachment with lagged self and partner behavior (self- and interactive contingency). Attachment was used as a categorical measure in three analyses, comparing secure (B) with (1) insecure (nonB: A, C, D), (2) resistant (C) and (3) disorganized (D) classifications. Demographic variables were controlled as outlined above. Each model included a chi-square test of improvement of fit to the data. Standardized regression coefficients are presented in all tables. Type I error was set at $p < .05$ for each model of the nine modality-pairings; all tests were 2-tailed. With 84 dyads $\times$ 150 s = 12,600 s per partner per communication modality, we had ample power to detect effects.

Introduction to Chapters 3, 4, and 5: Results and discussions

The results are presented in 3 chapters, organized by attachment classifications. Chapter 3 presents contrasts of nonB ($N = 37$) vs. B ($N = 47$), Chapter 4 presents contrasts of C ($N = 16$) vs. B, and Chapter 5 presents contrasts of D ($N = 17$) vs. B. The results in each chapter are organized by qualitative features of behavior, followed by self- and interactive contingency. We refer to 4-month dyads as "future" secure/insecure, since the classification is not made until 12 months. We refer to infants as male, to distinguish infants from mothers. There were no significant associations between attachment and maternal education, age or ethnicity. One association of infant gender and infant disorganized attachment is presented in Chapter 5.

In each chapter, we first present the results, and then a two-part discussion. In Chapter 3, Discussion Part I addresses the findings of future secure dyads, whereas Discussion Part II addresses the findings of future insecure (vs. secure) dyads. In Chapters 4 (C vs. B) and 5 (D vs. B), Discussion Part I addresses the findings of future C and D dyads, respectively. Discussion Part II offers a more speculative formulation of the origins of internal working models of future C and D dyads, respectively. Discussion Part II also evaluates the use of the interaction patterns described in the Introduction (Contingencies and Internal Working Models), as well as possible infant disturbances in coming to know and be known by the mother's mind, as well as coming to know his own mind. We do not make these evaluations for the future nonB infants because future C and D infants are combined in the nonB analysis. Finally we provide a general discussion in Chapter 6.

Chapter 3. Results: Future insecure (nonB) vs. secure (B) dyads

This chapter presents findings first for qualitative behavioral features, and then for self- and interactive contingency, in 4-month "future" nonB vs. B dyads. Although dyads classified at 12 months as A, C, and D were included in the nonB group, because A dyads were so few ($N = 4$), the nonB group is composed primarily of C and D. Following presentation of the results, we provide a discussion in two parts: a discussion of the findings of the secure subgroup, and then a comparison of the secure and insecure (nonB) subgroups.

Differences in qualitative behavioral features in future nonB vs. B dyads

We first asked whether qualitative features of 4-month behaviors (such as amount of gazing away) differentiated future nonB vs. B dyads, using two approaches: (1) the means of ordinalized behavioral scales, and (2) behavioral extremes. Whereas the means of the ordinalized behavioral scales used the full range of behaviors in the scales (such as the mean of the maternal touch scale), the behavioral extremes approach examined the prevalence of specific behaviors at the extremes of the scales (such as intrusive maternal touch). This approach explored several measures, tailored to each behavior as appropriate: (a) the mean percent time of a specific behavior (such as mother intrusive touch); (b) when distributions were very skewed, the percent of participants who ''ever'' used a particular behavior; or (c) percent of participants showing excessive use of a specific behavior, defined as 20% time or more in a particular behavior (such as 20% + time in mother intrusive touch). Table 4 presents these results, first for infants, then mothers. Web Appendix 3 (posted on our website) presents the rates of behaviors for the three measures above, as well as ranges of percent time, across the group, and for B and nonB dyads.

Table 4 shows that when qualitative features of behaviors were evaluated as means of ordinalized behavioral scales, which tapped the full range of behaviors coded, there was only one significant finding for future nonB infants. The frequency of infant-initiated touch (measured as no touch [0], any one type of touch [1], or more than one type of touch [2] per second), was lower in future nonB (mean = .64, SD = .26) than B infants (mean = .75, SD = .23) ($t = -2.07$, $p < .04$)

Table 4. Associations between 4-month qualitative features of behavior and 12-month infant attachment.

	Means of ordinalized behavioral scales				Behavioral extremes		
Modality	nonB	C	D	Modality	nonB	C	D
INFANT							
Gaze	–	–	–	Gaze away	–	–	–
Facial affect	–	–	–	Negative facial affect	–	–	–
Vocal affect	–	–	–	Negative vocal affect	–	–	↑
				Distress (facial or vocal)	–	–	↑
				Facial /vocal discrepant	–	–	↑
Touch frequency	↓	–	↓	No touch	↑	–	↑
				Touch own skin	–	–	↓
Head orientation	–	–	–	60° – 90° avert	–	–	–
				Arch	–	–	–
MOTHER							
Gaze	–	–	–	Gaze away	–	–	↑
Facial affect	–	–	–	Negative facial affect	–	–	–
				Positive facial affect	–	–	–
Touch	–	–	–	Interruptive touch	–	–	–
				Intrusive Touch	↑	↑[b]	–
Spatial orientation	–	–	–	Loom	↑	–	↑
				Chase + Dodge	↑	↑	–
DYADIC[a]							
				Mother positive facial affect/Infant distress	–	–	↑

Note: ↑ = significant increase (↓ = significant decrease) in behavior for nonB, C and D, each compared to B ($p < .05$); – = not significant.
[a]Dyadic codes were tested exclusively as behavioral extremes.
[b]Increased maternal intrusive touch p = .066 for C (vs. B); see footnote 7.

(see Appendix A for code definitions). Illustrating with ‘‘no touch’’ (failure to touch at all), 12.8% of B infants but 33.3% of nonB infants failed to touch, over twice as many. In contrast, Table 4 shows that when qualitative features of behaviors were evaluated as rates of behavioral extremes, associations with attachment were more visible. Thus averaging our behavioral scales missed essential patterns that the analysis of behavioral extremes revealed. In what follows we present results of these analyses.

Infant gaze away

Defined as *looking away* from mother’s face, across all infants, an examination of the distribution of percent time looking away from mother’s face revealed a relatively uniform distribution. Web Appendix 3 (posted on our website) shows that all infants gazed away at some point across the 2.5 min coded; infant looking away at least 20% of the time was common (91.7% of infants met this criterion). Percent time infants gazed away ranged from 2–97% (mean percentage time 55.5%, SD = 26.4). There were no differences in mean values of percent time infant gaze away, or excessive infant gaze away (20% of the time or more), for future nonB vs. B classifications.

Infant negative facial affect

Defined as codes *frown, grimace, pre-cry, and cry-face*, infants showed *negative facial affect* between 0–68.5% of the time (mean = 7.7%, SD = 13.8) (see Web Appendix 3, posted on our website). Percentage of infants ‘‘ever’’ showing negative facial affect was 58.3%, and percentage with excessive use was 15.5%. Using percent time in negative facial affect, and excessive use of negative affect, future nonB vs. B infants did not differ.

Infant negative vocal affect

Defined as *fuss, whimper, angry protest, or cry*, infant *negative vocal affect* yielded a skewed distribution. Many infants showed at least some distress but few showed much. Percent time in infant vocal distress ranged from 0–89.2% (mean = 10.7%, SD = 15.2). Percentage of infants ‘‘ever’’ showing negative vocal affect was 68.4%; percentage showing excessive use was 24.1%. Future nonB vs. B infants did not differ in average percent time in negative vocal affect.

Infant facial/vocal distress

We created a new variable, *infant facial/vocal distress*, number of seconds (of 150) in which infants showed negative facial and/or vocal affect. The mean percent time in facial/vocal distress was 13.1% (SD = 18.0) across the group. There were no differences in future nonB vs. B infants.

Infant discrepant facial/vocal affect

Defined as simultaneous (within same second) positive affect in one modality (facial or vocal) and negative affect in the other, infant *discrepant affect* was rare, ranging 0–5.3% of the time across the group, and representing 1.1% of the data set

(215 s). It was over twice as likely to be positive facial affect and negative vocalization (72.5% s), as negative facial affect and positive vocalization (27.5%). The percentage of infants across the group ''ever'' showing discrepant affect was 26.2; there was no excessive use. Tested as presence/absence of any discrepant affect, future nonB vs. B infants did not differ.

Infant 60–90° avert/arch

Infant head orientation 60–90° *avert* indicates head movement away from the vis-à-vis to approximately 60–90°. Infant *arch* indicates a whole body movement, head and back arching away from the vis-à-vis. Both these behaviors were relatively rare. Across the group, infants ranged 0–27.3% time in 60–90° avert (mean = 3.7%, SD = 6.4). Across the group, 57.1% of infants ''ever'' used 60–90° avert; percentage of infants showing excessive use was rare (6.0%). Across the group, infants ranged 0–47.3% time in arch (mean = 2.2%, SD = 6.6); 42.9% of infants ''ever'' used arch; percentage of infants showing excessive use was rare (2.4%). Tested as presence/absence and as percent time, neither 60–90° avert nor arch tested individually, nor the two behaviors tested together, differentiated future nonB vs. B infants. Most likely we failed to find associations because both 60–90° avert and arch showed few individual differences; roughly half the infants ''ever'' used these behaviors, but few infants used them much.

Infant touch

As noted above, when infant-initiated *touch* was tested as the *mean* of the ordinalized touch scale (none, any one type of touch, or more than one), future B infants showed more touch than nonB. Infant touch was examined with the mean percent time in separate codes (*none, touch/suck own skin, touch/suck object [own clothing, strap, chair], touch/suck mother*). The mean percent time in ''no touch'' across the group was 33.7% (SD = 22.1) (range 1.0–95.0). Percent time in ''no touch'' was more frequent in future nonB (mean = 40%, SD = 43.6) than B infants (mean = 29.2%, SD = 19.7) ($t = 2.27$, 81 df, $p = .03$). The mean percent time infants spent in ''touch own skin'' across the group was 13.0% (SD = 17.6) (range 0.0–87.0), but did not differentiate future nonB vs. B infants. The codes of infant touch object (20.7% time), touch mother (28.6%), or more than one type of touch (4.0%) yielded no effects.

Mother gaze away

Across the group, mother *gaze away* from infant's face ranged 0–53.0% time (mean = 15.8%, SD = 13.4); the percentage of mothers ''ever'' showing gaze away was 97.6%; the percentage showing excessive use (20% time or more) was 26.2%. Using excessive use of percent time gazing away, 14.9% of B and 29.7% of nonB mothers met this criterion, but contrasts were not significant (by chi-square test).

Mother negative facial affect

Defined as *frown, grimace, and tight compressed lips* (see Appendix A), across the group, maternal *negative facial affect* ranged from 0–9.3% of the time (mean = 1.0%, SD = 2.1), a rare behavior. Percentage of mothers ''ever'' showing negative facial affect was 34.5%, yet 90% of mothers showed it under 5% (mean = 2.8%) of the time. Two-thirds of mothers never showed it; no mothers showed excessive use. Because it was highly skewed, we tested it as presence/absence. The percentage of mothers "ever" using negative facial affect did not differ for mothers of future B (44.0%) vs. nonB (35.1%) infants.

Mother positive facial affect

Defined as smile 2, smile 3, or mock surprise (see Appendix A), across the group mothers ranged 0–80% time in *positive facial affect* (mean = 23.2, SD = 17.5). Percentage of mothers "ever" showing it was 96.4%; 50% showed 20% time + in positive affect; 15.5% showed 40% time (60 s) or more. Percentage of mothers meeting 20% time + was 51.1% for future B and 48.6% for nonB; percentage meeting 40% + was 17.0% for future B mothers and 13.5% for nonB, not significant differences.

Mother positive/surprised while infant distressed

Following Lyons-Ruth et al. (1999), we tested whether mothers of future insecure infants are positive while infants are distressed, a form of "affective error." Infant distress episodes (minimum of 2 s) were identified, initiated by any second in which infants showed negative vocal and/or facial affect. Mother positive facial affect was defined as moderate to full-display smiles, as well as mock surprise (a minimum of smile 2 or higher: see Appendix A). We computed the number of seconds during which the mother showed a positive/surprise face in a 4 s window: 1 s in which infant showed distress, and the following 3 s. Because infants had different numbers of distress episodes, we analyzed the infant distress episode in which the mother expressed the greatest number of seconds of positive facial affect. This measure of *mother positive/infant distressed* occurred in 53.1% of dyads. Neither parametric nor nonparametric testing yielded significant nonB vs. B contrasts.

Mother interruptive touch

Attempting to replicate findings that C mothers tend to interfere and interrupt infant ongoing activity (see Cassidy & Berlin, 1994), we used number of seconds of the maternal touch code *push, constrain movement, force or control infant movement*, (e.g. force infant's hand down) (code 16: see Website Appendix 1). Mothers showed a range of 0–76% time in interruptive touch (mean = 1.5%, SD = 8.6). The percentage of mothers "ever" showing interruptive touch was 15.5%; the percentage showing excessive use was 1.2%. Because the data were heavily skewed, with most mothers showing no interruptive touch, we tested presence/absence. Future B (12.8%) vs. nonB (18.9%) mothers did not differ in "ever" using this code.

Mother intrusive touch

Defined as codes *rough touch [scratch, pull, push, pinch, poke]/high intensity aggressive touch*, the distribution of mother *intrusive touch* was highly skewed. Mothers ranged 0–94% time in intrusive touch (mean = 7.1%, SD = 16.4); half of mothers (53.6%) showed none. Percentage of mothers who "ever" used intrusive touch was 46.4%; percentage showing excessive use (30 s or more) was 13.1%; 25% of mothers used intrusive touch more than 4.5% of the time. Average values of intrusive touch frequency did not differ for future nonB vs. B mothers, nor did percentage of mothers using "any" time in intrusive touch. However, "excessive use" of intrusive touch was more prevalent in mothers of future nonB (21.6%) than B (6.5%) infants, by Fisher's exact test ($p = .055$). Thus, difficulty in mother touch was found not in average values of intrusive touch, nor in its mere presence, but in its "excessive use." We previously reported on the "slope" of progressively less affectionate touch across the 2½ min sample (Beebe et al., 2003), another way of looking at behavioral extremes. Contrasting mothers whose touch behavior remained relatively stable (86.4%), from those who showed a decreasing slope (13.6%), the latter was associated with future nonB (vs. B) mothers ($p = .04$).[7]

Mother loom

Mother *looming* into the infant's face was a rare behavior (mean = 14.6%, SD = 25.2). Looming ranging 0–100% of the time (one mother loomed 100% of the time). About half the mothers (46.6%) "ever" loomed, and one quarter (24.7%) showed "excessive use." Mean percent time spent in loom was 10.1% (SD = 23.3) for mothers of future B infants, and 20.8% (SD = 26.7) for mothers of nonB. Nonparametric testing of the skewed distribution showed greater percent time in loom in mothers of future nonB (vs. B) infants (Mann-Whitney U = 402.5, $p = .02$). To test extreme use of loom, because of the shape of the distribution we separated levels of loom into none, medium (1–29 s), and excessive (30+ sec; range 20%–100% time). Overall, 24.7% of women showed excessive use of loom (30+ sec). Mothers of future B infants mostly do not loom (61.9% of B mothers did not loom), some loomed moderately (26.2%), and a few were excessive loomers (11.9%). For mothers of future nonB infants, 41.9% showed no loom, 16.1% loomed moderately, and 41.9% excessively. Excessive use of loom was significantly greater in mothers of future nonB (vs. B) infants ($\chi^2 = 8.678$, $p = .013$), by chi-square contrasts (2 df).

Dyadic "chase and dodge"

This dyadic code represents a minimum of 2 consecutive seconds in which mother moves her head (from forward or loom positions) toward the infant's face while the infant simultaneously (or in the following second) orients his head away from vis-à-vis (see Appendix A). *Chase and dodge* is relatively rare, with percent time ranging 0–44.7% (mean = 32.9%, SD = 47.3). Percentage of dyads "ever" showing it was 32.9%; 6.8% of dyads showed "excessive use." Percentage of future B dyads "ever" showing chase and dodge was 21.4%, and 51.8% for future nonB. Testing mean percent of time in chase and dodge nonparametrically, because of the heavily skewed distribution, future nonB showed more chase and dodge (mean = 48.4%, SD = 51.0) than future B (mean = 21.4%, SD = 41.5) (Mann-Whitney U = 465, $p = .005$). Because these analyses of behavioral extremes were exploratory, these findings need to be taken with caution and require replication. We note that the exact nature of the measure was critical in identifying significant associations.

Contingency differences in future insecure (nonB) vs. secure (B) dyads

In this section we present results of testing for differences in self- and interactive contingency in future nonB vs. B dyads. We report significant estimates (β) of conditional effects of 12-month attachment category on 4-month self- and interactive contingency, tested as secure vs. insecure (B [$N = 47$] vs. nonB [$N = 37$]). Although nonB included A ($N = 3$), C ($N = 17$), and D ($N = 17$) dyads, because A infants were so few, nonB refers primarily to C and D infants.

The notation in the following tables and figures of I $\rightarrow$ I for infant *self*-contingency indicates that infant lagged behavior in the prior few seconds predicts infant behavior in the current moment; similarly, M $\rightarrow$ M indicates mother self-contingency. The notation M $\rightarrow$ I for infant *interactive* contingency indicates that mother lagged behavior in the prior few seconds predicts infant behavior in the current moment: infant "coordinates" with mother. Similarly, I $\rightarrow$ M indicates mother interactive contingency: mother "coordinates" with infant. The term coordination is used synonymously with interactive contingency.

Table 5 presents associations of mother and infant self- and interactive contingency with nonB vs. B attachment, by modality-pairings. Illustrating with the first modality pairing, infant gaze – mother gaze, the 6 lines of data under infant gaze present findings when predicting infant gaze behavior; likewise the 6 lines of data under mother gaze present findings when predicting mother gaze behavior. Line 1 represents the average value of the behavior of the dependent variable in question (here gaze), and Line 2 represents the average amount that the dependent variable is altered by the nonB classification. We do not interpret Line 2 because, as noted in Method, we chose to test for effects with bivariate analyses in our behavioral qualities analyses, without having controlled for the various other variables in our multi-level models. Lines 3 and 4 of each modality-pairing represent self- and interactive contingency values for the *secure group only*. For example, in the modality-pairing of infant gaze – mother gaze, I $\rightarrow$ I $\beta = 3.699$ ($p < .001$) indicates a significant value for infant gaze self-contingency. That is, infant gaze is predictable from moment-to-moment in secure infants.

Values of secure dyads are illustrated in Figure 3A; the left column of circles represents infants, and the right column, mothers. Arrows represent significant contingency values among secure infants and their mothers. Arrows curving from infant to mother represent mother interactive contingency (and vice-versa); arrows curving back into one partner's behavior represent self-contingency. Brackets in the margins demarcate five domains: attention (pairing 1), emotion (pairing 2, 3 and 4), maternal touch in relation to infant behavior (5, 6, and 7), spatial orientation (8), and infant intra-personal organization of vocal affect and touch (6). In future secure dyads, significant self-contingency indicates predictable rhythms within the individual's stream of behavior. Significant infant interactive contingency indicates that infant current behavior is predictable from the prior behavior of mothers (vice-versa for mothers).

Lines 5 and 6 of each modality-pairing in Table 5 present tests of whether nonB (vs. B) dyads differ in self- and interactive contingency values. A significant finding indicates that contingency values of insecure infants or their mothers were either higher (positive sign), or lower (negative sign), than those of secure. For example, in the modality-pairing of infant gaze – mother gaze, illustrating for infant gaze, nonBvB $\times$ I $\rightarrow$ I $\beta = 0.015$ ($p = .905$) indicates that infant gaze self-contingency did not differ in future nonB vs. B infants.

Figure 3B depicts findings where contingency values of insecure (nonB) dyads differ from those of secure (depicted in Figure 3A). Note that Figure 3B depicting insecure dyads is to be interpreted in relation to Figure 3A depicting secure dyads. *Broken* bolded arrows represent findings where nonB attachment was associated with *lowered* contingency values (compared to B); *unbroken* bolded arrows represent findings where nonB attachment was associated with *higher* contingency values; and *absence of arrows represents no differences between B vs. nonB attachment*. We turn to Table 5.

(1) Infant gaze – mother gaze

Secure (B). Future B infants and their mothers showed significant 4-month self- and interactive contingency of gaze (see Table 5, pairing 1, lines 3 and 4). Figure 3A, pairing (1), illustrates these findings with arrows in all 4 locations: from infant gaze in the prior few moments to mother gaze in the current moment (I $\rightarrow$ M), from mother gaze in the prior few moments to infant gaze in the current moment (M $\rightarrow$ I), from infant gaze in the prior few moments to infant gaze in the current moment (I $\rightarrow$ I), and from mother gaze in the prior few moments to mother gaze in the current moment (M $\rightarrow$ M). Thus within each individual's behavioral stream, the rhythms of gaze on and off the partner's face are predictable; and each individual's gaze on or off is predictable from the partner's just prior gaze on or off.

Insecure (nonB). Mothers of future nonB infants showed lowered 4-month gaze self-contingency, compared to mothers of future B infants, as shown in Table 5, pairing (1), mother gaze, line 5, nonBvB $\times$ M $\rightarrow$ M $\beta = -.510$ ($p = .011$). Figure 3B illustrates this finding in pairing (1) with a broken arrow which curves back into mother's gaze.

(2) Infant facial affect – mother facial affect

Secure (B). Future B infants and their mothers showed significant 4-month self- and interactive contingency of facial affect.

Insecure (nonB). There were no differences in contingency values of future nonB vs. B dyads. Figure 3B illustrates the absence of differences by an absence of arrows in pairing (2).

(3) Infant vocal affect – mother facial affect

Secure (B). Future B infants showed significant 4-month self-contingency of vocal affect, and contingent vocal affect coordination with mother facial affect. Mothers of future B infants showed significant 4-month facial self-contingency and contingent facial coordination with infant vocal affect.

Insecure (nonB). No differences between insecure and secure dyads.

(4) Infant engagement – mother engagement

Secure (B). Future B infants and their mothers showed significant 4-month self-contingency of engagement. Whereas future B infants did not contingently

Table 5. Insecure vs. Secure (nonB vs. B) attachment: Effects upon self- and interactive contingency.

(1)	Infant Gaze				Mother Gaze		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	−.269	.126	.036	Intercept	2.555	.129	<.001
nonBvB	.083	.175	.638	nonBvB	−.284	.136	.041
I → I	3.699	.084	<.001	M → M	2.766	.158	<.001
M → I	.492	.192	.011	I → M	.701	.122	<.001
nonBvB · I → I	.015	.129	.905	**nonBvB · M → M**	**−.510**	**.200**	**.011**
nonBvB · M → I	.217	.286	.448	nonBvB · I → M	−.312	.169	.065
(2)	Infant Facial Affect				Mother Facial Affect		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	56.076	.387	<.001	Intercept	68.301	.498	<.001
nonBvB	.583	.425	.175	nonBvB	−.492	.404	.227
I → I	.653	.015	<.001	M → M	.520	.021	<.001
M → I	.045	.014	.001	I → M	.143	.019	<.001
nonBvB · I → I	.006	.018	.739	nonBvB · M → M	.011	.018	.542
nonBvB · M → I	.014	.021	.499	nonBvB · I → M	−.004	.018	.813
(3)	Infant Vocal Affect				Mother Facial Affect		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	2.843	.045	<.001	Intercept	67.447	.464	<.001
nonBvB	.044	.067	.507	nonBvB	.065	.334	.846
I → I	.665	.014	<.001	M → M	.607	.023	<.001
M → I	.002	.0006	.001	I → M	1.521	.248	<.001
nonBvB · I → I	−.026	.018	.134	nonBvB · M → M	.026	.017	.119
nonBvB · M → I	−.0007	.0010	.471	nonBvB · I → M	−.269	.354	.448
(4)	Infant Engagement				Mother Engagement		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	11.209	.133	<.001	Intercept	5.013	.083	<.001
nonBvB	.116	.177	.516	nonBvB	−.106	.088	.231
I → I	.693	.011	<.001	M → M	.475	.015	<.001
M → I	.036	.026	.156	I → M	.066	.009	<.001
nonBvB · I → I	**−.040**	**.016**	**.011**	nonBvB · M → M	−.016	.022	.479
nonBvB · M → I	**.095**	**.039**	**.015**	nonBvB · I → M	−.005	.011	.644
(5)	Infant Engagement				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	11.206	.127	<.001	Intercept	7.440	.107	<.001
nonBvB	.191	.173	.273	nonBvB	−.159	.079	.048
I → I	.697	.010	<.001	M → M	.738	.009	<.001
M → I	.037	.017	.030	I → M	.004	.006	.555
nonBvB · I → I	−.022	.015	.140	nonBvB · M → M	−.009	.013	.486
nonBvB · M → I	**−.064**	**.026**	**.016**	nonBvB · I → M	.0001	.009	.991

(*continued*)

Table 5. (*Continued*).

(6)	Infant Vocal Affect				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	3.009	.017	< .001	Intercept	7.320	.088	< .001
nonBvB	−.005	.014	.713	nonBvB	−.161	.085	.062
I → I	.690	.020	< .001	M → M	.734	.009	< .001
M → I	.004	.002	.061	I → M	.112	.048	.020
nonBvB · I → I	−.017	.018	.351	nonBvB · M → M	−.009	.013	.528
nonBvB · M → I	−.003	.003	.368	nonBvB · I → M	−.080	.070	.251

(7)	Infant Touch				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	1.677	.046	< .001	Intercept	7.206	.273	< .001
nonBvB	−.019	.012	.126	nonBvB	−.159	.083	.060
I → I	.813	.030	< .001	M → M	.813	.047	< .001
M → I	−.0006	.002	.800	I → M	.164	.058	.005
nonBvB · I → I	**.025**	**.012**	**.041**	nonBvB · M → M	−.009	.014	.500
nonBvB · M→I	−.004	.003	.214	nonBvB · I → M	−.078	.069	.258

(8)	Infant Head Orientation				Mother Spatial Orientation		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	5.176	.089	< .001	Intercept	2.074	.076	< .001
nonBvB	.055	.057	.339	nonBvB	−.046	.031	.147
I → I	.662	.015	< .001	M → M	.523	.042	< .001
M → I	.101	.045	.025	I → M	−.008	.005	.068
nonBvB · I → I	.001	.016	.973	**nonBvB · M → M**	**−.087**	**.014**	**< .001**
nonBvB · M→I	.026	.038	.491	nonBvB · I → M	−.002	.006	.971

(9)	Infant Vocal Affect				Infant Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	2.997	.013	< .001	Intercept	1.687	.020	< .001
nonBvB	−.005	.014	.718	nonBvB	−.023	.013	.077
IVQ → IVQ	.667	.014	< .001	ITch → ITch	.771	.009	< .001
ITch → IVQ	.037	.010	.0004	IVQ → ITch	.055	.023	.018
nonBvB · IVQ→IVQ	−.008	.018	.664	nonBvB · ITch → ITch	.022	.012	.072
nonBvB · ITch→IVQ	−.029	.015	.056	nonBvB · IVQ → ITch	.016	.016	.335

Note:

1. Estimated fixed Effects (β) of attachment classification in interaction with M → M, I → M, (or I → I, M → I), based on the "basic models;" SE = Standard Error of the Beta.
2. Intercept: estimated β represents the average value of the dependent variable.
3. "nonBvB": estimated β represents the average amount that the dependent variable is altered by nonB classification; 0 = B, 1 = nonB (insecure attachment: A, C, D).
4. "I → I" (infant self-contingency): estimated β represents the prediction of current infant behavior from the weighted lag of infant behavior, for the secure (B) subgroup.
5. "M → I": estimated β represents the prediction of current infant behavior from the weighted lag of mother behavior (infant interactive contingency), for the secure (B) subgroup.
6. "nonBvB × I → I": estimated β represents the effect of non B attachment classification on infant self-contingency. Illustrating this finding with pairing (2), I facial affect self-contingency (I → I) = .653; nonBvB × I → I = .006; thus insecure infants show facial affect self-contingency increased by .006, yielding a β of .659.
7. "nonBvB × M → I": estimated β represents the effect of nonB attachment classification on infant interactive contingency.
8. Negative signs indicate lower estimates of self- and interactive contingency with insecure attachment.
9. All parameter entries are maximum likelihood estimates fitted using GLIMMIX Macro (gaze) or SAS PROC MIXED (all other modalities).
10. Significant conditional effects of attachment are bolded.

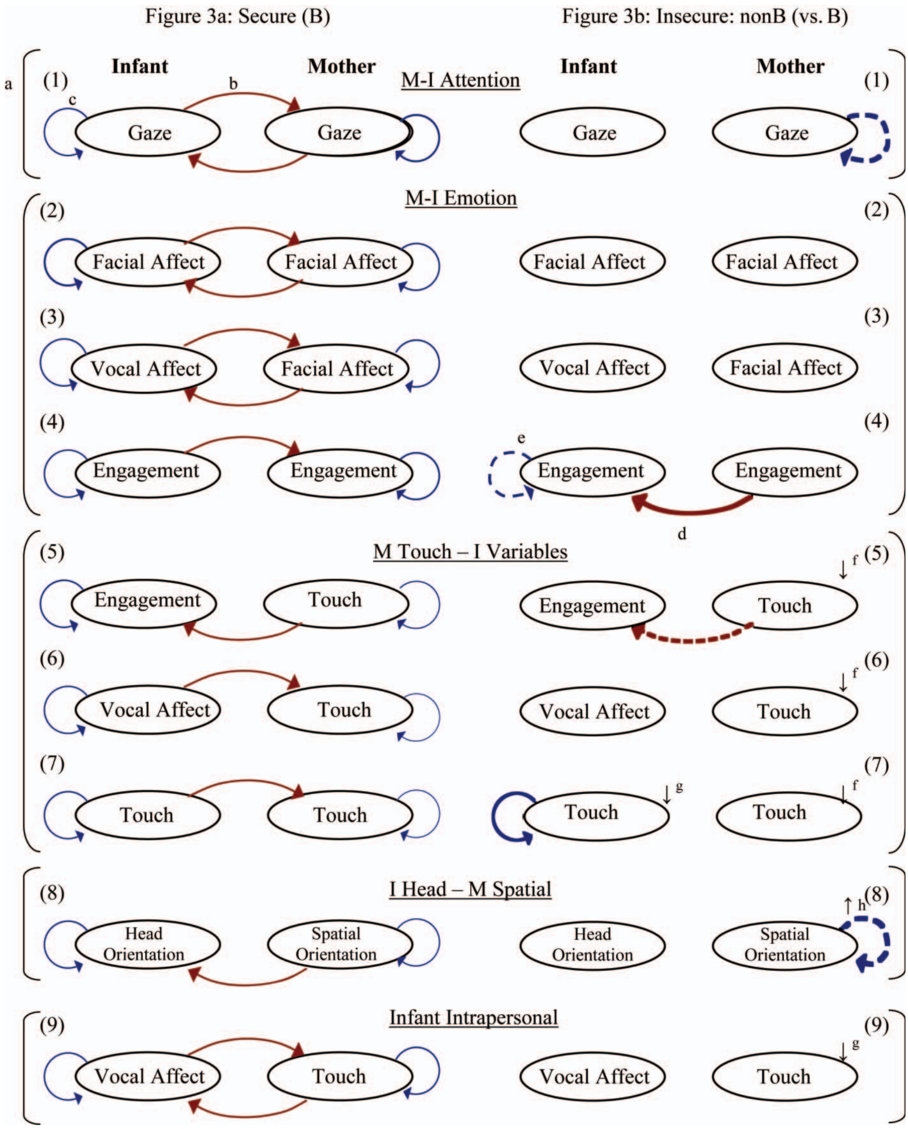

Figure 3. Self- and interactive contingency in Secure (B) and Insecure (nonB) dyads (see Table 5).

Note:

[a]Domains: attention (pattern 1), emotion (2, 3, 4), mother touch (5, 6, 7), orientation (8) and infant intrapersonal (9).

[b]interactive contingency
[c]self contingency
} Fig 3A → are significant in secure dyads

[d]interactive contingency
[e]self-contingency
} Fig 3B
→ If infant is insecure, contingency is **higher** than secure
- - → If infant is insecure, contingency is **lower** than secure.
If **NO ARROW**: No difference from secure.

[f]M Touch ↓ = less positive in nonB (vs. B).
[g]I Touch ↓ = less frequent in nonB (vs. B).
[h]M loom ↑ = higher in nonB (vs. B); chase and dodge ↑ = higher in nonB (vs. B).

coordinate engagement with mother engagement, their mothers did significantly coordinate engagement with infant engagement.

Insecure (nonB). Future nonB (vs. B) infants showed lowered engagement self-contingency but heightened contingent engagement coordination with mother engagement. Thus only future nonB infants coordinated their engagement with maternal engagement. Figure 3B illustrates the lowered engagement self-contingency in future nonB infants in pairing (4) with a broken arrow which curves back into infant's engagement. Figure 3B illustrates the heightened infant interactive contingency in future nonB infants in pairing (4) with an unbroken arrow which curves from mother engagement to infant engagement.

(5) Infant engagement – mother touch

Secure (B). Future B infants showed significant 4-month self- and interactive contingency of engagement in the context of mother touch. This relation indicates that as maternal touch patterns became more affectionate, infant engagement became more positive (and vice-versa). Mothers of future B infants showed significant touch self-contingency, but did not contingently coordinate their touch patterns with infant engagement.

Insecure (nonB). Future nonB (vs. B) infants showed lowered 4-month contingent engagement coordination with mother touch. Figure 3B illustrates the lowered infant interactive contingency in future nonB infants in pairing (5) with a broken arrow which curves from mother touch to infant engagement. The downward arrow within the mother touch circle represents the finding that mother touch is less affectionate in future nonB mothers. Thus future nonB infants lower their engagement coordination with less affectionate maternal touch.

(6) Infant vocal affect – mother touch

Secure (B). Future B infants showed significant 4-month self-contingency of vocal affect, but did not coordinate vocal affect with mother touch; their mothers showed significant 4-month touch self-contingency, and contingent touch coordination with infant vocal affect.

Insecure (nonB). No differences between insecure vs. secure dyads.

(7) Infant touch – mother touch

Secure (B). Future B infants showed significant self-contingency of touch, but did not contingently coordinate their touch with mother touch; their mothers showed significant 4-month touch self-contingency, and contingent touch coordination with infant touch.

Insecure (nonB). Touch self-contingency was heightened in future nonB (vs. B) infants. Figure 3B (pairing 7) illustrates this finding: an unbroken arrow curves back into infant's touch.

(8) Infant head orientation – mother spatial orientation

Secure (B). Future B infants showed significant 4-month self-contingency of head orientation (vis-à-vis to arch), and coordinated head orientation with mother spatial orientation (upright, forward, loom); their mothers showed significant 4-month spatial orientation self-contingency, but did not coordinate spatial orientation with infant head orientation.[6]

Insecure (nonB). Maternal spatial orientation self-contingency was lowered in mothers of future nonB (vs. B) infants. Figure 3B illustrates this finding in pairing (8) with a broken arrow which curves back into mother's spatial orientation.

(9) Intrapersonal infant vocal affect – infant touch

Secure (B). Future B infants showed significant self-contingency of vocal affect and touch, and significant crossmodal contingent coordination of infant vocal affect with infant touch (I Tch → I Voc), and coordination of infant touch with infant vocal affect (I Voc → I Tch).

Insecure (nonB). No significant differences between insecure and secure dyads.

We turn now to an evaluation of the percentage of significant analyses; 5% may be expected by chance. Future nonB infants differed from B in the following 4-month patterns: 20% (two of 10 possible) of self-contingency analyses, and 25% (two of eight possible) interactive contingency findings. Future nonB mothers differed from B in 25% (two of eight possible) self-contingency analyses, but in no interactive contingency analyses.

Discussion Part I: Self- and interactive contingency findings of future secure dyads

In this section we address the findings of future secure dyads. In *Discussion Part II* we turn to a comparison of future insecure vs. secure dyads. Within the subset of future *secure* dyads, all 4-month mother and infant *self*-contingency values were significant. Thus all mother and infant behaviors evaluated had predictable individual rhythms, facilitating predictability within each individual's experience and "readability" of each individual for the partner. Four-month *infant interactive* contingency patterns (predicting infant behavior from prior maternal behavior) were significant for future secure infants in 5 of the 8 interpersonal modality-pairings. Infants did not coordinate engagement with mother engagement (pairing 4); and infants did not coordinate vocal affect or touch with mother touch (pairings 6 and 7). Four-month *mother interactive contingency* patterns were significant in all modality-pairings except 2 (pairing 5, mother touch coordination with infant engagement; and pairing 8, maternal spatial orientation coordination with infant head orientation). In the 4-month *infant intrapersonal* pattern (pairing 9), infant vocal affect and infant touch each showed a significant contingent coordination with the other. All significant contingency findings carried a positive sign in all modality pairings, with one exception, infant head orientation predicting mother spatial orientation, significant with a negative sign.[6] These contingency findings within the secure subset provide the comparison for all three analyses of insecurity (nonB, C, and D). We now turn to a detailed examination of these findings for the future *secure* subset, illustrated in Figure 3A.

Interactive contingency of visual attention (pairing 1). As illustrated in Figure 3A, in future secure dyads, mothers and infants each follow each other's direction of attention as each looks and looks away from the partner's face, a bi-directional attention pattern in which each can predict the other's attention pattern. If the procedural expectation developed in a secure dyad could be translated into words, it might be: "We follow each other's direction of attention as we look and look away from each other's faces." The infant's procedural representation or internal working model might be, "I know your rhythms of looking at me; I feel seen by you."

Interactive contingency of facial-vocal affect (pairings 2, 3). In future secure dyads, mothers facially follow the direction of infant facial and vocal affect as it becomes more and less positive and negative. Infants reciprocally follow the direction of maternal facial affect with their own facial and vocal affect (see Figure 3A). This is a bi-directional contingent facial/vocal mirroring process: each can predict the other's affective behavior, and each can anticipate that the partner will follow his or her own direction of affective change.

The expectation developed in a secure dyad might be: "We follow each other's faces up and down, as we become more and less positive; we go up to the top positive peak together, and then come back down together toward interest." The infant's procedural representation might be, "I can count on you to share my state, to go up with me as I get excited and happy, and to come down with me as I become distressed. I can influence you to follow me, I can count on you to 'get' what I feel, I feel known by you. I know how your face goes, I know you."

Interactive contingency of engagement (pairing 4). In future secure dyads, mothers follow infant direction of engagement (more and less engaged), but infants do not follow mothers, a uni-directional contingency pattern (see Figure 3A). This finding indicates that mothers of future secure infants are sensitive to how their infants "package" gaze and facial/vocal affect; infants do not show this same sensitivity. Future secure infants may develop the expectation, "As I look at you, and as I feel more positive, I can expect that you will follow me, reciprocally looking at me and feeling more positive (and vice-versa)."

Interactive contingency of mother touch–infant behaviors (pairings 5, 6, 7). In future secure dyads, examining maternal coordination with infants, as infant vocal affect is more positive (pairing 6), maternal touch patterns are more affectionate (and vice-versa). And as infants touch more, from none, to one, to more than one touch behavior per second (pairing 7), maternal touch patterns are more affectionate (and vice-versa). Thus future secure infants can anticipate that mothers will follow their vocal and touch behaviors with corresponding maternal touch patterns. Future secure mothers, however, do not contingently coordinate their touch patterns with infant facial-visual engagement (pairing 5). Thus future secure infants can predict maternal touch patterns from their own vocal affect and touch behavior, but not from their combined facial-visual engagement behavior.

Examining infant coordination with mothers in future secure dyads (in pairings 5, 6, and 7), as maternal touch patterns are more affectionate, infant engagement is more positive (and vice-versa) (pairing 5). But infants do not contingently coordinate their vocal affect (pairing 6) or touch (pairing 7) behaviors with mother touch. Thus mothers can predict infant engagement (but not infant affect or touch) from their touch behavior, and anticipate that infants will follow maternal touch patterns with corresponding infant engagement changes. This system is uni-directional rather than bi-directional. Furthermore, where mothers coordinate their touch with infants (vocal affect, touch), infants do not coordinate; where infants coordinate with maternal touch (through infant engagement), mothers do not coordinate through touch. Thus mothers and infants "carry" different aspects of the predictability in the maternal touch domain. Perhaps future secure infants do not coordinate with mother touch with their own vocal affect or touch because maternal touch is "good enough," and thus in the background. Only in the gestalt variable of infant facial-visual engagement do we see infant coordination with mother touch.

If the developing expectations could be translated into words, infants may come to expect that, as their vocal affect is more positive, and as they touch more, their mothers will touch in more affectionate and tender ways (and vice-versa): "I can influence you to touch me in more tender ways when I need it." However, infants come to expect that, as their facial-visual engagement becomes more positive, mothers are *not* more likely to show more affectionate touch patterns (and vice-versa). For their part, mothers may come to expect that, as their touch patterns are more affectionate, they can influence infant facial-visual engagement to become more positive, and vice-versa. However, mothers come to expect that infant vocal affect and touch are *not* specifically influenced by the degree to which their touch is more vs. less affectionate.

Interactive contingency of mother spatial orientation–infant head orientation (pairing 8). In future secure dyads, we documented a uni-directional process in which future secure infants are sensitive with their head movements to maternal spatial orientation, but mothers are not reciprocally sensitive with their spatial orientation to infant head orientation (see Figure 3A). As mothers move from sitting upright to leaning forward to looming in, infants contingently coordinate head orientation away, from vis-à-vis to orienting away to arch; as mothers move back toward upright, infants move toward vis-à-vis. Thus mothers come to expect that, as they approach toward loom, their infants withdraw, orienting away toward arch; as mothers sit back upright, infants reorient into vis-à-vis. In contrast, mothers of future secure infants do not significantly coordinate their spatial behavior with infant head orientation. Thus infants may come to expect that their head orientation behavior, from vis-à-vis to arch, does *not* specifically affect mothers' spatial orientation behavior, upright to loom.

Infant intrapersonal contingency of vocal affect – touch (pairing 9). The relation between infant vocal affect and infant-initiated touch carried a positive sign: in future secure infants, as infant affect is more positive, infant touch is more likely, and vice-versa. Thus infant touch is facilitated by a climate of positive infant vocal affect. Reciprocally, as infant touch is more likely, infant vocal affect is more positive (and vice-versa). Increasing infant touch functions to maintain vocal affect positive (and vice-versa) in future secure infants, a coping mechanism. Thus future secure infants learn to expect that touching maintains positive vocal affect, and positive vocal affect leads to more touch.

Overall, future secure infants and their mothers may develop an internal working model of face-to-face interactions that includes the expectations that, "We each can anticipate when the other will look and look away; we follow each other's feelings up and down as we feel more happy or more distressed; what we feel and what we do resonates in the other" (Estelle Shane, personal communication, November 12, 2006). In addition, future secure infants may come to expect, "I know I can influence you to touch me more tenderly when I need it." Mothers of future secure infants may come to represent, "I know that when I touch you more affectionately, you will look at me and smile more. I know that moving forward and looming in is hard for you, and you orient away. I know that when I move farther back, you come back to me."

The analyses were not designed to examine individual differences within the future secure subgroup. Lest the above descriptions seem too idealized, we note that extensive clinical observation of the secure subset showed a great deal of variability among these dyads, with many seeming far from ideal, yet "good enough." We compared these findings within the future secure 4-month subset ($N = 47$) with our prior findings in this data set across the full 4-month group ($N = 132$), which can be conceptualized as the "average" infant in the data set (Beebe et al., 2003, 2008b). The future secure subset is less than half the full group, yet infant self-contingency findings are identical, and interactive contingency findings are very similar, compared to the average dyad across the group.[8] Thus at 4 months, the future secure infant, and the "average" infant, are very similar. The future secure subset are "average" dyads rather than ideal.

Figure 4 presents an illustration of a secure dyad in a pattern of "disruption and repair." They begin both facially positive and looking at each other. In frame 2, the infant moves his head and arms back, and mother leans in, sobering. In frame 3, the infant frowns and grimaces, turning his head slightly away, and mother moves back toward upright. In frame 4, the infant reorients, gaze down, with his lower lip drawn in, an "uh oh" expression; remarkably, mother exactly matches this expression. In frame 5, the infant looks at the mother and both mother and infant reach out their hands toward the other, while mother has a sober face. In frame 6, the infant reaches with both hands, and mother reaches to join him with a slight smile. In frame 7, they both make hand contact. In frame 8, the infant is again positive, and mother high positive. This sequence illustrates maternal management of infant distress by "joining the infant's distress." The infant begins the repair by reaching for mother, and they both participate in the repair, reaching for each other and gradually building back up to the original positive affect state.

Discussion Part II: Differences in contingency findings of future insecure (vs. secure) dyads

In this section we first note the ways in which future insecure (nonB) dyads do not differ from future secure dyads. We then evaluate differences in future nonB vs. B dyads in the domains of attention, spatial orientation, touch, affect, and infant intrapersonal vocal affect – touch. Differences in both qualitative behaviors and self- and interactive contingency are considered together. We construe such differences as *dysregulation* in the future nonB dyads.

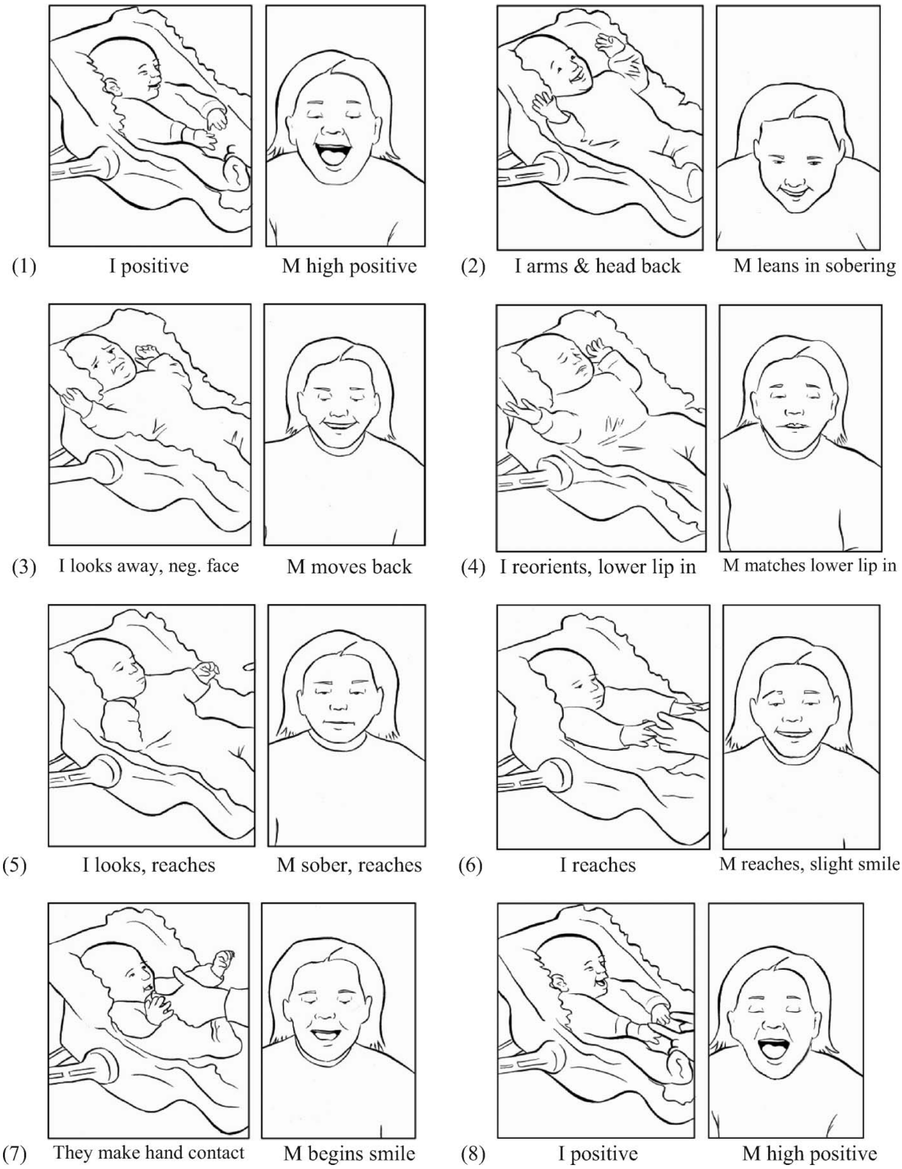

Figure 4. Illustrations of Secure (B) attachment: disruption and repair.

There are many areas in which future insecure vs. secure dyads are indistinguishable. Regarding interactive contingency, as illustrated in Figure 3B, future nonB (vs. B) infants do not differ in interactive contingencies except engagement. Mothers of future nonB (vs. B) infants do not differ in *any* interactive contingencies. Regarding self-contingency, future nonB (vs. B) infants differ only in facial-visual engagement and touch; mothers of future nonB (vs. B) infants differ in only in gaze and spatial orientation. Thus maternal interactive contingency is entirely intact. Mother and infant self-contingency show 2 findings each.

Regarding behavioral qualities, mothers of future nonB (vs. B) infants show more intrusive touch, loom, and chase and dodge, discussed below; but do not differ in prevalence of gazing away, positive or negative affect, interruptive touch, or mother positive while infant distressed. Future nonB (vs. B) infants show only less use of touch; otherwise they do not differ. We now turn to the ways that future nonB dyads differ from future B.

Attention dysregulation in future nonB dyads. Mothers of future nonB (Vs. B) infants showed lowered self-contingency of gaze: their pattern of gaze on and off the infant's face was less predictable, making it harder for future nonB infants (as well as mothers) to anticipate maternal patterns of visual attention. If the procedural expectation could be translated into words, future nonB infants might represent, "I do not know when you will look at me or for how long; I cannot count on your gaze." Mothers of future nonB (vs. B) infants may themselves sense (out of awareness) a less steady ability to focus on their infants.

Spatial dysregulation in future nonB dyads. Mothers of future nonB (vs. B) infants showed more looming head movements, and lowered self-contingency of spatial orientation. In the latter finding, maternal spatial orientation positions among sitting upright, leaning forward, and looming in were less predictable, making it harder for future nonB infants (as well as mothers) to anticipate maternal patterns of spatial orientation. Future nonB dyads showed more "maternal chase – infant dodge," a maternal approach-infant avoid pattern in which the mother moves head and body toward the infant as the infant moves head and body away from the mother (Beebe & Stern, 1977; Kushnick, 2002; Stern, 1971). In future nonB infants these patterns generate an expectancy of maternal intrusive head movements, both looming and "chasing." If we could translate the infant's experience into words, the maternal chasing may generate an infant feeling of, "I don't feel free to look away; I can't get away when I need to settle down." Future nonB infants may come to sense the unpredictability of maternal looming, generating a fearful or unsettled feeling, such as, "I do not know your intent." Their mothers may come to sense procedurally (out of awareness) their own "going after" the infant, perhaps an urgent need for contact or acknowledgment, or a need to control the contact.

Touch dysregulation in future nonB dyads. Mothers of nonB infants had more intrusive touch, evident only in an extreme use of intrusive touch, 30 s (20% of the time) or more across the 2½ min analyzed. If the expectation could be translated into words, future nonB infants may feel, "I don't like the way you touch me sometimes." Thus mothers of future nonB infants moved in toward infants to touch intrusively, to loom, and to chase, and in the process their spatial orientation became less predictable. This is a coherent constellation of head and touch behaviors involving maternal intrusion into the infant's body, face-space, and freedom to look away. We propose that both future nonB infants and their mothers come to expect this intrusive constellation as a central aspect of what it is like to be with each other.

Analyses of ordinalized behavioral scales showed that infants classified as nonB at 12 months showed less touch at 4 months. Analysis of specific infant touch codes revealed that future nonB (vs. B) infants spent more time in the code "no touch."

Despite decreased infant use of touch, infant touch self-contingency was heightened in future nonB (vs. B) infants (when analyzed paired with mother touch, pairing 7). A t to $t + 1$ transition matrix revealed that nonB infants were more likely to stay in the state of "no touch," leading to the heightened self-contingency (heightened stability). We interpret greater likelihood of staying in a state of "no touch" metaphorically as future nonB infants getting "stuck" in states of being unable to touch. This difficulty in access to touch in future nonB infants is likely linked to the maternal touch and spatial intrusion. Future nonB infants may come to expect that, not only are mother's head movements likely to be intrusive, and her touch not likely to be comforting, but his own touching is not easily used to help himself cope and self-soothe: "I can't use my own touch or mother's touch to help me calm down."

Engagement dysregulation in future nonB infants. Future nonB (vs. B) infants showed an approach-withdrawal discordance (conflict) in facial-visual engagement. These infants lowered their engagement coordination with maternal touch (inhibition of both distressed response to less positive maternal touch, as well as of positive response to more affectionate maternal touch). But future nonB infants also heightened their engagement coordination with mother engagement, a form of infant vigilance for maternal facial-visual shifts. This is a remarkable discordance, in which the same behavioral constellation, infant engagement, is both inhibited (to maternal touch) and activated (to maternal engagement). Thus future nonB (vs. B) infants are working hard in opposite directions, both inhibiting and activating engagement coordination.

This discordance in future nonB infants makes sense from an ethological perspective. By inhibiting their engagement coordination with maternal touch intrusion, infants cannot escape the intrusion, but they can actively lower the degree to which they are contingently organized by it, a remarkable coping effort. Future nonB infants seem already to have constructed an expectancy that maternal touch is likely to be intrusive, and a mode of coping by inhibiting their response. However future nonB infants are overly coordinated with mothers' moment-to-moment facial-visual engagement shifts, interpreted as an effort to "stay with" mother's attention and affect. Infants may look to maternal facial-visual engagement to interpret more of what is happening. If we could translate the infant's experience into words, it might be, "I must carefully monitor and track where you are looking and what you are feeling, to see if there is any other kind of threat."

The future nonB (vs. B) infant's heightened engagement coordination with mother engagement was accompanied by lowered infant engagement self-contingency: an imbalance between self- and interactive contingency (see Figure 3B). Lowered infant engagement self-contingency is interpreted as a "destabilization" and suggests that future nonB infants as well as their mothers have more difficulty anticipating infants' next engagement "move."

Thus these infants were overly involved with their mothers' engagement at the expense of self-stability, one possible pattern of disturbance noted in the Introduction. In this finding, infant intrapersonal and interpersonal dysregulations are linked. This imbalance may further accentuate infant engagement vigilance. If we could translate it into words, the experience of the future nonB infant may be, "I become destabilized, I lose my sense of my own affect and attention rhythms, as I work hard to track yours."

Infant intrapersonal vocal affect – touch. There were no differences.

Summary of nonB dyads

Mothers of future nonB infants showed extreme use of intrusive touch, two forms of spatial intrusion, loom and "chase and dodge," as well as lowered self-predictability of spatial orientation. These mothers also showed lowered gaze self-contingency. The lowered gaze and spatial self-contingency make it more difficult for infants (as well as mothers) to anticipate maternal patterns of visual attention and spatial orientation.

The maternal contribution of spatial/touch intrusion, and less predictable self-contingency patterns of spatial orientation and gaze, poses a considerable challenge. Future nonB infants are working hard to cope with this challenge, manifesting a complex "approach-withdraw" pattern. By inhibiting their engagement coordination with maternal touch intrusion, a withdrawal pattern, infants cannot escape the intrusion, but they actively lower the degree to which they are contingently organized by it, a remarkable coping effort. But they simultaneously vigilantly coordinate their engagement with mother engagement, an approach pattern, carefully monitoring her. These efforts occur at the cost of destabilized infant engagement self-predictability, less access to touch, and greater likelihood of staying in the state of "no touch," compromising the infant's ability to use touch to cope. The internal working model of the future nonB infant, if it could be translated into words, might be, "I can't rely on your attention. You might touch me in an uncomfortable way. You might loom in unpredictably, or you might chase me when I need to look away. I have to be careful. I can't afford to be too affected by your intrusive touch. I have to carefully coordinate with your attention and feelings, to be sure I know what you are feeling. But I can't use my own touch, or your touch, to help me when I need to calm down."

Chapter 4. Results: Future resistant (C) vs. secure (B) dyads

This chapter presents findings first for qualitative behavioral features, and then for self- and interactive contingency, in 4-month "future" C vs. B dyads. Following presentation of the results, we provide a discussion in two parts: a discussion of the empirical findings, followed by a discussion of the origins of the working model of attachment of C infants.

Differences in qualitative behavioral features in future C vs. B dyads

We first asked whether qualitative features of behaviors (such as amount of looking away) were associated with infant C ($N = 16$) vs. B ($N = 47$) attachment classifications, using two approaches: (1) the means of ordinalized behavioral scales, and (2) behavioral extremes. For definitions of behavioral extremes, see Table 3. The behavioral extremes approach explored several measures, tailored to each behavior as appropriate: (a) the mean percent time of a specific behavior (such as mother intrusive touch); (b) when distributions were very skewed, the percent of participants who "ever" used a particular behavior; or (c) percent of participants showing excessive use of a specific behavior, defined as 20% time or more in a particular behavior (such as mother intrusive touch). Web Appendix 3 (posted on our website) presents the rates of behaviors for the three measures above, as well as ranges of percent time, across the group and for B and C dyads. Table 4 presents these results, first for infants, then mothers. Table 4 shows that differences between future C vs. B dyads were visible only when qualitative features of behaviors were evaluated as rates of behavioral extremes (vs. as means). In what follows we present results of these analyses, modality by modality.

Infant gaze away

Future C vs. B infants did not differ in percent time infant *gaze away* (looking away from mother's face), or excessive infant gaze away (20% of the time or more).

Infant negative facial affect

Defined as *frown, grimace, pre-cry, and cry-face*, infant negative facial affect did not differ in future C (vs. B) infants (percent time, excessive use).

Infant negative vocal affect

Defined as codes *fuss, whimper, angry protest, or cry*, the average percent time in negative vocal affect did not differ for future C vs. B infants.

Infant facial/vocal distress

A new variable of infant *facial/vocal distress*, number of seconds (of 150) in which infants showed negative facial and/or vocal affect, did not differ in future C (vs. B) infants, measured as mean percent time in facial/vocal distress (future B: 10.4%, $SD = 15.5$; future C: 11.8%, $SD = 14.6$), and as excessive use (20% time+).

Infant discrepant facial/vocal affect

Defined as simultaneous (within the same second) positive affect in one modality (either facial or vocal) and negative affect in the other, percentage of infants showing any discrepant affect was 12.5% for future C, and 19.1% for future B. Tested as presence vs. absence of any discrepant affect, future C (vs. B) infants did not differ.

Infant 60–90° avert/arch

Infant head orientation 60–90° *avert* indicates head movement away from the vis-à-vis to approximately 60–90°. Infant *arch* indicates a whole body movement of head and back arching away from the vis-à-vis. Tested both as presence/absence and as percent time, neither 60–90° avert nor arch tested individually, nor the two behaviors tested together, showed any differences in future C vs. B infants, most likely because both behaviors showed few individual differences.

Infant touch

Examined with the mean percent time in separate codes (*none, touch/suck own skin, touch/suck object [own clothing, strap, chair], and touch/suck mother*) infant touch did not differ in future C (vs. B) infants, tested as percent time in any of the touch codes.

Mother gaze away

Using excessive use of percent time (20%+) mother gazes away from infant face, 14.9% of future B mothers, and 31.3% of future C mothers, met this criterion, but contrasts were not significant (by chi-square test).

Mother negative facial affect

Defined as *frown and/or grimace and/or tight compressed lips, negative maternal facial affect* was highly skewed. Tested as presence/absence, the percentage of mothers of future B infants "ever" using negative facial affect (44.0%) did not differ from that of mothers of future C (31.2%) (by chi square test).

Mother positive facial affect

Defined as smile 2 (moderate degree of display) and above (see Appendix A), *maternal positive facial affect* did not differ in mothers of future C (vs. B) infants, tested as excessive use (percentage of mothers meeting the criterion of 20% time + [37.5% C vs. 51.1% B], and percentage meeting the criterion of 40% + [6.3% C vs. 17.0% B]).

Mother interruptive touch

Attempting to replicate findings that C mothers tend to interfere and interrupt infant ongoing activity (see Cassidy & Berlin, 1994), we used number of seconds of the specific maternal touch code "push, constrain movement, force or control infant movement" (e.g. force infant's hand down) (code 16: see Website Appendix 1). Because the data were heavily skewed, with most mothers showing no interruptive touch, we tested it as presence/absence. By chi-square test, mothers of future C vs. B infants did not differ ($\chi^2 = .349$, 2 df, $p = .55$). Whereas 15.5% of all mothers "ever" used this touch code, 12.8% of future B mothers, and 18.8% of future C mothers "ever" used it.

Mother intrusive touch

The distribution of mother intrusive touch (*codes rough touch [scratch, pull, push, pinch, poke]/high intensity aggressive touch*) was highly skewed, with half of mothers (53.6%) showing none. The average values of the frequency of intrusive touch did not differ for future C vs. B mothers. Examination of the distribution of percentage of mothers using "any" time in intrusive touch also revealed no differences. "Excessive use" of intrusive touch (20% time+) was more prevalent in mothers of future C (25%) than B (6.5%) infants, but Fisher's exact test showed a nonsignificant trend (p = .066). However, we previously reported increased intrusive maternal touch in future C mothers by another measure, the ‘‘slope’’ of progressively less affectionate touch across the 2.5 min sample (Beebe et al., 2003),[7] another way of looking at behavioral extremes. Differentiating mothers whose touch behavior remained relatively stable (86.4%), from those who showed a decreasing slope (13.6%), from affectionate toward more intrusive touch as the session progressed, decreasing maternal touch slope was associated with mothers of future C (vs. B) infants (p = .006).

Mother loom

Mother *loom* into the infant’s face was a rare behavior with a skewed distribution. Using nonparametric testing, there were no differences in percent time in loom (Mann-Whitney U), or excessive use of loom (30+ s) (chi-square contrasts) in mothers of future C vs. B infants.

Dyadic ‘‘chase and dodge’’

Defined as a minimum of 2 consecutive seconds in which mother moves her head in toward the infant’s face, while the infant simultaneously (or in the following second) orients his head away from the vis-à-vis position (see Appendix A for definitions), this code showed a skewed distribution. Tested nonparametrically, percent time in chase and dodge was twice as frequent in future C (mean = 46.2%, SD = 51.9) as future B dyads (mean = 21.4%, SD = 41.5) (Mann-Whitney U = 196, p = .025).

Dyadic mother positive/surprise while infant distressed

This analysis tested the presence of moments when mothers are positive while infants are distressed (see previous chapter for description of analysis). Future C vs. B mothers did not differ in this behavior, by parametric or nonparametric testing. Because these analyses of behavioral extremes were exploratory, these findings need to be taken with caution and require replication. We note that the exact nature of the measure was critical to identifying significant associations.

Contingency differences in future resistant (C) vs. secure (B) dyads

In this section we present differences in self- and interactive contingency in future C (N = 16) vs. B (N = 47) dyads. We report significant estimates (β) of the conditional effects of 12-month attachment category on 4-month self- and interactive contingency. Significant results indicate that 4-month contingency patterns predict 12-month C (vs. B) attachment.

The notation in the following tables and figures of I $\rightarrow$ I for infant *self*-contingency indicates that infant lagged behavior in the prior few seconds predicts infant behavior in the current moment; similarly, M $\rightarrow$ M indicates mother self-contingency. Self-contingency indicates the degree to which there are predictable rhythms within the individual’s stream of behavior. The notation M $\rightarrow$ I for infant *interactive* contingency indicates that mother lagged behavior in the prior few seconds predicts infant behavior in the current moment: infant ‘‘coordinates’’ with mother. Similarly, I $\rightarrow$ M indicates mother interactive contingency: mother "coordinates" with infant. The term coordination is used synonymously with interactive contingency.

Table 6 presents the associations of 12-month B ($N = 47$) vs. C ($N = 16$) attachment with 4-month mother and infant self- and interactive contingency. Lines 5 and 6 of each modality-pairing test whether self- and interactive contingency values of future C dyads differ from those of B. For example, in Table 6, in modality-pairing (1) infant gaze-mother gaze, for infants, C vs. B $\times$ I $\rightarrow$ I $\beta = 0.251$, $p = .140$, indicates that infant gaze self-contingency did not differ in C vs. B infants. Contingency patterns for C (vs. B) dyads are illustrated in Figure 5A. Note that Figure 5A depicting C (vs. B) dyads is to be interpreted in relation to Figure 3A depicting secure dyads.

(1) Infant gaze – mother gaze. No differences in C (vs. B) dyads (Table 6, Figure 5A).

(2) Infant facial affect – mother facial affect. No differences.

(3) Infant vocal affect – mother facial affect. No differences.

(4) Infant engagement – mother engagement. Future C (vs. B) infants showed lower engagement self-contingency, but higher engagement coordination with mother engagement.

(5) Infant engagement – mother touch. Future C (vs. B) infants showed lower engagement coordination with mother touch.

(6) Infant vocal affect – mother touch. Future C (vs. B) infants showed lower vocal affect coordination with mother touch.

(7) Infant touch – mother touch. No differences.

(8) Infant head orientation – mother spatial orientation. Mothers of future C (vs. B) infants showed lowered spatial orientation self-contingency.

(9) Intrapersonal infant vocal affect – infant-initiated touch. No differences.

We turn now to an evaluation of the percentage of significant analyses. Of 36 total possible analyses, 5 were significant, approximately 14%. With one exception, the findings concerned infants. Future C infants differed from B in 10% (1 of 10 possible) of self-contingency analyses and approximately 38% (3 of 8 possible) of interactive contingency analyses. Mothers of future C infants differed from secure in 12.5% (1 of 8 possible) of self-contingency analyses (spatial orientation). This maternal self-contingency finding was evident in all three analyses of nonB, C (and D below) and thus we consider it to be robust.

Discussion Part I: Future resistant (C) vs. secure (B) dyads

In this section we first note areas in which future C dyads do not differ from future B. We then discuss differences in future C (vs. B) dyads in the domains of attention, touch, spatial orientation, affect, and infant intrapersonal vocal affect – touch, integrating differences in qualitative behavioral features and in degrees of self- and interactive contingency. In *Discussion Part II* we offer a somewhat more speculative

Table 6. Resistant vs. Secure (C vs. B) attachment: Effects upon self- and interactive contingency.

(1)	Infant Gaze				Mother Gaze		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	−.214	.122	.086	Intercept	2.512	.138	<.001
CvB	.095	.215	.660	CvB	−.177	.174	.313
I → I	3.705	.085	<.001	M → M	2.822	.170	<.001
M → I	.492	.193	.011	I → M	.669	.124	<.001
CvB · I → I	.251	.170	.140	CvB · M → M	−.227	.274	.407
CvB · M → I	.025	.372	.946	CvB · I → M	−.152	.219	.488

(2)	Infant Facial Affect				Mother Facial Affect		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	55.834	.402	<.001	Intercept	68.452	.541	<.001
CvB	.639	.507	.212	CvB	−.976	.552	.082
I → I	.673	.015	<.001	M → M	.503	.217	<.001
M → I	.042	.013	.001	I → M	.141	.022	<.001
CvB · I → I	.001	.021	.961	CvB · M → M	.011	.024	.655
CvB · M → I	−.016	.026	.548	CvB · I → M	.008	.025	.745

(3)	Infant Vocal Affect				Mother Facial Affect		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	2.827	.044	<.001	Intercept	67.364	.497	<.001
CvB	.066	.086	.448	CvB	−.418	.434	.340
I → I	.673	.014	<.001	M → M	.589	.025	<.001
M → I	.002	.0006	.0002	I → M	1.507	.246	<.001
CvB · I → I	−.040	.024	.089	CvB · M → M	.031	.022	.170
CvB · M → I	−.0009	.001	.470	CvB · I → M	−.257	.506	.612

(4)	Infant Engagement				Mother Engagement		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	11.205	.138	<.001	Intercept	4.975	.097	<.001
CvB	.230	.224	.308	CvB	−.227	.122	.067
I → I	.682	.011	<.001	M → M	.452	.015	<.001
M → I	.041	.025	.101	I → M	.072	.009	<.001
CvB · I → I	**−.045**	**.021**	**.031**	CvB · M → M	−.041	.030	.178
CvB · M → I	**.168**	**.052**	**.001**	CvB · I → M	.015	.014	.296

(5)	Infant Engagement				Mother Touch		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	11.207	.130	<.001	Intercept	7.421	.108	<.001
CvB	.224	.219	.310	CvB	−.198	.097	.046
I → I	.683	.010	<.001	M → M	.735	.009	<.001
M → I	.038	.017	.023	I → M	.004	.006	.520
CvB · I → I	−.011	.019	.586	CvB · M → M	.024	.018	.178
CvB · M → I	**−.122**	**.035**	**.001**	CvB · I → M	−.001	.012	.929

(*continued*)

Table 6. (*Continued*).

(6)	Infant Vocal Affect				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	2.988	.018	< .001	Intercept	7.371	.089	< .001
CvB	−.004	.015	.773	CvB	−.179	.105	.092
I → I	.697	.023	< .001	M → M	.734	.009	< .001
M → I	.004	.002	.069	I → M	.112	.047	.017
CvB · I → I	−.027	.024	.261	CvB · M → M	.017	.018	.327
CvB · M → I	**−.008**	**.004**	**.051**	CvB · I → M	−.089	.094	.345

(7)	Infant Touch				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	1.701	.050	< .001	Intercept	7.249	.295	< .001
CvB	−.013	.016	.427	CvB	−.208	.111	.066
I → I	.763	.033	< .001	M → M	.857	.050	< .001
M → I	−.0003	.002	.889	I → M	.135	.061	.027
CvB · I → I	−.007	.017	.655	CvB · M → M	.022	.018	.240
CvB · M → I	−.002	.004	.553	CvB · I → M	.103	.095	.282

(8)	Infant Head Orientation				Mother Spatial Orientation		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	5.050	.113	< .001	Intercept	2.117	.078	< .001
CvB	.017	.076	.827	CvB	.013	.035	.704
I → I	.683	.026	< .001	M → M	.808	.043	< .001
M → I	.164	.060	.007	I → M	−.006	.006	.333
CvB · I → I	.032	.024	.179	**CvB · M → M**	**−.053**	**.017**	**.002**
CvB · M → I	.043	.056	.446	CvB · I → M	.003	.007	.675

(9)	Infant Vocal Affect				Infant Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	2.988	.013	< .001	Intercept	1.708	.022	< .001
CvB	.001	.016	.939	CvB	−.018	.017	.299
IVQ → IVQ	.670	.014	< .001	ITch → ITch	.779	.009	< .001
ITch → IVQ	.037	.010	.0002	IVQ → Tch	.053	.025	.035
CvB · IVQ → IVQ	−.010	.025	.701	CvB · ITch → ITch	−.008	.017	.659
CvB · ITch → IVQ	−.039	.021	.060	CvB · IVQ→ ITch	.021	.024	.383

Note:
1. Estimated fixed effects (β) of attachment classification in interaction with M → M, I → M, (or I → I, M → I), based on the "basic models;" SE = Standard Error of the Beta.
2. Intercept: estimated β represents the average value of the dependent variable.
3. CvB: estimated β represents the average amount that the dependent variable is altered by C classification; 0 = C, 1 = B (C = resistant attachment).
4. "I → I" (infant self-contingency): estimated β represents the prediction of current infant behavior from the weighted lag of infant behavior.
5. "M → I": estimated β represents the prediction of current infant behavior from the weighted lag of mother behavior (infant interactive contingency).
6. "CvB × I → I": estimated β represents the effect of C attachment classification on infant self-contingency.
7. "CvB × M → I": estimated β represents the effect of C attachment classification on infant interactive contingency.
8. Negative signs indicate lower estimates of self- and interactive contingency with anxious/resistant attachment.
9. All parameter entries are maximum likelihood estimates fitted using GLIMMIX Macro (gaze) or SAS PROC MIXED (all other modalities).
10. Significant conditional effects of attachment are bolded.

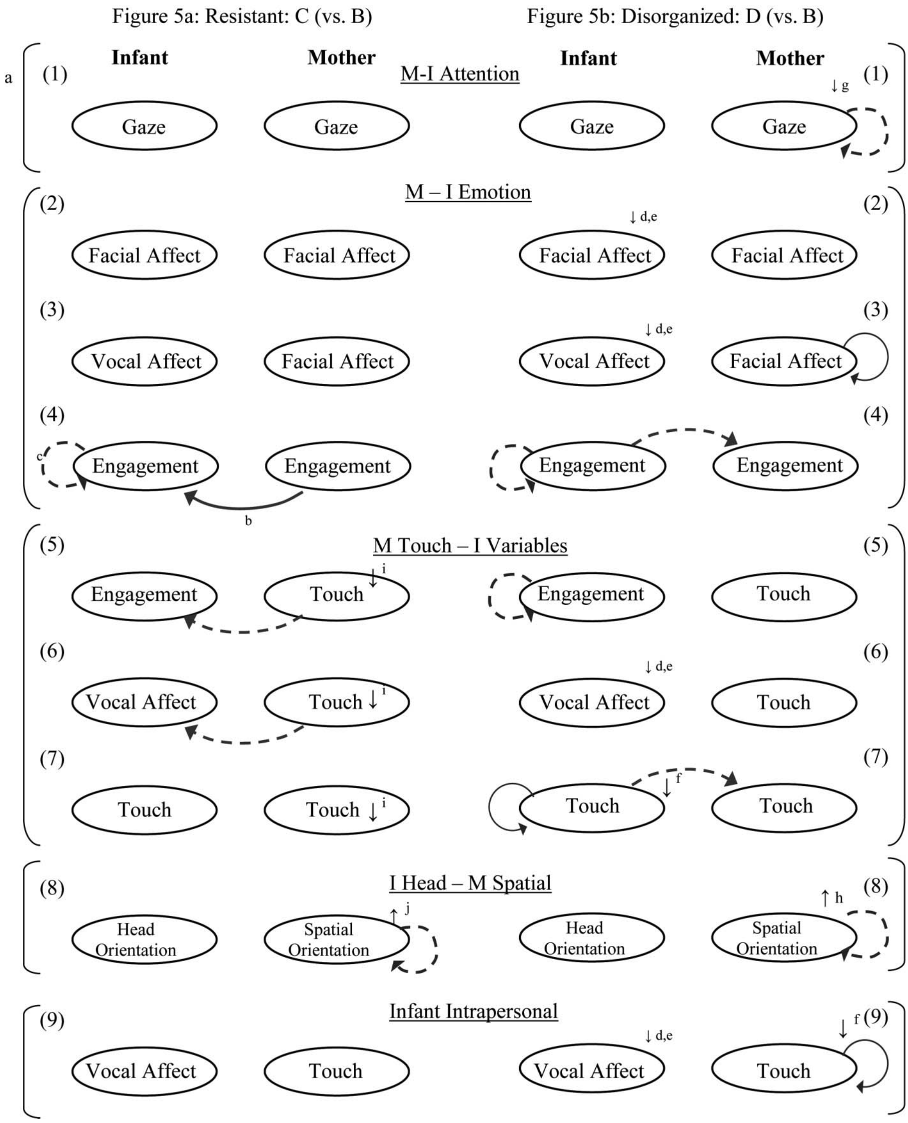

Figure 5. Self- and interactive contingency in Future C (vs. B) and D (vs. B) dyads (see Tables 6 and 7).

Note:

[a]Domains: attention (pattern 1), emotion (2, 3, 4), mother touch (5, 6, 7), orientation (8) and infant intrapersonal (9).

[b]interactive contingency } ——▶ If infant is insecure, contingency is **higher** than secure.

[c]self-contingency } - - - -▶ If infant is insecure, contingency is **lower** than secure.

If **NO ARROW**: No difference from secure.

[d]# secs I facial/vocal distress ↑ = higher in D (vs. B).

[e]I facial/vocal discrepancy ↑ = higher in D (vs. B).

[f]I touch ↓ = % time any type of touch lower in D (vs. B), and = % time touch skin lower in D (vs. B).

[g]M gaze ↓ = % time lower in D (vs. B).

[h]M loom ↑ = more frequent in D.

[i]M touch ↓ = less positive in C.

[j]Chase and dodge ↑ = more frequent in C.

formulation of the origins of working models of attachment in future C infants at 4 months.

In many areas future C dyads are indistinguishable from future B dyads. Regarding interactive contingencies, as illustrated in Figure 5A, future C (vs. B) infants differ in engagement coordination with mother engagement, and engagement and vocal affect coordination with maternal touch. Mothers of future C (vs. B) infants do not differ in *any* interactive contingencies. Thus future C infants and their mothers contingently coordinate with each other, and in many respects are indistinguishable from future B dyads. Regarding self-contingencies, future C (vs. B) infants differ only in facial-visual engagement; mothers of future C (vs. B) infants differ only in spatial orientation. Thus maternal interactive contingency is entirely intact, and mother and infant self-contingency are largely intact. Regarding behavioral qualities, mothers of future C (vs. B) infants show progressively less affectionate, more active touch, and chase and dodge, discussed below; but otherwise do not differ. Future C (vs. B) infants do not show *any* differences in behavioral qualities. We now turn to the ways that future C dyads differ from future B. Mothers of future C infants bring their own difficult attachment histories. Cassidy and Berlin (1994) suggest that, because of a history of not being able to trust attachments, mothers of C infants feel more comfortable when the attachment system is activated, to be sure that their infants need them.

Attention dysregulation in future C dyads. There were no differences.

Touch dysregulation in future C dyads. Mothers of future C (vs. B) infants showed progressively less positive touch, an increasing likelihood of less affectionate, more active touch patterns as the 2.5 min session progressed. We construe this less positive maternal touch to be a central disturbing factor in the picture of future C dyads.

Spatial dysregulation in future C dyads. "Mother chase–infant dodge" was more prevalent in future C (vs. B) dyads. This intrusive spatial pattern was accompanied by lowered maternal self-contingency of spatial orientation, a disturbance of the "spatial frame." Thus as mothers move from sitting upright to leaning forward to looming in, to chase, they are less predictable: a form of "unpredictable chase." Because chase and dodge was absent in future D dyads (see below, p. 81), we infer that this pattern is specific to future C dyads. Thus mothers of future C (vs. B) infants showed a coherent constellation of progressively less positive touch, less self-predictable spatial orientation, and disturbance of the infant's freedom to look away by "chasing" with head/body in the direction of infant "dodges" (movements away from vis-à-vis). Mothers of C infants are generally described as remote and under-involved (Belsky, 1997; Cassidy & Berlin, 1994). However, our findings of maternal spatial/tactile intrusion are consistent with the literature reviewed by Cassidy and Berlin (1994) documenting maternal interference with infant autonomy, exploration or ongoing activity.

Engagement dysregulation in future C infants. Consistent with our hypothesis, future C infants demonstrated approach-withdrawal discordance (conflict), in facial-visual engagement. These infants lowered their engagement coordination with maternal touch (less likely to show facial/vocal distress as maternal touch becomes more intrusive, and to become positive as maternal touch becomes more affectionate), but heightened their engagement coordination with mother engagement, an infant vigilance for maternal facial-visual shifts. This is a remarkable discordance, in which the same behavioral constellation, infant engagement, is both inhibited (to maternal touch) and activated (to maternal engagement). Because these patterns were present for future nonB infants, but absent for future D (see below, p. 81), we infer that they are specific to future C (vs. B) infants. Future C (vs. B) infants amplified the nonB infant pattern of withdrawal from maternal touch by manifesting both lowered engagement *and* lowered vocal affect coordination with maternal touch, accentuating that it is an infant attentional/emotional withdrawal.

Not only did future C infants heighten engagement coordination with maternal engagement, but they also lowered their engagement self-contingency, an imbalance tilting toward interpersonal involvement at the expense of self-stability. Such lowered self-contingency makes it harder for infants to anticipate their own next move, as well as harder for mothers to anticipate infant engagement shifts. It is striking that infants showed "destabilized" self-contingency in precisely the channel in which they heightened their contingent coordination with mother: infant intrapersonal and interpersonal engagement dysregulation are linked here.

Infant intrapersonal vocal affect – touch. There were no differences.

In summary, we introduced a number of new concepts in the 4-month origins of C attachment: (1) progressively less affectionate/more active forms of maternal touch; (2) dyadic "chase and dodge"; (3) less predictable maternal spatial orientation patterns, a disturbance of the maternal spatial "frame," which also indicates a relatively unpredictable maternal "chase" pattern; (4) infant inhibition of emotional coordination with maternal touch (less likely to protest as maternal touch becomes more intrusive, and to become positive as maternal touch becomes more affectionate); (5) infant vigilant engagement coordination with maternal engagement, at the expense of infant engagement self-stability; and (6) findings from (4) and (5) together indicate an infant discordance: infant engagement coordination is inhibited with maternal touch but activated with maternal engagement.

Discussion Part II: Origins of internal working models in future C infants

Based on the work of Bretherton (1980) and Main, Kaplan, and Cassidy (1985), we began this study with the proposal that 4-month infant procedural expectancies of contingent patterns of self- and partner contingency, as well as of specific behavioral qualities, provide ways of defining processes by which patterns of intimate relating and attachment security are constructed: the origins of working models of attachment. We suggest that the patterns identified for future C (vs. B) dyads form the basis for emerging infant "working models" of procedurally organized expectancies of action sequences, as early as 4 months. In this section we become somewhat more speculative about what the inner experience of future C infants may be like. We also discuss ways in which the findings may suggest disturbances in the infant's ability to "know" and be "known" by his mother's mind, as well as to know his own mind.

As noted above, because of histories of not being able to trust attachments, mothers of C infants feel more comfortable when the attachment system is activated, to be sure that their infants need them (Cassidy & Berlin, 1994). In the Strange Situation at 12 months, mothers of C infants often linger as they leave, activating the child's request that the mother stay, perhaps in an effort to be sure to be needed. At 4 months, mothers of future C infants may become upset when infants "go away," for example, when infants inevitably at times look way and orient away. Perhaps these mothers then feel abandoned or unimportant. Clinically, we observed mothers of future C infants saying things like, "What are you looking at?" "Hey, look at me," or "Where are you going?" Following Cassidy and Berlin, the maternal "chase" behavior and tactile intrusion in mothers of future C infants are interpreted as ways of saying to the infant "Come here, don't go away, I need you" (Jude Cassidy, personal communication, October 18, 2006). We interpret mothers of future C infants as overly concerned with the infant's attention and emotional presence, and their intrusion behaviors as their wish for infants to stay with them. However, mothers of future C (vs. B) infants showed intact interactive contingency, safeguarding the infant's interactive agency. Like that of the future B infant, the internal working model of the future C infant will preserve the expectancy that he can influence maternal behaviors to coordinate with his own, so as to match his direction of behavioral change.

Maternal touch dysregulation

Mothers of future C (vs. B) infants showed a disturbance in their touch patterns. These mothers used progressively less affectionate/more active forms of touch as the session progressed, which may indicate the mother's increasing need for the infant to stay with her. Less affectionate maternal touch occurred in the context of lowered maternal spatial self-predictability. The constellation of less predictable orientation as mother reaches in to touch, and progressively less affectionate maternal touch, is likely to disturb the infant's development of a confident expectation that maternal touch will be affectionate and comforting. The infant's procedural representation of "state transforming," the expectation of being able to transform an arousal state through the contribution of the partner (see Stern, 1985), is likely disrupted with respect to maternal touch. Difficulty with state-transforming is construed as an "ongoing dysregulation," a recurrent pattern across the session.

Infant inhibition of emotional coordination with maternal touch

Future C (vs. B) infants inhibited their vocal affect and engagement coordination with maternal touch. They were not as likely to signal vocal and engagement distress as maternal touch patterns became less affectionate; nor to become more positive (in vocal and engagement patterns) as maternal touch patterns became more affectionate. Thus future C infants resisted being emotionally organized by maternal touch: a remarkable demonstration of agency. This infant inhibition also indicates that infant ability to use maternal touch for "state transforming" will likely be disrupted. Thus both infant and mother contribute to a disruption in the infant's expectation of being able to transform arousal states through mother's touch.

Infant inhibition of coordination with maternal touch is linked to the disturbance in maternal touch patterns. Thus future C infants down-regulate by using engagement/vocal affect to inhibit response to maternal touch, in an effort to manage maternal stimulation. However, infant inhibition of a distressed response to maternal touch may lead to a disturbance in infants' ability to communicate what they "like" or do not "like," ultimately a confusion in sensing their own state in relation to maternal touch. Future C infants learn to mask their distress, which may lead to a dissociative loss of awareness of distress in relation to maternal touch, and to later somaticization of distress (Mary Sue Moore, personal communication, July 2, 2007).

This finding has a parallel in the Strange Situation at one year, in which C infants may be upset but passive, not doing anything to ameliorate their distress, or ineffective in getting comfort from mother (Cassidy & Berlin, 1994; Jude Cassidy, personal communication, October 18, 2006). Although by 4 months future C infants have learned to "tune out" maternal touch, this "tuning out" may disturb the 12-month C infant's ability to use maternal touch to be soothed in the reunion following the separations of the Strange Situation (George Downing, personal communication, October 25, 2006). Future research could analyze the moment of reunion in the Strange Situation for infant response to maternal touch. Infant "tuning out" of maternal touch can be seen as a premature separation from mother's touch, which may have later implications for infant autonomy (John Auerbach, personal communication, July 11, 2007).

Dyadic approach-avoid: "chase and dodge"

Moreover, future C dyads showed a spatial "approach-avoid" pattern termed "chase and dodge": as mothers pursued ("chased"), infants oriented away ("dodged"), and vice-versa (Beebe & Stern, 1977; Stern, 1971). In this pattern, which clinically conveys painful moments, the infant has "veto" power (through myriad dodging maneuvers) over maternal efforts to establish mutual gaze. This pattern generates an infant expectation of misregulation of spatial orientation patterns, such that, "As you move in, I move away; as I move away, you move in." This pattern disturbs infant freedom to look away. As infants look and orient away, mothers pursue by following in the infant's direction of movement. Because infant looking away is a key method of down-regulating arousal (Field, 1981), maternal chase also disturbs "state-transforming," the expectation that one's arousal regulation will be facilitated by the partner. Chase and dodge occurred in the context of maternal lowered self-predictability of spatial movements (upright, forward, loom), generating infant difficulty in being able to anticipate when this intrusion might occur, which might be frightening for infants. This lowered maternal spatial self-predictability is a disturbance in the stability of the maternal "spatial frame" of the face-to-face encounter, a background sense of spatial structure that mothers usually provide.

The maternal behaviors of progressively less affectionate touch, lowered predictability of spatial position, and chase and dodge, define a coherent constellation of maternal spatial/tactile intrusion. But the future C mother does not seem to sense that her spatial/tactile intrusion may be forcing her infant to withdraw emotionally from her touch, likely disturbing the infant's feeling of being sensed or acknowledged by her. Perhaps the mother of the future C infant cannot grasp these consequences because she is so self-preoccupied with her needs to be important and needed by her infant (John Auerbach, personal communication, July 11, 2007). In the Adult Attachment Interview, the C mother tends to be so self-preoccupied that she may lose track of the interviewer (Main, Hesse, & Goldwyn, 2008).

What might the infant's procedural experience be, if we could translate it into words? Beebe and Lachmann (2002, see also Beebe & Lachmann, 1988) previously suggested that the *infant's* experience in the chase and dodge pattern might be, ''As you move in, I move away; as I move away, you move in . . . I feel over-aroused and inundated . . . No matter where I move in relation to you, I cannot get comfortable'' (p. 114). The *mother's* experience might be, ''When I want to connect with you, I become aware of how much I need to be responded to. I feel you move away from me as I show my wish to engage. I cannot find a comfortable place in relation to you. I feel anxious and rejected'' (Beebe & Lachmann, 2002, p. 114). Although this interpretation of the chase and dodge pattern was originally written in 1988, without reference to attachment patterns, it is strikingly consistent with Cassidy and Berlin's (1994) description of the C mother as vulnerable to feeling abandoned and unimportant when the infant goes away. We now add that the future C infant's experience of chase and dodge is further colored by the relative unpredictability of the mother's spatial movements as she moves in to chase.

Infant simultaneous inhibition/activation of engagement coordination

In addition to the dyadic approach-avoid pattern of ''chase and dodge,'' future C infants made complex ''approach-avoid'' adaptations. These infants *simultaneously inhibited, and activated, the same behavioral configuration*, engagement, in the different contexts of maternal touch, and maternal engagement, respectively. The infant thus generates opposite expectancies of the ways he responds to the mother through his own interactive contingency of engagement, construed as an ''ongoing dysregulation'' across the session. On the one hand future C infants *dampened* their emotional (engagement/vocal affect) coordination with less positive maternal touch, seeming not to be ''reacting,'' ''tuning it out.'' On the other hand, future C infants *heightened* their engagement coordination with maternal engagement, a vigilance to mother's facial/visual state.

This infant intermodal discordance is a complex and confusing organization. In the touch domain, the infant seems to be forced into premature separation or autonomy; in the facial-visual domain, the infant seems to be forced into premature vigilance. The expectancy of the infant may be, ''My mother really responds to me. But when will she move in toward me in that uncomfortable way? Uh-oh, I have to watch out when she touches me like that. I better watch her carefully to see what she is feeling.'' Although the discordant use of engagement coordination in future C infants could be characterized as ambivalence, it is better characterized as an ethologically coherent, adaptive pattern. However, these difficulties may set the stage for infant confusion regarding his response to his mother, and for infant difficulties in sensing his own state. They may also set the stage for the C infant's later difficulties with autonomy (John Auerbach, personal communication, July 11, 2007).

Emotional vigilance in future C infants has a parallel in the Strange Situation at 12 months. Unlike secure infants in the Strange Situation, C infants cannot count on mother's emotional availability, so that they do not have the luxury of *not* attending to mother (Cassidy & Berlin, 1994; Jude Cassidy, personal communication, October 18, 2006). At the point at which mother and stranger begin to talk, C infants are more likely than B infants to look to mother, suggesting that C infants need to watch mother to be sure that they can get her attention (Dickstein, Thomson, Estes, Malkin, & Lamb, 1984).

If the 4-month infant's procedural experience could be translated into words, perhaps the experience of the future C infant's *inhibition* of emotional coordination with maternal *touch* might be, "I can't afford to 'go with' your touch; as your touch becomes less affectionate, I can't afford to be affected by you or to show my distress; as your touch becomes more affectionate, I can't be comforted or feel good. I can't rely on your touch." If the mother's procedural experience could be translated into words, the mother might feel: "I can't affect you with my touch. I can't reach you. You don't need me. I have to try harder." This interaction pattern presumably also disturbs the mother's own sense of agency through her touch.

If the future C infant's procedural experience could be translated into words, perhaps the experience of *heightened engagement* coordination with maternal *engagement* might be, "I need to pay very careful attention to you. I struggle to stay with you emotionally. As you are looking at me and becoming facially positive, reciprocally I look at you and become more positive with you; as you dampen your face, I stay with you and dampen my own. I feel too affected by you" (Estelle Shane, personal communication, November 12, 2006). This heightened infant engagement coordination might be interpreted as infant efforts to see what mother wants (needs), and to stay with her, to "cooperate" to keep them both happy (Cassidy & Berlin, 1994; Jude Cassidy, personal communication, October 18, 2006). The mother might feel, "Wow, I have so much effect on you; I have so much power." This power may be comforting to C mothers, who need reassurance that their infants need them. However, the combination of lowered maternal ability to affect infants in the tactile realm, but heightened ability to affect infants in the facial-visual engagement realm, is likely to be confusing to both partners. This confusing intermodal discordance in the infant's coordination with mothers may exacerbate the future C mother's sense of insecurity as to whether her infant really needs her.

Thus future C infants are vigilant to mother's emotional state, and coordinate very carefully with her facial-visual engagement, which enables them to anticipate what both the self and the mother will feel next. We suggest that this vigilance is an attempt to cope with maternal tactile/spatial intrusion. We imagine a spiraling sequence in which, as mother's touch becomes progressively less affectionate, and as the infant inhibits response to maternal touch, mother may become insecure about feeling needed by her infant, and may "chase" as the infant looks and turns away. In this process, the infant dampens his distress response to maternal less affectionate touch, and instead stays vigilant to mother's attention and affect (Mary Sue Moore, personal communication, July 2, 2007).

Lowered infant engagement self-predictability: infant "destabilization"

Meanwhile, future C infants experience lowered self-predictability in the ongoing rhythm of facial-visual-vocal engagement. We infer a decreased sense of self-familiarity and coherence over time, metaphorically an emotional "destabilization" (Doris Silverman, personal communication, November 6, 2006). One cost of this complex adaptation is that from moment-to-moment it is more difficult for future C infants (and their mothers) to anticipate the next infant state of engagement, an "ongoing dysregulation" potentially confusing to both infants and mothers.

Knowing and being known

We now return to the topic that the organization of intimate relating is at stake in these early infant working models. Intimate relating entails the fundamental issue of how the infant comes to know, and be known by, another's mind, as well as how the infant comes to know his own mind. We construe ''mind'' here from the point of view of the infant, that is, expectancies of procedurally-organized action sequences.

Regarding *feeling known* by mother, intact maternal interactive contingency safeguards the future C infant's interactive agency and expectation that mother will contingently ''go with'' his direction of affective change, thus sharing his states. However, we propose that the future C infant will nevertheless have difficulty *feeling sensed and known* by his mother in the arena of her spatial/tactile intrusion. Perhaps because of needs to feel needed, the future C mother does not seem to sense that her spatial/tactile intrusion may force her infant to withdraw emotionally from her touch. We propose that the future C infant will have difficulty *knowing* his mother's mind as he has difficulty predicting what mother will do next spatially: sit upright, lean forward, loom in, or chase. We propose that the future C infant will have difficulty *knowing himself* (a) as his own lowered engagement self-contingency makes it more difficult to sense and come to expect the rhythms of his facial-visual action tendencies from moment-to-moment; and (b) as he simultaneously inhibits his engagement coordination with mother touch, and activates his engagement coordination with mother engagement. The infant thus generates opposite expectancies of the ways he responds to mother with his engagement, a complex, confusing, but nevertheless adaptive organization. We note that these difficulties of the future C infant are identified not through disturbances in maternal affective correspondence and state-sharing, as described by Meltzoff (2007), Trevarthen (1998), Stern (1985), and Sander (1977), but rather through dysregulated tactile and spatial exchanges.

Internal working models of future C infants

We propose that the intact maternal facial mirroring of infant facial/vocal affect in mothers of future C infants generates infant expectancies of feeling affectively ''on the same wavelength.'' Overall the future C infant comes to expect a shared corresponding affective process, and to expect that he can influence maternal behaviors so as to match his direction of behavioral change. However, future C infants come to expect a maternal tactile/spatial impingement and to expect that they will ''dodge'' as their mothers ''chase,'' an experience of ''moving away'' as mother ''moves in.'' They come to expect that they must manage mother's touch by tuning it out. This adaptation is costly, sacrificing infants' ability to communicate their distress response to maternal touch, an important aspect of the infant's ability to regulate affect and arousal. Thus future C infants come to expect that they cannot use mother's touch to help them regulate their arousal, and that looking away to down-regulate arousal is interfered with by maternal chase. They come to expect difficulty in state transforming. At the same time future C infants come to expect their vigilant facial-visual engagement coordination with mother's engagement, but at the cost of engagement self-destabilization. High emotional coordination may be what C mothers need. However, the future C infant comes to expect a complex and confusing pattern of simultaneously being facially-visually too "hooked-in" to maternal engagement, and yet facially-visually too "separate" or tuned-out to maternal touch. Thus he comes to expect his own opposite tendencies toward his mother, as he struggles to make complex adaptations.

These dyadic patterns at 4 months shed light on how the future C mother's own self-preoccupation with being needed and loved is communicated to the infant, and how mother and infant both develop complex adaptations in this emotional context. We propose that future C infants represent the patterns described above as internal working models in the form of procedural self- and interactive expectancies. These expectancies presumably bias the trajectory of how experience is organized, activating certain pathways and inhibiting others, ultimately limiting the range and flexibility of social experience.

Chapter 5. Results: Future disorganized (D) vs. secure (B) dyads

This chapter presents findings first for qualitative behavioral features, and then for self- and interactive contingency, in 4-month "future" D vs. B dyads. Following presentation of the results, we provide a discussion in three parts: (1) a discussion of the empirical findings, (2) a discussion of the origins of the working model of attachment of D infants, and (3) a comparison of the internal working models of future C vs. D infants. Although there were no associations of maternal ethnicity, age or education with future D vs. B infants, male infants were over-represented in future D infants ($\chi^2 = 572$, 1 df, $p = .02$).

Differences in qualitative behavioral features of future D vs. B dyads

We first asked whether qualitative features of behaviors (such as amount of gazing away) were associated with infant D vs. B attachment classifications, and with the 7-point degree of disorganization scale, using two approaches: (1) the means of ordinalized behavioral scales, and (2) behavioral extremes. For definitions of behavioral extremes, see Table 3. The behavioral extremes approach explored several measures, tailored to each behavior as appropriate: (a) the mean percent time of a specific behavior (such as mother intrusive touch); (b) when distributions were very skewed, the percent of participants who "ever" used a particular behavior; or (c) percent of participants showing excessive use of a specific behavior, defined as 20% time or more in a particular behavior (such as mother intrusive touch). Web Appendix 3 (posted on our website) presents the rates of behaviors for the three measures above, as well as ranges of percent time, across the group and for B and D dyads.

Table 4 shows that when qualitative features of behaviors were evaluated as means of ordinalized behavioral scales, which tapped the full range of behaviors coded, there was only one significant finding for future D infants. Frequency of infant-initiated touch was lower in future D (mean = .61, SD = .30) than B infants (mean = .75, SD = .23) ($t = -1.99$, $p < .05$). Infant touch was ordinalized as no touch (0), any one type of touch (1), or more than one type of touch per second (2) (see Appendix A). In contrast, Table 4 shows that when qualitative features of behaviors were evaluated as rates of behavioral extremes, associations with future D attachment were more visible. In what follows we present results of these analyses.

Infant gaze away

Future D vs. B infants did not differ in mean values of percent time looking away.

Infant negative facial affect

Future D vs. B infants did not differ in infant *negative facial affect* (*frown, grimace, pre-cry, and cry-face*), measured as percent time and excessive use. Using excessive use, there was no association with the 7-point degree of disorganization scale.

Infant negative vocal affect

Defined as *fuss, whimper, angry protest or cry*, infant *negative vocal affect* tested as average percent time did not differ for future D vs. B infants. However, percent time negative vocal affect was positively correlated with the 7-point degree of disorganization scale ($r = .294$, $p = .008$). Illustrating these differences, negative vocal affect is the sixth most prevalent behavior for B infants (mean % time 8.4, SD = 12.4; see Web Appendix 3, on our website), but the third most prevalent for D infants (mean % time 18.2, SD = 22.4). Within future B infants, three-quarters (75%) showed negative vocal affect 11.3% of time or less; whereas within future D infants, three-quarters (76.5%) showed negative vocal affect 24.7% of time or less, twice as much. Infant negative vocal affect is elevated in future D (vs. B) infants in all measures, but only significant when tested one way, illustrating the sensitivity to the precise measurement of the variable.

Infant facial/vocal distress

We created a variable of infant *facial/vocal distress*, number of seconds (of 150) in which infants showed negative facial and/or vocal affect. Future D infants showed twice as much facial/vocal distress (mean % time 21.2, SD = 25.2) as B infants (10.4%, SD = 15.5). Testing percentage time or excessive use of facial/vocal distress, future D vs. B infants did not differ. However, future D infants showed greater variability (higher SD) than future B infants ($t = 2.02$, df = 59, $p = .047$). In addition, percentage time infants were facially/vocally distressed was significantly correlated with the 7-point degree of disorganization scale ($r = .272$, $p = .015$).

Infant discrepant facial/vocal affect

Infant *discrepant affect* was defined as simultaneous (within same second) positive affect in one modality (either facial or vocal) and negative affect in the other. Tested as percentage time discrepant affect, our hypothesis that D infants display more discrepant affect was supported by Mann-Whitney test (U = 254, $p = .030$). Percentage of future D infants showing any discrepant affect (52.9%) was over twice that of future B infants (19.1%).

Infant touch

When *infant-initiated touch* was tested as the mean of the ordinalized touch scale (none, any one type of touch, or more than one), future D vs. B infants did not differ. However, examining infant touch in the separate codes (*none, touch/suck own skin, touch/suck object [own clothing, strap, chair], touch/suck mother*), mean percent time in "no touch" was more frequent in future D (mean = 44.3%, SD = 48.2) than B infants (mean = 29.2%, SD = 19.7) ($t = 2.56$, 62 df, $p = .01$). Greater percent time in "no touch" was also correlated with higher degree of disorganization ($r = .28$, $p = .01$). Future D infants spent less than half the time (6.8%, SD = 9.9) in the code "touch own skin" as future B infants (15.7%, SD = 19.7) ($t = -2.41$, 553 df, $p = .02$). Thus future D (vs. B) infants spent more time in "no touch" and less time in "touch own skin."

Infant 60–90° avert/arch

Infant head orientation 60–90° avert indicates head movement away from the vis-à-vis to approximately 60–90°. Infant *arch* indicates a whole body movement, head and back arching away from the vis-à-vis. Tested as presence/absence and as percent time, neither 60–90° avert nor arch tested individually, nor the two behaviors tested together, showed differences between future D vs. B infants (tested categorically and as degree of disorganization). Most likely we failed to find associations because both 60–90° avert and arch showed few individual differences.

Mother gaze away

Using excessive maternal use of percent time *gazing away* (20%+), 14.9% of B, and 35.3% of D mothers met this criterion, but contrasts were not significant (by chi-square test). However, excessive use of percent time mother gaze away was elevated with degree of disorganization ($t = 2.55$, 82 df, $p = .01$). To illustrate, 72.3% of mothers who gazed away excessively had infants with higher degrees of disorganization (of 4–7), whereas 36.4% of mothers who did not gaze away excessively had infants with higher degrees of disorganization.

Mother negative facial affect

Mother *negative facial affect (frown, grimace, tight compressed lips)* was a rare behavior and highly skewed. Tested as presence/absence, percentage of mothers "ever" using negative facial affect was 44.0% for mothers of future B infants, and 47.1% for mothers of future D, not significant (by chi square test). Degree of disorganization, tested in relation to maternal percent time in negative facial affect, and to "ever" using negative facial affect, were not significant.

Mother positive facial affect

Maternal positive facial affect (smile 2, smile 3, mock surprise) did not differ in mothers of future D vs. B infants, when positive affect was tested as 20%+ time

(51.1% for future B, 64.7% for future D), or as 40%+ time (17.0% for future B, 17.6% for future D).

Mother interruptive touch

Testing whether future D mothers tend to interfere and interrupt infant ongoing activity, we used number of seconds of the maternal touch code *push, constrain movement, force, or control infant movement*, (e.g. force infant's hand down) (code 16: see Web Appendix 1). Because interruptive touch was a rare behavior and the data were heavily skewed, we tested it as presence/absence. There was no difference between the 11.8% of future D mothers who "ever" used it, and the 12.8% of future B mothers.

Mother intrusive touch

The distribution of mother *intrusive touch* (*codes rough touch [scratch, pull, push, pinch, poke]/high intensity aggressive touch*) was highly skewed; half the mothers (53.6%) showed none. Future D vs. B mothers did not differ, by attachment categories, or the 7-point degree of disorganization scale, using average frequency of mother intrusive touch, percentage of mothers using "any" time in intrusive touch, or the touch slope measure.[7]

Mother loom

Mother *loom* into the infant's face was a rare behavior (mean = 14.6%, SD = 25.2) with a skewed distribution. Using nonparametric testing, mean percent time spent in loom did not differ for future D vs. B mothers. Percent time mother loom was elevated with increasing degree of disorganization (using the 7-point scale) but not significant (Spearman rho = .22, $p = .10$). To test extreme use of loom, because of the shape of the distribution we separated levels of loom into none, medium (1–29 s), and excessive (30+ s [range 20–100% time]). Mothers of future B infants mostly did not loom (61.9%), some loomed moderately, 1–29 s (26.2%), and a few were excessive loomers, 30+ s (11.9%). Mothers of future D infants had a bimodal distribution: 50% never loomed, and 50% loomed excessively. Excessive loom was greater in mothers of future D (vs. B) infants ($\chi^2 = 11.030$, $p = .004$), by chi-square contrasts (2 df).

Dyadic "chase and dodge"

This dyadic code represents a minimum of 2 consecutive seconds in which mother moves her head in toward the infant's face while the infant simultaneously (or in the following second) orients his head away from vis-à-vis (see Appendix A). *Chase and dodge* is a relatively rare behavior. Percentage of dyads "ever" showing it was 21.4% for future B dyads and 46.2% for D. Because the distribution was heavily skewed, we tested mean percent of time nonparametrically, by Mann-Whitney U tests. Percent time in chase and dodge was elevated in future D vs. B dyads, but not significant ($p = .085$). There was no association (by t-test) of presence/absence of chase and dodge with the 7-point degree of disorganization scale. Excessive use was not tested.

Dyadic: mother positive while infant distressed

This analysis tested the concept that mothers of D infants are positive while infants are distressed. Infant distress episodes (minimum of 2 s) were identified, initiated by any second in which infants showed negative vocal and/or facial affect. Mother positive facial affect was defined as a minimum of smile 2 or higher (see Appendix A). We computed the number of seconds during which the mother showed positive facial affect in a 4 s window: the second in which the infant first showed distress, and the following 3 s. Because infants had different numbers of distress episodes, we analyzed the infant distress episode in which the mother expressed the greatest number of seconds of positive facial affect. This measure of infant distressed/mother positive occurred in 53.1% of dyads. Using the D vs. B attachment categories, neither parametric nor nonparametric testing yielded any significant contrasts. However, using the 7-point scale, degree of disorganization, mothers who used more positive facial affect within the 4s distress window were more likely to have infants with greater 12-month degree of disorganization ($r = .273$, $p = .029$). Because these analyses of behavioral extremes were exploratory, the findings need to be taken with caution and require replication. We note that the exact nature of the measure was critical to identifying significant associations.

Contingency differences in future disorganized (D) vs. secure (B) dyads

In this section we present the results of testing whether differences in 4-month degrees of self- and interactive contingency predict future D ($N = 17$) vs. B ($N = 47$) dyads. We report significant estimates (β) of the conditional effects of 12-month attachment category on 4-month self- and interactive contingency. The notation in the following tables and figures of I $\rightarrow$ I for infant *self*-contingency indicates that infant lagged behavior in the prior few seconds predicts infant behavior in the current moment; similarly, M $\rightarrow$ M indicates mother self-contingency. The notation M $\rightarrow$ I for infant *interactive* contingency indicates that mother lagged behavior in the prior few seconds predicts infant behavior in the current moment: infant "coordinates" with mother. Similarly, I $\rightarrow$ M indicates mother interactive contingency: mother "coordinates" with infant. The term coordination is used synonymously with interactive contingency.

Table 7 presents associations of 12-month D vs. B ($N = 64$) attachment with 4-month mother and infant self- and interactive contingency. Lines 5 and 6 of each modality-pairing test whether self- and interactive values of future D dyads differ from those of B. For example, in Table 7, in modality-pairing (1) infant gaze-mother gaze, for mothers, DvB $\times$ M $\rightarrow$ M $\beta = -0.770$, $p = .002$, indicates that mother gaze self-contingency differed for mothers of D vs. B infants; the negative sign indicates a lowered value. Contingency patterns for future D (vs. B) dyads are illustrated in Figure 5B. Note that Figure 5B depicting D (vs. B) dyads is to be interpreted in relation to Figure 3A depicting secure dyads.

(1) Infant gaze – mother gaze. Mothers of future D (vs. B) infants showed lowered 4-month gaze self-contingency.

(2) Infant facial affect – mother facial affect. No differences in future D vs. B dyads.

(3) Infant vocal affect – mother facial affect. Mothers of future D (vs. B) infants showed higher 4-month facial self-contingency.

(4) Infant engagement – mother engagement. Future D (vs. B) infants showed lower 4-month engagement self-contingency; their mothers showed lower engagement coordination with infant engagement.

(5) Infant engagement – mother touch. Future D (vs. B) infants showed lower 4-month engagement self-contingency.

(6) Infant vocal affect – mother touch. No differences.

(7) Infant-initiated touch – mother touch. Future D (vs. B) infants showed higher touch self-contingency; their mothers showed lower touch coordination with infant touch.

(8) Infant head orientation – mother spatial orientation. Mothers of future D (vs. B) infants showed lowered spatial orientation self-contingency.

(9) Intrapersonal infant vocal affect – infant-initiated touch. Future D (vs. B) infants showed higher 4-month touch self-contingency.

We turn now to an evaluation of the percentage of significant analyses. Nine of 36 possible equations were significant. Future D infants differed from future B in 40% (4 of 10 possible) of self-contingency analyses, but no interactive contingency analyses. Thus roughly half (4 of 9) of the findings concerned infant self-contingency. Mothers of future D infants differed from mothers of future B in 38% (3 of 8 possible) self-contingency analyses, and in 20% (2 of 8 possible) interactive contingency analyses. Despite fewer degrees of freedom in the D ($N = 17$) vs. B, compared to nonB ($N = 37$) vs. B analyses, the number of D findings is 9 of 36, whereas that of the nonB findings is 6 of 36.

Discussion Part I: Future disorganized (D) vs. secure (B) dyads

In this section we first note areas in which future D dyads do not differ from future B. We then discuss differences in future D (vs. B) dyads in the domains of attention, spatial orientation, touch, affect, and infant intrapersonal vocal affect – touch, integrating differences in behavioral qualities and degree of contingency. We then discuss the finding that male infants are over-represented in future D infants. In *Discussion Part II* we offer a somewhat more speculative formulation of the origins of working models of attachment in future D infants at 4 months.

Future D dyads were indistinguishable from future B in many areas. Regarding interactive contingencies, as illustrated in Figure 5B, future D infants did not differ from future B; their mothers differed only in interactive contingencies of engagement and touch. Thus there is no question that future D mothers and infants perceived and contingently coordinated with each other. This finding is consistent with other literature that mothers of future D infants are no less sensitive than mothers of future B infants (Fonagy, 2001; Lyons-Ruth & Jacobvitz, 2008). Regarding self-contingencies, future D (vs. B) infants differed in facial-visual engagement and touch, but not gaze, vocal affect, facial affect, or head orientation; their mothers differed in gaze, facial affect, and spatial orientation, but not engagement or touch. Regarding behavioral qualities, future D (vs. B) mothers showed more gazing away,

Table 7. Disorganized vs. Secure (D vs. B) attachment: Effects upon self- and interactive contingency.

(1)	Infant Gaze				Mother Gaze		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	−.289	.138	.040	Intercept	2.531	.131	<.001
DvB	.146	.245	.554	DvB	−.472	.164	.006
I → I	3.692	.084	<.001	M → M	2.857	.167	<.001
M → I	.493	.192	.010	I → M	.691	.122	<.001
DvB · I → I	−.299	.170	.078	**DvB · M → M**	**−.770**	**.249**	**.002**
DvB · M → I	.559	.361	.122	DvB · I → M	−.360	.211	.088
(2)	**Infant Facial Affect**				**Mother Facial Affect**		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	55.968	.417	<.001	Intercept	68.214	.589	<.001
DvB	.586	.565	.304	DvB	.074	.532	.890
I → I	.632	.016	<.001	M → M	.486	.025	<.001
M → I	.050	.014	.0002	I → M	.137	.022	<.001
DvB · I → I	.004	.022	.873	DvB · M → M	.044	.024	.063
DvB · M → I	.039	.027	.151	DvB · I → M	−.025	.022	.265
(3)	**Infant Vocal Affect**				**Mother Facial Affect**		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	2.850	.045	<.001	Intercept	66.980	.521	<.001
DvB	.042	.079	.603	DvB	.567	.415	.178
I → I	.669	.015	<.001	M → M	.582	.028	<.001
M → I	.002	.0006	.001	I → M	1.537	.252	<.001
DvB · I → I	−.015	.021	.470	**DvB · M → M**	**.043**	**.022**	**.045**
DvB · M → I	−.0008	.001	.470	DvB · I → M	−.585	.419	.163
(4)	**Infant Engagement**				**Mother Engagement**		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	11.177	.136	<.001	Intercept	5.100	.075	<.001
DvB	.061	.233	.793	DvB	−.051	.116	.661
I → I	.693	.011	<.001	M → M	.462	.015	<.001
M → I	.037	.025	.141	I → M	.079	.007	<.001
DvB · I → I	**−.055**	**.019**	**.005**	DvB · M → M	.007	.027	.790
DvB · M → I	.057	.046	.216	**DvB · I → M**	**−.026**	**.013**	**.050**
(5)	**Infant Engagement**				**Mother Touch**		
	β	*SE*	*p* =		*β*	*SE*	*p* =
Intercept	11.194	.132	<.001	Intercept	7.372	.107	<.001
DvB	.166	.231	.475	DvB	−.043	.087	.622
I → I	.694	.010	<.001	M → M	.737	.009	<.001
M → I	.038	.017	.025	I → M	.003	.006	.646
DvB · I → I	**−.050**	**.019**	**.010**	DvB · M → M	−.020	.018	.262
DvB · M → I	.003	.035	.925	DvB · I → M	.013	.012	.261

(continued)

Table 7. (*Continued*).

(6)	Infant Vocal Affect				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	3.011	.018	< .001	Intercept	7.347	.085	< .001
DvB	−.016	.016	.312	DvB	−.053	.089	.551
I → I	.708	.023	< .001	M → M	.731	.009	< .001
M → I	.004	.002	.075	I → M	.106	.048	.027
DvB · I → I	−.011	.022	.606	DvB · M → M	−.011	.017	.526
DvB · M → I	.007	.004	.088	DvB · I → M	−.053	.083	.518

(7)	Infant Touch				Mother Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	1.683	.058	< .001	Intercept	7.250	.323	< .001
DvB	−.024	.016	.141	DvB	−.045	.103	.662
I → I	.857	.037	< .001	M → M	.849	.059	< .001
M → I	.00006	.003	.981	I → M	.202	.062	.001
DvB · I → I	**.034**	**.015**	**.025**	DvB · M → M	−.022	.018	.232
DvB · M → I	−.005	.004	.170	**DvB · I → M**	**−.299**	**.087**	**.001**

(8)	Infant Head Orientation				Mother Spatial Orientation		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	5.176	.094	< .001	Intercept	2.179	.092	< .001
DvB	.168	.065	.013	DvB	−.078	.040	.056
I → I	.650	.021	< .001	M → M	.810	.053	< .001
M → I	.158	.057	.006	I → M	−.015	.007	.025
DvB · I → I	−.039	.022	.080	**DvB · M → M**	**−.090**	**.016**	**< .001**
DvB · M → I	.055	.044	.211	DvB · I → M	−.007	.007	.380

(9)	Infant Vocal Affect				Infant Touch		
	β	*SE*	$p =$		β	*SE*	$p =$
Intercept	2.999	.013	< .001	Intercept	1.689	.022	< .001
DvB	−.014	.016	.404	DvB	−.027	.016	.101
IVQ → IVQ	.670	.015	< .001	ITch → ITch	.766	.009	< .001
ITch → IVQ	.038	.010	.0002	IVQ → ITch	.094	.031	.002
DvB · IVQ → IVQ	−.0008	.021	.970	**DvB · ITch → ITch**	**.034**	**.015**	**.026**
DvB · ITch → IVQ	−.018	.018	.309	DvB · IVQ→ ITch	.018	.019	.358

Note:

1. Estimated fixed effects (β) of attachment classification in interaction with M → M, I → M, (or I → I, M → I), based on the "basic models;" SE = Standard Error of the Beta.
2. Intercept: estimated β represents the average value of the dependent variable.
3. "DvB": estimated β represents the average amount that the vocal affect (pairing 3) is altered by D classification; 0 = D, 1 = B (D = disorganized attachment).
4. "I → I" (infant self-contingency): estimated β represents the prediction of current infant behavior from the weighted lag of infant behavior.
5. "M → I": estimated β represents the prediction of current infant behavior from the weighted lag of mother behavior (infant interactive contingency).
6. "DvB × I → I": estimated β represents the effect of D attachment classification on infant self- contingency.
7. "DvB × M → I": estimated β represents the effect of D attachment classification on infant interactive contingency.
8. Negative signs indicate lower estimates of self- and interactive contingency with disorganized attachment.
9. All parameter entries are maximum likelihood estimates fitted using GLIMMIX Macro (gaze) or SAS PROC MIXED (all other modalities).
10. Significant conditional effects of attachment are bolded.

more excessive looming, and mother smile/surprise while infant was distressed, but did not differ in positive or negative affect, or touch. Future D (vs. B) infants, however, showed differences in many measures, failing to differ only in prevalence of gazing away, negative facial affect, and head aversion/arch.

We now turn to the ways that future D dyads differed from future B. Mothers of future D infants bring their own difficult attachment history and are likely to suffer from unresolved loss, abuse, or trauma (Lyons-Ruth, 1999; Main & Hesse, 1990). Their difficulties with their own distress are likely to disturb the management of distress in the infant. In the Adult Attachment Interview these mothers may become emotionally incoherent or dissociated.

Attention dysregulation in future D dyads. Mothers who gazed away from the infant's face excessively (30 s or more across the 2.5 min coded) were more likely to have infants with greater degree of disorganization at 12 months. Future D mothers not only looked away excessively, but they did so in a less predictable fashion. Lowered gaze self-contingency occurred in mothers of future nonB and D, but not C infants; thus it is specific to D.

Spatial dysregulation in future D dyads. Mothers of future D (vs. B) infants showed excessive looming (30 sec+) into the infant's face. Looming was evident in mothers of future nonB and D, but not C infants; thus it is specific to D. Maternal loom was accompanied by lowered maternal self-contingency of spatial orientation from sitting upright to leaning forward to looming in. Looming into the infant's face elicits a protective response in the early weeks of life: infants put their hands in front of their faces and turn their heads away (Bower et al., 1970). Loom behavior is one postulated as frightening by Main and Hesse (1990); it is coded in the "intrusiveness/negativity" dimension of the "Ambiance" coding system (Lyons-Ruth et al., 1999). Our loom finding is consistent with Tomlinson et al. (2005), who found 2-month maternal intrusive-coercive behavior associated with future disorganized attachment.

Dyadic touch dysregulation in future D dyads. Future D infants spent more time in "no touch," and less time in "touch own skin," which lowered infant access to self-soothing through touch. In the current data set, infants of depressed mothers showed the opposite finding, increased touching one's own skin (Hentel, Beebe, & Jaffe, 2000). Our across-group analysis of this data set documented that infant touch functions to modulate infant vocal affect, specifically vocal distress. The more infants touch, the more likely vocal affect is positive, and vice-versa (Beebe et al., 2008b). This relation continues to obtain for D as well as B infants. Future D infants are vocally distressed (discussed below). Thus, with increased vocal distress, future D infants have less access to touch. Reciprocally, less infant touch increases the likelihood that vocal affect will be distressed. Lowered availability of touch, and of touching one's own skin, is likely to interfere with infant arousal regulation of vocal distress, a hallmark of future D infants.

Future D (vs. B) infants heightened their touch self-contingency in two contexts (mother touch, infant vocal affect). Inspection of t to $t+1$ transition matrices revealed greater likelihood of continuing in the code of "no touch." Thus, future D (vs. B) infants had less access to touch, specifically to touching their own skin, and they were more likely to stay in states of "no touch," further exacerbating difficulties in regulating vocal distress through touch. Heightened touch self-contingency was present in future nonB and D, but not C infants; thus it is specific to D.

In this context of difficulty using touch in future D (vs. B) infants, their mothers lowered their contingent touch coordination with infant touch: a reciprocal dysregulation. Our prior across-group analysis (Beebe et al., 2008b), and the analysis of the secure subset, documented a positive sign in the association between infant and maternal touch: the more likely infant touch, the more likely maternal touch was affectionate (and vice-versa). Thus mothers are procedurally ''aware'' of infant touch behavior, and when infant touch increases, maternal touch patterns become more affectionate (and vice-versa). This association was lowered in mothers of future D infants. Perhaps mothers of future D infants lowered their touch coordination with infant touch because infant touch was a ''weaker signal,'' in the sense that infants used it less. However, when future D infants did touch more frequently, their mothers showed lower coordination. Lowered maternal touch contingency is interpreted as a maternal ''withdrawal'' from coordination.

Affect dysregulation in future D infants. Future D (vs. B) infants showed complex facial/vocal patterns of distress, largely consistent with our hypotheses. They showed more (1) vocal distress, (2) combined facial and/or vocal distress, and (3) discrepant affect (simultaneous positive and negative facial and vocal affect within the same second). Discrepant affect was twice as likely to be vocal distress while facially positive, as the reverse. These multiple dimensions of infant distress are consistent with the finding that D infants show the highest cortisol following the Strange Situation (Spangler & Grossman, 1993).

Future D (vs. B) infants also showed lowered self-predictability of facial-visual engagement, in two contexts (paired with mother engagement, and mother touch). We infer that it is harder for future D (vs. B) infants to sense their own next engagement ''move,'' as well as harder for their mothers to anticipate infant engagement shifts. Because future D infants lowered their engagement self-contingency in the context of lowered maternal engagement coordination (discussed next), we conjecture that these two findings are compensatory. That is, infant engagement ''self-destabilization'' may occur in relation to maternal failure to adequately coordinate with infant engagement (or vice-versa): an infant intrapersonal dysregulation linked to a maternal interpersonal dysregulation.

Affect dysregulation in future D mothers. Mothers of future D (vs. B) infants *lowered* their *engagement interactive contingency*. Lowered contingent coordination is a form of maternal withdrawal; mothers are not as correlated with prior infant behavior. Lowered *engagement* interactive contingency indicates that mothers of future D (vs. B) infants were less likely to follow infant direction of gaze, to become facially positive as their infants became facially/vocally positive, and to dampen their facial affect toward interest, neutral, or ''woe face'' as their infants became facially/vocally distressed. Because future D infants had more combined vocal/facial distress than B infants, lowered maternal engagement coordination indicates a lowered maternal ability to emotionally ''enter'' and ''go with'' infant facial and vocal distress, via contingent changes.

Future D mothers also showed heightened facial self-contingency, remaining overly facially stable. The combination of lowered maternal engagement coordination with infant engagement, but heightened maternal facial self-contingency, suggests that mothers of future D infants were procedurally "preoccupied" with facial self-management, at the expense of coordination with the infant: a self- vs. interactive contingency imbalance exacerbating maternal withdrawal (see Tronick, 1989). Heightened maternal facial self-contingency indicates that maternal facial behavior is overly predictable or stable in mothers of future D (vs. B) infants. Facial affect and gaze on/off partner, which usually operate as a "package," were altered in opposite directions: heightened facial self-contingency, but lowered gaze self-contingency. The two altered contingency findings together, however, produced a coherent constellation of lowered maternal visual and facial availability for the infant.

Following Lyons-Ruth et al. (1999), we showed that mothers who were more likely to show positive expressiveness or surprise while infants were facially/vocally distressed were more likely to have infants with greater degree of disorganization at 12 months. We suggest that infant simultaneous positive/negative emotion parallels maternal positive emotion during infant negative emotion. Maternal interpersonal emotional discordance is thus echoed in infant intrapersonal emotional discordance (Jude Cassidy, personal communication, October 25, 2006).

Our finding also has a parallel in the work of Madigan et al. (2006; Goldberg, Benoit, Blokland, & Madigan, 2003), who found affective communication errors (coded by the Ambience Scale during free play at 12 months) in both D and C dyads. Whereas Lyons-Ruth et al.' s finding was evident within the Strange Situation, and Madigan et al.' s was evident outside the Strange Situation, both at 12 months, ours identifies this pattern at 4 months, with a different method, indicating robustness of the phenomenon.

Lowered maternal facial-visual engagement coordination, and maternal positive facial expressiveness while infants are distressed, together form a coherent constellation in future D dyads. The first is a contingency analysis over time, indicating that mothers lowered their coordination in *both* directions, as infants became more positive as well as more negative, and as infants looked as well as looked away. The second is an analysis of particular moments, addressing only a portion of this process, i.e. maternal violation of facial empathy as infants became distressed (see Malatesta et al., 1989). Although recent work has documented that mothers of disorganized infants show frightened or frightening faces during the Strange Situation (Lyons-Ruth et al., 1999; Main & Hesse, 1990), we failed to find differences in the future D mother's use of negative facial affect (frown, grimace, compressed lips). However, we did not specifically code anger or disgust, which would have been a closer parallel to frightened/frightening faces.

Infant intrapersonal vocal affect – touch. There were no differences.

Gender differences in future D infants. Male infants were over-represented in future D infants, consistent with the literature. Boys (vs. girls) are more likely to develop insecure attachments (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). Male infants are more emotionally reactive than female (Weinberg, 1992; Weinberg, Tronick, Cohn, & Olson, 1999). Furthermore, it is possible that response to threat is influenced by gender. Males are more likely to show fight/flight responses to threat, and females are more likely to "tend and befriend" (Taylor, Klein, Lewis, Grunewald, Gurung, & Updegraff, 2000). Lyons-Ruth et al. (1999) found that male (vs. female) infants showed more disorganized conflict behavior and avoidance when mothers showed high levels of frightening or withdrawing behavior in the Strange Situation.

Summary of future D (vs. B) dyads. In summary, 4-month infants who will be classified D (vs. B) at 12 months were more likely to be male, and they showed complex forms of emotional distress and dysregulation: (1) more vocal distress, and more combined facial/vocal distress, (2) more *discrepant* facial and vocal affect, (3) lowered engagement self-contingency, an emotional destabilization, and (4) more failure to touch, less touching one's own skin, and greater likelihood of continuing in a "no touch" state, all of which compromise infant access to arousal regulation through touch, in the context of increased distress.

Mothers of 4-month infants who will be classified D (vs. B) at 12 months showed: (1) excessive (20%+ time) gazing away from infant's face, and less predictable gaze on/off self-contingency patterns, compromising infant ability to expect and rely on predictable maternal visual attention; (2) excessive "looming" head movements, in the context of lowered self- predictability of spatial orientation (sitting upright, leaning forward and looming positions), both interpreted as potentially threatening; (3) greater likelihood of positive/surprise expressions while infants were distressed, interpreted as emotional "denial" of infant distress; (4) lowered emotional (via engagement) coordination with infant emotional (engagement) ups and downs, interpreted as emotional withdrawal from distressed infants; (5) heightened maternal facial self-contingency, an overly stable face leading to a "closed-up" face; (6) heightened facial self-contingency, but lowered facial-visual engagement coordination with infant engagement, an imbalance tilting toward maternal preoccupation with facial self-contingency, exacerbating withdrawal from distressed infants; (7) lowered maternal contingent touch coordination with infant touch. The two findings of lowered maternal engagement and touch coordination compromise infant interactive efficacy in these domains.

Discussion Part II: Origins of internal working models in future D infants

In this section we return to the proposal that the recurrent nature of the infant's experiences leads to the development of procedural representations or "working models" of self and others that influence the infant's emotional experiences and expectations (Bowlby, 1973; Bretherton, 1980; Bretherton & Munholland, 1999; Main et al., 1985). We proposed that 4-month infant procedural expectancies of patterns of self and partner contingency, as well as of specific behavioral qualities, provide ways of defining processes by which patterns of intimate relating and attachment security are constructed: the origins of emerging working models of attachment. In this section we become somewhat more speculative about the inner experience of future D infants at 4 months. Although we conceptualize the internal working model of future D infants in general, the picture we describe below is more likely to characterize male infants. As noted above, mothers of future D infants bring their own difficult attachment histories, fears regarding intimate attachments, and difficulties managing their own distress.

In what follows we argue that our findings show many forms of intrapersonal and interpersonal conflict, intermodal discordance, or contradiction, leading to confusion and incoherent working models in future D infants. We will propose that infant internal working models are characterized by expectancies of emotional distress and emotional incoherence, difficulty predicting what will happen, both in the self and the partner, disturbance in experiences of recognition, and difficulty in obtaining comfort. Our results provide one response to Madigan et al.' s (2006) call for better identification of the details of the elusive behaviors of anomalous parenting directly implicated in the development of D attachment.

To set the stage, the many ways in which maternal contingent coordination with infants is intact in mothers of future D infants suggest that there is no general maternal confusion, no overall failure of empathy, or failure to register or read infant states. However, contingent coordination of engagement and touch are lowered, discussed below. Instead, many difficulties of mothers of future D infants occur at specific heightened moments of contradictory behavior patterns, triggered at moments of infant distress (Lyons-Ruth, personal communication, October 17, 2008). Presumably out of her own unresolved fears about intimate relating, and her fears of being re-traumatized by the infant's distress, at specific moments the mother of the future D infant mobilizes complex contradictory "defensive" behaviors, such as simultaneous activation of contradictory behavioral tendencies, that derail the infant. We use an ethological definition of conflict, in which behavior is organized simultaneously in opposing directions, rather than a psychoanalytic definition of conflict as impulse and defense. The infant's distress may be so over-arousing and terrifying to the future D mother that she repeats aspects of her own childhood feelings through the procedural action-sequence mode, or defends herself against re-experiencing them (Mary Sue Moore, personal communication, July 2, 2007). Finally, we will propose that many of the dysregulated patterns provide specific ways of defining *how* the infant's ability to "know" and be "known by" the mother's mind, as well as the infant's ability to "know" his own mind, may become derailed.

Infant distress and discrepant affect

Future D (vs. B) infants show more vocal distress, and combined facial/vocal distress. Figure 6 (1, 2, 3) presents visual illustrations of infant facial distress. Future D infants also show discrepant negative and positive affect in the same sec, especially positive facial affect such as smile, with distressed vocal affect such as whimper. To our knowledge, this is the first such documentation of *simultaneous* discrepant infant affect, disturbing the usual inter-modal redundancy in communication channels. Infant discrepant affect suggests affective conflict, confusion, and struggle, a striking intrapersonal affective dysregulation. We conjecture that the infant's stress response is heightened at such moments consistent with known heightened cortisol levels in D infants following the Strange Situation (Spangler & Grossman, 1993). Infant discrepant affect illustrates the principle of *heightened affective moments*, in which dramatic moments may become formative out of proportion to mere temporal duration or frequency.

This infant pattern of discrepant affect fits an ethological definition of conflict. For example, one future D infant joined sweet maternal smiles with smiles of his own, but meanwhile he whimpered as mother pushed his head back and roughly smacked his hands together. This mother thus also showed an intermodal discrepancy between facial affect and touch. We infer that the infant's discrepant affect reflects his need for affective contact with mother, despite being distressed by her rough handling. Because of discrepant affect, it may be difficult for future D infants eventually to know what they feel, or how to make sense of their contradictory feelings (Jean Knox, personal communication, March 3, 2009). This picture at 4 months predicts similar contradictory approach/withdrawal behavior at 12 months in the Strange Situation, and also is related to later contradictory/unintegrated mental processes, particularly dissociative processes, characteristic of these infants as they approach adulthood (Lyons-Ruth, 2008; Dutra, Bureau, Holmes, Lyubchik, & Lyons-Ruth, 2009). Infant emotional distress and discrepant affect is one central feature differentiating future D infants from future C infants.

Discrepant affect in future D infants is reminiscent of Weinberg and Tronick's (1996) description of infant ambivalence during the reunion episode following the still-face. Infants showed even more joyful faces, and increased looking at mother in the reunion episode compared to baseline play, but they also continued to show the increased incidence of sadness and anger shown during the still-face. Our findings also document remarkable differentiation, specificity, and ambivalence in the infant's intermodal affective organization.

Dyadic affective conflict: Maternal smile/surprise to infant distress

Not only the infant but also the dyad was in affective conflict. Mothers of future D (vs. B) infants were likely to show smile/surprise faces specifically during infant facial/vocal distress: an emotional "denial" of infant distress. Thus, mothers of future D infants "opposed" or "countered" infant distress, literally going in the opposite affective direction, as if attempting to "ride negative into positive." This finding illustrates the principle of *heightened affective moments*, and can also be construed as a disruption, without repair. Moreover, the infant's expectation of matching and being matched in the direction of affective change, which lays the groundwork for feeling "attuned to" or "on the same wavelength," is disturbed.

Figure 6 (1) illustrates maternal surprise to infant distress; Figure 6 (2, 3) illustrates maternal smile to infant distress. The sequence of (1) and (2) occurs across 3 s. First the mother shows a surprise face, including the whites of her eyes, and then she smiles broadly as the infant looks away and strikingly covers his face, so that he does not see her smile. Mothers certainly perceive infant distress at such moments, reflected in comments such as, "Don't be that way," or "You don't want to be like that," or "No fussing, no fussing, you should be very happy." Instead of postulating that mothers of future D infants do not register infant distress, we propose that unresolved fears about intimate relating in the mother of the future D infant trigger complex "defensive" maneuvers and contradictory behavioral tendencies that derail the infant (Karlen Lyons-Ruth, personal communication, October 17, 2008).

We infer that this maternal "countering" of infant distress confuses future D infants, and makes it difficult for infants to feel that their mothers sense and acknowledge their distress. We infer that infants come to *expect* that mothers do not empathically share their distress. This finding evokes Winnicott's (1965) description of an impingement in which, instead of mirroring the infant's gesture (distress), the mother substitutes her own gesture (smile/surprise) (Lin Reicher, personal communication, December 2, 2008). Malatesta et al. (1989) found that maternal positive, surprise, or "ignore" responses to infant distress predicted toddler attempts to dampen negative affect. We conjecture that D infants as toddlers may have similar difficulties.

Our finding of maternal smile/surprise to infant distress included infant vocal as well as facial distress. Van Egeren, Baratt, and Roach (2001) found that, given infant fuss, maternal vocalization was most likely, whereas maternal smile/social play was *suppressed* (significantly unlikely). Thus, our finding of maternal smile to infant vocal

Figure 6. Illustrations of disorganized attachment.
Note: Although the mother and infant are shown as if side by side, they are filmed facing each other. Frames (1) and (2) comprise a sequence, 3s apart (24, 27). Frames (3) and (4) are taken from separate sections of the interaction. Frames (6–8) comprise a 4s sequence (59, 01, 02) illustrating high mother face self-contingency, "stabilized face." Frames (9–10) comprise a 2s maternal loom sequence (18, 19). Frames (11–14) illustrate a second maternal loom sequence across 3s (50, 51, 51, 52).

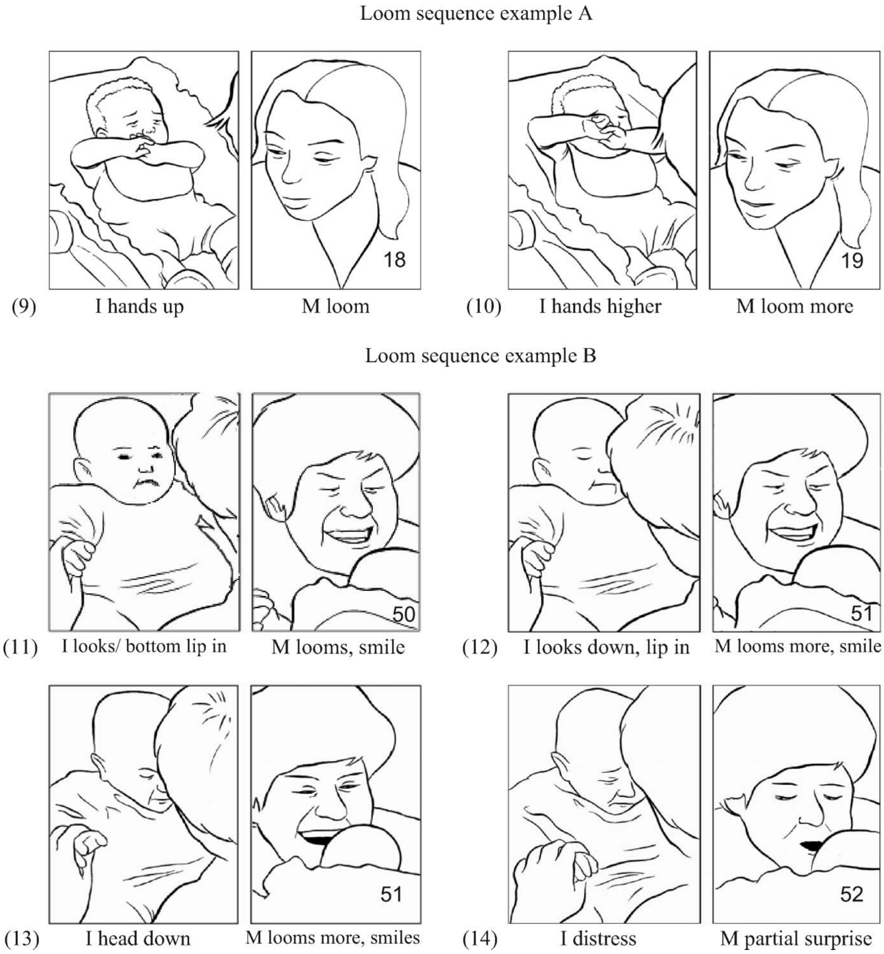

Figure 6. (*Continued*).

distress is highly atypical, a maternal failure of empathy which disturbs infant ability to come to expect matching and being matched in the direction of affective change.

We propose that the intrapersonal discrepant affect of future D infants is in part fueled by seeing their mothers' positive facial affect while they themselves are distressed. Maternal interpersonal affective discrepancy is echoed in infant intrapersonal affective discrepancy (Jude Cassidy, personal communication, October 23, 2006). An alternative possibility is that the infant's discrepant signals regarding facial vs. vocal affect contribute to the future D mother's propensity to smile when infants are distressed.

Dyadic conflict: Attention dysregulation

A second form of dyadic conflict can be seen in the finding that, despite greater facial/vocal distress in future D infants, their mothers showed excessive looking away from the infant's face (20% of the time or more), a striking finding, illustrated in Figure 6 (4, 5). It may lead to infant feelings of being too visually "separate" from their mothers, of not being "seen," and of being confused about mother's visual presence and availability. Moreover, mothers of future D infants showed a lowered self-predictability in patterns of gazing at and away from the infant's face. Maternal excessive looking away, in a less predictable fashion, disturbs the "visual frame" of the face-to-face encounter: a background sense of structure that mothers usually provide. Thus infant ability to rely on a predictable maternal pattern of visual attention is compromised.

Excessive maternal looking away may reflect maternal discomfort with intimate engagement through mutual gaze (Karlen Lyons-Ruth, personal communication, January 12, 2007); or it may reflect moments of maternal dissociation (George Downing, personal communication, April 18, 2007). If the future D mother looks at her infant in distress, there may be a greater likelihood that similar levels of distress will be activated in her. Looking away may reflect a maternal attempt to down-regulate arousal (Jude Cassidy, personal communication, October 23, 2006). Hodges and Wegner (1997) propose that individuals who become overwhelmed with the emotion of another can protect themselves from "automatic" forms of empathy with forms of "exposure control," such as looking away (see also Peck, 2003).

Maternal intermodal discordance

Mothers of future D infants themselves exhibited an intermodal discordance between excessive gazing away, thus "too far away"; and excessive looming, thus "too close in." Figure 6 illustrates two maternal looming sequences (frames 9–10 and 11–14). In the first, in frame 9 the infant puts his hands up in front of his face (a defensive gesture available from the beginning of life) as mother looms; in frame 10 the infant raises his hands still more as mother looms in further. In the second loom sequence (frames 11–14), in frame 11 the infant looks at mother with his bottom lip pulled in (a gesture of "uh-oh") as mother looms in, smiling. In frame 12, as mother looms further, the infant closes his eyes and pulls his lips into a full "compressed lips" expression. In frame 13, as mother looms in further with a bigger smile, the infant dips his head down, with a slightly negative expression. In frame 14, the infant shows an unhappy grimace; only now does mother's partial surprise face show that she senses something is wrong. At each point the infant signals discomfort, but mother over-rides that signal until the final frame.

Mothers of future D infants may reveal their desire for contact by excessive looming, in conflict with their need to be visually "away" (Karlen Lyons-Ruth, personal communication, January 12, 2007). Looming may reflect the mother's need for control over the contact (Mary Sue Moore, personal communication, July 2, 2007). Both looking away and looming in disturb the potential for mutual gaze. Because eye contact is arousing, we conjecture that both these maternal behaviors reflect concerns about visual intimacy, which may be over-arousing.

It is striking that both excessive gaze away and excessive loom occurred in the context of lowered maternal visual and spatial self-predictability. Not only is there an intermodal discordance (looming in and looking away), but these discordant behaviors unfold in relatively unpredictable ways. Thus mothers of future D infants disturb both the "spatial frame" and the "visual frame," a background sense of structure in the ways mothers set the stage for the interaction (George Downing, personal communication, April 18, 2007). This loss of predictability further exacerbates infant difficulty in decoding and predicting maternal behavior, decreases infant sense of agency, and increases the possibility that the infant may feel unsafe (Mary Sue Moore, personal communication, July 2, 2007). It will be difficult for the infant to generate a coherent percept from the contradictory intermodal maternal discordance coupled with lowered maternal self-predictability. Both infants and mothers will have difficulty sensing what mother feels and what she will do next. Is she or isn't she coming in to loom? Is she or isn't she ''going away'' visually, or ''coming back''?

Dyadic conflict: Lowered maternal engagement coordination

A third form of dyadic conflict was seen in the finding that, despite infant distress, mothers of future D infants lowered facial-visual engagement coordination with infant engagement: an emotional/attentional withdrawal from contingently coordinating with infant positive as well as distress moments. They did not join the infant's attentional/affective direction, disturbing the likelihood of shared affective processes (Beebe & Lachmann, 1988, 1994; Lyons-Ruth, 2008), consistent with our hypothesis. Although the prevalence of *behavioral qualities* of positive or negative facial affect did not differ in future D vs. B mothers, the ways that mothers *contingently coordinated* their facial-visual behavior with that of the infants differed: the *process* of relating rather than the content. This pattern was an ''ongoing dysregulation.''

This maternal withdrawal makes it difficult for future D infants to come to expect that their emotional/attentional states can influence mothers to coordinate with them, to expect that their mothers will join their distressed as well as positive states. Infants are thus relatively helpless to affect mothers with their facial/visual engagement processes, disturbing the infant's sense of interactive efficacy. This finding is consistent with Koos and Gergely's (2001) proposal that mothers of D infants subject the infant to loss of contingent ''control'' over maternal behavior. Lowered maternal coordination in the context of infant facial/vocal distress may be fear-arousing, another possible route to a frightening mother, one current description of a central dynamic of the D category (Lyons-Ruth et al., 1999; Main & Hesse, 1990). A perceived lack of behavioral control in the future D infant may be related to the finding that these infants may have over-controlling styles later in development (Lyons-Ruth & Block, 1996).

We note that lowered maternal facial coordination with infant facial or vocal affect, or lowered maternal gaze coordination with infant gaze, was not found in mothers of future D infants when these modalities were analyzed separately. Thus mothers of future D infants *perceive* the infant's affect and gaze and in many ways are adequately responsive. Instead, it is only when the overall gestalt of infant facial-visual *engagement* (which includes infant head orientation and vocal affect as well) is considered that we find lowered maternal coordination. Thus, although facial-mirroring seems intact, mirroring of the entire infant engagement gestalt is not. The future D mother does not seem to be able to relate to the overall gestalt of her infant.

Our findings of maternal withdrawal here parallel those of Lyons-Ruth (2008), who found that maternal withdrawal from the infant's attachment-related cues at 12 months was the best predictor of adult borderline or conduct symptoms. Such maternal withdrawal, through failure to join the infant's affective direction, may disturb the developing child's ability to share attentional, affective, and mental states with others (Lyons-Ruth, 2008).

We theorize that mothers of future D infants cannot coordinate with infant emotional ups and downs, and cannot acknowledge moments of infant distress, because they cannot bear to pay attention to their own emotional distress. Their own distress may be evoked by the infant's distress, and efforts to manage their own distress may ensue. Eisenberg (Eisenberg & Fabes, 1992; Fabes, Eisenberg, & Miller, 1990; Peck, 2003) proposes that when individuals who are skilled at regulating their emotions are faced with another's distress, they are free to focus on the needs of the other because they do not become overly emotionally aroused as they vicariously experience the other's distress. This picture might describe mothers of future secure infants. In contrast, less skilled individuals may experience their own personal distress in response to another's distress, and then need to manage their own distress. This picture seems consistent with mothers of future D infants. However, the issue may not be maternal "skill" but trauma.

We interpret the future D mother's lowered contingent engagement coordination with infant engagement, as well as maternal smile/surprise to infant distress, as maternal emotional "denial" of infant distress. Although minimization of distress has been associated with avoidant attachment styles (Belsky, 1997; Cassidy, 1994; Cassidy & Kobak, 1988), the forms of maternal denial of distress documented here are different from minimization. Lowered emotional coordination communicates to the infant, "You can't affect me." Showing the opposite (positive) emotion to the infant's negative emotion constitutes an "opposing" of the infant's emotion, communicating, "I'm not going there." We propose that the infant represents these maternal responses to his distress through procedurally organized expectancies of action sequences.

Heightened maternal facial self-contingency: "closing up one's face"

Maternal lowered engagement coordination was accompanied by heightened maternal facial self-contingency, a maternal inhibition of the variability of facial changes, remaining overly facially stable or too "steady-state" like a momentary "still-face" (Tronick, 1989). We interpret this finding as mothers "closing up their faces," another way of not being available to the "play of faces," another way of saying "you can't affect me." Figure 6 (frames 6, 7, 8) illustrates mother "closing up" her face, across a 4 s sequence. As the distressed infant opens his eyes (frames 6 to 7), mother's closed-up face remains stabilized, although her head angle shifts; likewise as infant distress increases (frames 7 to 8), mother's facial affect remains stabilized.

Mothers of future D infants may sense the risk of greater facial variability, which would facilitate greater facial coordination with the infant's facial affect. Clinically we observed that mothers' "closing up" their faces often occurred at moments of infant distress, as if mother is "going blank." To remain empathic to infant distress might re-evoke mother's own original traumatized state.

The constellation of momentarily closing her face, lowering her coordination with the infant's emotional shifts, and extensive looking away from her infant's face, may be ways of shutting herself down in a self-protective effort, possibly dissociative (Mary Sue Moore, personal communication, July 2, 2007). Mothers of future D infants may, out of awareness, be afraid of the facial and visual intimacy that would come from more gazing at the infant's face, more coordination with the infant's facial-visual shifts, and more "joining" the infant's distressed moments. These findings confirm and extend Lyons-Ruth's (2008; Lyons-Ruth et al., 1999) proposals that mothers of disorganized infants engage in disrupted and contradictory forms of affective communication, especially around the infant's need for comfort when distressed.

If her procedural experience could be put into words, we imagine that the mother of the future D infant might feel, ''I can't let myself be too affected by you. I'm not going to let myself be controlled by you and dragged down by your bad moods'' (Karlen Lyons-Ruth, personal communication, October 17, 2008). ''I refuse to be helpless. I'm going to be upbeat and laugh off your silly fussing.'' She might feel, ''I can't bear to know about your distress. Don't be like that. Come on, no fussing. I just need you to love me. I won't hear of anything else. You should be very happy.'' And she might feel, ''Your distress frightens me. I feel that I am a bad mother when you cry'' (Estelle Shane, personal communication, November 12, 2006). Or she might feel, ''Your distress threatens me. I resent it. I just have to shut down'' (Mary Sue Moore, personal communication, July 2, 2007).

We conjecture that infants may experience the combination of maternal withdrawal of engagement coordination and ''too-steady'' faces as a kind of affective ''wall.'' Maternal positive facial affect specifically at moments of infant distress further connote a ''stone-walling'' of infant distress: an active maternal emotional refusal to ''go with'' the infant, a refusal to join infant distress, disturbing the infant's ability to feel sensed. We infer that future D infants come to expect that their mothers do not ''join'' their distress with acknowledgments such as maternal ''woe face,'' an empathic form of maternal facial mirroring. Instead they come to expect that their mothers are happy, surprised, or ''closed'' when they are distressed.

Lowered infant engagement self-predictability: Infant ''destabilization''

In the context of lowered maternal engagement coordination, future D (vs. B) infants lowered their engagement self-predictability, a more variable process in which the infant's ability to anticipate moment-to-moment action tendencies is lowered. We infer a decreased sense of self-familiarity and coherence over time (Doris Silverman, personal communication, November 6, 2002), metaphorically ''destabilized,'' which constitutes an ''ongoing dysregulation.'' Lowered infant engagement self-contingency, an intrapersonal dysregulation, is linked to maternal failure to adequately coordinate with infant engagement, a maternal interpersonal dysregulation.

Dyadic touch dysregulation

Mothers of future D (vs. B) infants not only lowered their contingent engagement coordination with infant engagement, disturbing infant interactive efficacy in the facial-visual realm, but they also lowered contingent touch coordination with infant touch, disturbing infant interactive efficacy in the touch realm. Both patterns constitute ''ongoing dysregulations.'' Future D (vs. B) mothers were less able to acknowledge increasing frequency of infant touch as a cue for more affectionate, tender touch. This is a new finding, that infant-initiated touch behavior enters the interpersonal exchange as a communicative signal (George Downing, personal communication, October 26, 2006). Perhaps future D mothers' lowered touch coordination reflects difficulty tolerating an infant behavior that reflects self-soothing, because of their own difficulties with distress. Or perhaps these mothers lacked affectionate touch in their own childhoods, and have difficulty identifying infant need for more affectionate touch. Or perhaps the future D infant's lowered use of touch has lowered the signal value of infant touch for mothers.

We infer that future D infants come to expect that their mothers will be unavailable to help modulate states of affective distress through touch coordination with their own touch behavior: an interpersonal touch dysregulation. Infants are left too alone, too separate, in the realm of touch (Anni Bergman, personal communication, November 16, 2006). Simultaneously future D infants showed an intrapersonal touch dysregulation: less touch overall, specifically less touching of their own skin, and greater likelihood of continuing in states of "no touch," metaphorically "getting stuck" in states of "no touch." This configuration again depicts an infant intrapersonal dysregulation linked to a maternal interpersonal dysregulation.

Lowered infant access to touch further disturbs infant arousal regulation of vocal distress: the less likely infant touch, the more likely infant vocal distress (Beebe et al., 2008b). Given the facial/vocal distress of future D infants, their heightened physiological arousal (Spangler & Grossmann, 1993), and our findings that infant touch functions to modulate infant vocal distress (Beebe et al., 2008b), we infer that these interpersonal and intrapersonal forms of touch dysregulation compromise infant interactive efficacy, and infant self-agency, in the capacity to self-soothe through touch. Getting metaphorically "stuck" in states of "no touch" may disturb the infant's visceral bodily feedback, laying one groundwork for the dissociative symptoms known to characterize these D infants once they are young adults (Dutra et al., 2009; Lyons-Ruth, 2003). Future D (vs. B) infants cannot rely on mothers to help in the touch domain, nor can they rely on themselves to provide self-comfort and modulation of vocal distress through touch.

Together, future D infants and their mothers showed a dyadic touch dysregulation. This constellation of findings illustrates a disturbance in the interaction pattern of "dyadic state transforming," the expectation of being able to transform an arousal state through the contribution of the partner (Beebe et al., 1997; Stern, 1985). As a corollary, the infant findings (less touch, less touching one's own skin, in the context of greater vocal distress) illustrate a disturbance in an infant "intrapersonal state transforming," the expectation of being able to help oneself transform arousal states.

Future D infants thus come to expect that they are relatively helpless to affect mothers, in the realms of both facial-visual engagement and touch. Future D infants are left too alone to manage their distress on their own. But they also come to expect that they are relatively helpless to help themselves, by providing touch self-comfort and touch modulation of vocal distress.

If their procedural experience could be put into words, we imagine D infants might experience, "I'm so upset and you're not helping me. I'm smiling at you and whimpering; don't you see I want you to love me? When I'm upset, you smile or close up or look away. You make me feel worse. I feel confused about what I feel and about what you feel. I can't predict you. I don't know what is going on. What am I supposed to do? I feel helpless to affect you. I feel helpless to help myself. I feel frantic."

Because altered infant self-contingency represented half of all mother and infant contingency findings in future D (vs. B) dyads, we consider the infant touch self-contingency findings (greater likelihood of continuing in "no touch" states) and lowered engagement self-contingency findings (facial-visual destabilization) to be important aspects of the experience of future D infants, generating difficulties in sensing, predicting, and modulating one's own state. Thus infant intra-personal forms of dysregulation accompany the overt emotional distress of future D infants, and the maternal failures to acknowledge and respond to this distress.

Why did future D infants show no findings in interactive contingency? Whereas future C (vs. B) infants attempted to manage mother's spatial/tactile intrusion by altering their own contingent coordination with maternal touch and engagement, future D infants showed no such efforts. We speculate that future D infants may have given up on this effort. However, based on our work in which we showed that future D infants tightly (''vigilantly'') contingently coordinate vocal rhythms with their mother's vocal rhythms (Jaffe et al., 2001), if vocal rhythm had been assessed, these future D infants might have had this vigilant vocal rhythm coordination as well.

Procedural mechanisms of sensing the state of the other

In an effort to understand further the problematic communication of future D mothers, we return to the topic of procedural ''mechanisms of sensing the state of the other'' (see Introduction). A facial expression produced by one person tends to evoke a similar expression in the partner, out of awareness (Dimberg et al., 2000), a powerful way of participating in the state of the other. This is such a robust phenomenon that some researchers dub it an ''automatic'' facial mimicry (Hatfield, Cacioppo, & Rapson, 1993; Hodges & Wegner, 1997; Peck, 2003). Perhaps mirror neurons, an ''action-recognition'' mechanism in which the actor's actions are reproduced in the premotor cortex of the observer, help explain why this is such a robust phenomenon. But as we have seen, future D mothers do not match the facial distress of their infants.

Furthermore, we know from adult research that, as partners match each other's affective patterns, each recreates a psychophysiological state in the self similar to that of the partner, an additional way of participating in the subjective state of the other (Beebe & Lachmann, 1988, 2002; Ekman et al., 1983; Levenson et al., 1990). Evidently this further layer of information about the infant's state also cannot be used by future D mothers. Thus these mothers are highly unusual. They do not operate in accordance with what is known about the behavioral, physiological, or neuronal organization of emotional communication. We propose that these means of sensing the state of the other, highly biologically primed, are inhibited for defensive reasons (Virginia Demos, personal communication, March 3, 2007). Additionally, the ways that future D mothers process emotional communication may be altered from their own stressful development, which likely involves unresolved loss or trauma (Main & Hesse, 1990).

We conjecture that future D mothers cannot process emotional information in the moment because they are flooded by their experience of the infant's distress, which may re-evoke earlier traumatic states of their own. They may shut down their own emotional processing, and be unable to use the infant's distress behaviors as communications, in a momentary dissociative process (Mary Sue Moore, personal communication, July 2, 2007). For example, as one of the future D infants showed a sharp increase in vocal distress and turned away with a pre-cry face, the mother's head jerked back, as if ''hit'' by the infant's distress; she then looked down with a ''closed up'' face. It is also possible that the mirror neuron system of future D mothers is disrupted during moments of infant distress. We construe moments of maternal inability to participate in the infant's state as "heightened affective moments," intensifying infant negative arousal, and organizing infant's experience out of proportion to mere frequency or duration.

Knowing and being known

We now return to the topic that the organization of intimate relating is at stake in these early working models. Intimate relating entails the fundamental issue of how the infant comes to know, and be known by, another's mind. We construe "mind" here from the point of view of the infant, that is, expectancies of procedurally-organized action sequences.

A number of authors (see Lyons-Ruth, 2008; Meltzoff, 1985; Melzoff & Moore, 1998; Sander, 1977, 1995; Stern, 1985, 1995; Trevarthen, 1998; Tronick, 1989) have argued across several decades that the infant's perception of correspondences (in time, form, and intensity) between his own behavior and that of the partner provides the infant with a means of sensing the state of the partner, and of sensing whether the state is shared, or not. These correspondences have been variously described as "changing with" and "affect attunement" (Stern, 1985), a resonance based on "matched specificities" (Sander, 1977), being "on the same wavelength" (Beebe & Lachmann, 1988), "a fundamental relatedness between self and other" (Meltzoff, 1985), "mutually sensitive minds," or "immediate sympathetic contact" (Trevarthen, 1998). These correspondences facilitate the development of infant agency, coherence, and identity (Sander, 1995; Stern, 1985; Trevarthen, 1998).

Our findings allow us to describe *how* the future D infant's ability to know, and be known by, another's mind, as well as to know his own mind, may be disturbed. We propose that the future D infant will have difficulty *feeling known* by his mother (a) in moments when he is distressed, and she shows smile or surprise expressions: Stern's (1985) moments in which the infant learns that his distress states are not shareable, which may accrue to later experiences of "not-me"; (b) in moments when the mother looks away repeatedly and unpredictably, so that he does not feel *seen*; (c) as mother does not coordinate her facial-visual engagement with his facial-visual engagement, and is thus not able to coordinate with the overall gestalt of her infant; (d) as mother does not coordinate her affectionate-to-intrusive touch patterns with his frequency of touch, generating infant expectations that mother does not *change with* him, and that she does not match his direction of change, in the arenas of facial-visual engagement and touch; and (e) by clinical observation, as mother does not seem curious about, and makes no efforts to repair, powerful disruptions, suggesting maternal difficulty thinking about the infant's mind and motivation (Fonagy, Gergely, Jurist, & Target, 2002).

We propose that the future D infant will have difficulty *knowing* his mother's mind (a) as he has difficulty integrating mother's discrepant smile/surprise face to his distress into a coherent percept; (b) as he has difficulty predicting whether mother will look or look away, and for how long; whether she will sit upright, lean forward, or loom in; (c) as she "closes up" her face and becomes inscrutable; (d) as mother's lowered contingent engagement coordination makes it difficult for the infant to "influence" mother with his facial-visual engagement, to use his own state to anticipate where she is going next; leading to the infant's expectation that mother does not join his direction of attentional/affective change; and (e) as mother's lowered contingent touch coordination makes it difficult for the infant to ''influence'' mother with the frequency of his touch behaviors, to anticipate the nature of her touch based on his own just prior touch behavior; leading to the infant's expectation that mother does not ''follow'' his touch behaviors by touching him more affectionately as he touches more (and vice-versa).

We propose that the future D infant will have difficulty *knowing himself* (a) in his moments of discrepant affect, for example as he smiles and whimpers in the same second; (b) as his own engagement self-contingency is lowered, making it more difficult to sense his own facial-visual action tendencies from moment-to-moment, more difficult to develop a coherent expectation of his own body; (c) as he has difficulty touching (self, object, mother), and specifically difficulty touching his own skin; and as he gets ''stuck'' in states of ''no touch''; all of which disturb his visceral feedback through touch, and disturb his own agency in regulating distress through touch. As Sander (1977, 1995) notes, infant inner experience is organized in the interactive context. Sander argues that the infant–caretaker system may both facilitate, and constrain, the infant's access to and awareness of his own states, and his ability to use his states in organizing his behavior. We propose that the future D infant experiences a disturbance in the experience of agency with regard to his own states. One important aspect of these difficulties of the future D infant's ability to know, and be known by, another's mind, as well as to know his own mind, is identified through disturbances in maternal affective correspondence and state-sharing (Meltzoff, 2007; Stern, 1985; Sander, 1977; Trevarthen, 1998). However, many other aspects of these difficulties are identified through dysregulated tactile, spatial, and attentional behaviors, an important addition.

As noted in the Introduction, Lyons-Ruth (1999, 2008) proposes that the outcome of the process of coming to know and be known by another's mind is dependent on whether the partner is capable of a *collaborative dialogue*. Overall the mother of the future D infant does not generate collaborative dialogues. Her infant will be unlikely to be able to generate internal working models in which both partners are represented as open to the full range of experiences of the other. Lyons-Ruth (1999, 2008) also suggests that failures of collaborative dialogue generate contradictory internal models. An example in our data are moments when infants whimper and smile in the same second, possibly generating an infant internal working model such as, ''I smile to find your smile, while I whimper to protest your uncomfortable touch.'' Another example of contradictory procedures are moments where infants are distressed but mothers smile or look surprised, possibly generating internal working models of, ''While I am upset, you are happy.'' Contradictory procedures, intrapersonal or dyadic, disturb the ability to know and be known by the partner, and to know the self. They disturb higher-order coordinations essential to social/cognitive development, and they set the stage for dissociative defenses in which contradictory arenas of knowledge are entertained (Lyons-Ruth, 1999).

Internal working models of future D infants

We propose that future D infants represent these individual and dyadic patterns as emerging internal working models in the form of procedural self- and interactive expectancies. These expectancies bias the trajectory of how experience is organized, activating certain pathways and inhibiting others, ultimately limiting the range, flexibility, and *coherence* of experience. One central feature of these expectancies is intense infant emotional distress and the inability to obtain comfort. In many ways future D infants are alone with their facial/vocal distress, helpless to affect their mothers with their distress and, at critical moments, opposed. A second feature is an expectancy of difficulty predicting what will happen, both within the self and within the partner. A third feature is difficulty in knowing what the self feels and what the partner feels: a form of emotional incoherence. A fourth feature is the expectation of not feeling "sensed" or "known," particularly when distressed. These future D infants do not experience Sander's (1995) "moment of meeting," a match between two partners such that the way one is known by oneself is matched by the way one is known by the other (Lin Reicher, personal communication, November 8, 2007). They come to expect that their distress states are not shareable (Stern, 1985). A fifth feature is the presence of intrapersonal and dyadic contradictory communications, conflict, and remarkable intermodal discrepancies. These contradictions disturb the coherence of the infant's internal working model.

Based on our dyadic model of procedural representations in which both roles are known to both people, we propose that the future D infant will come to know both roles of mother and infant. This may account for why, later in development, the D child plays out the mother's role of denial of distress, over-riding the state of the mother with a controlling style. Future research could examine whether the specific behaviors documented here in the mother of the future D infant may characterize the D child later in development, such as extensive and unpredictable looking away; smiling or acting surprised when the mother is distressed, or momentarily "closing up the face."

In sum, we have described many fundamental disturbances in the processes through which infants may come to feel known and can recognize being recognized, through which infants may come to know their mothers, and through which infants come to sense their own states. This picture provides detailed behavioral mechanisms that could result in the lack of a consistent strategy of dealing with negative emotions, characteristic of D infants in the Strange Situation by 12 months (van IJzendoorn et al., 1999). The disturbance in individual and dyadic emotional coherence in future D infants and their mothers offers a striking parallel to the contradictory and unintegrated affects of the D infant in the Ainsworth paradigm, and to the contradictory evaluations of attachment relationships in the AAI findings of their mothers.

Discussion Part III: Comparison of internal working models of future C vs. future D infants

In this section we summarize differences in how future C vs. D infants may organize 4-month internal working models. We first discuss the remarkable differentiation in patterns of behavioral qualities and contingencies in future C (vs. B) and D (vs. B) dyads. We then discuss central differences in the developing internal working models of future C and D infants.

Pattern of findings: Behavioral qualities and contingencies

Future C and D (vs. B) dyads were remarkably differentiated in the pattern of findings. Regarding *behavioral qualities*, there was no finding in common, for mothers or infants, in future C vs. D dyads. For *infants*, whereas the future C infant showed no difficulties in behavioral qualities, the future D infant showed intense emotional distress, and difficulties in access to his own touch. For *mothers*, behavioral qualities were altered in future C and D (vs. B) dyads, but in entirely different ways. Mothers of future C infants showed progressively less affectionate and more active touch, and chase and dodge; whereas mothers of future D infants showed excessive loom, extensive looking away from distressed infants, and mother smile/surprise face while infants were distressed.

Regarding *contingencies*, again the pattern of findings was strikingly differentiated for future C (vs. B) and D (vs. B) dyads. Future C and D infants shared only one finding: lowered engagement self-contingency, an emotional destabilization. Mothers of future C and D infants shared only one finding: lowered spatial self-contingency, generating infant difficulty in predicting mother's next spatial move.

Regarding *infants*, future C (vs. B) infants differed not in behavioral qualities, but rather in the *contingent process* of relating, particularly in *interactive* contingent coordination with mothers. In contrast, future D (vs. B) infants differed in behavioral qualities (vocal/facial distress, vocal/facial discrepancy, less touch), and in *self-contingency*, but not in *interactive* contingency. Whereas future C infants still seem to have the capacity to try to manage maternal stimulation by altering their contingent coordination with their mothers in a remarkable demonstration of agency (resisting being organized by maternal progressively less affectionate touch), we speculate that future D infants may have given up on this effort. Is infant distress too high? Is the mother's emotional withdrawal too difficult?

Regarding *mothers*, interactive contingencies of mothers of future C (vs. B) infants were intact, safeguarding the ability of future C infants to expect that they can influence mothers to match the direction of their behavioral change. In contrast, mothers of future D (vs. B) infants disturbed the *interactive process*, with lowered contingent coordination of engagement and touch, disturbing infant interactive efficacy in these arenas. Mothers of future C infants nevertheless showed spatial/tactile intrusion, a powerful impingement. Mothers of future D infants also showed lowered spatial self-predictability as they loomed, lowered self-predictability of looking and looking away from the infant, and heightened facial self-predictability which generated momentary "closed-up" faces.

Different central difficulties in internal working models of future C vs. D infants. We now turn to central differences in intrapersonal and dyadic disturbances that inform the developing internal working models of future C (vs. B) and future D (vs. B) infants. We compare dyads in terms of (1) the principles of salience, "ongoing regulation" and "heightened affective moments"; (2) the central interaction patterns of facial mirroring, state transforming, spatial approach/avoid (including maternal intrusion), and interpersonal and intrapersonal timing (contingencies), as well as new patterns identified in this study; and (3) disturbances in knowing and being known by the mind of the other, as well as in knowing one's own mind.

Principles of salience

The principle of "ongoing regulation" was applied to findings of contingencies over time, thus "ongoing"; "heightened affective" moments was applied to findings revealed through analysis of behavioral qualities, rates of specific behaviors taken out of time, thus "moments." As noted in the preceding discussions, both future C and D dyads had examples of findings that fit the principle of ongoing regulation, which we termed "ongoing dysregulation." But only future D dyads had findings that fit the principle of heightened affective moments, a central differentiating feature. These were momentary intrapersonal/interpersonal contradictory patterns in the context of infant distress.

Central interaction patterns

Table 8 presents a summary comparison of the central interaction patterns in the findings of future C (vs. B) and D (vs. B) dyads. Only future D dyads had difficulty in maternal facial mirroring and the more general arena of maternal affective correspondence, such as maternal smile/surprise expressions to infant distress, and not following the infant's direction affective/attentional change as he became more and less engaged. Thus only future D mothers showed difficulty in sharing the affect state of the infant, particularly distress. But only future C infants showed difficulty in affective correspondence, through heightened coordination of facial-visual engagement with maternal engagement, a vigilant form of mirroring. Both future C and D dyads showed difficulties with infant and dyadic state transforming (although they manifested in different ways). Only future C dyads showed spatial approach/avoid, in the pattern of "chase and dodge," but both future C and D dyads showed patterns of spatial intrusion. In patterns of temporal contingency, difficulties in mother and infant self-contingency were similar. But in patterns of interactive contingency, only future C dyads showed altered *infant* interactive contingency, whereas only future D dyads showed altered *maternal* interactive contingency.

A number of new interaction pattern disturbances are also presented in Table 8. A disturbance in the predictability of the maternal "spatial frame" was common to both future C and D mothers, but only the future D mother disturbed the predictability of the "attentional frame" as well. "Destabilized infant engagement self-contingency" was common to both future C and D infants. Infant "tuning out mother touch" was identified only in future C infants. Infant "lowered access to touch/touch own skin" and "simultaneous discrepant affect," and maternal "closing up the face," and "extensive looking away" were identified only in future D dyads.

The central difficulty of future C mothers was a spatial-tactile intrusion, coupled with an unstable spatial frame. We interpreted this pattern as the maternal wish for infants to stay with them, in the context of their own preoccupation with the infant's attention and emotional presence. But the future C mother cannot see that her very attempts to keep her infant involved with her will compromise her infant's involvement. The maternal spatial-tactile intrusion leads to difficulties in infant state transforming, and complex "approach-avoid" patterns, both dyadic and intrapersonal, in future C dyads. In the dyadic approach-avoid pattern, infants "dodge" as mothers "chase," and mothers chase as infants dodge. In the intrapersonal approach-avoid pattern, infants activate their engagement coordination with mother engagement, but inhibit their engagement coordination with mother less positive touch. This inhibition masks their distress and sacrifices their ability to communicate about maternal touch.

We proposed that in their internal working models, future C infants will represent the experience of moving away from mother as she moves in with spatial/tactile intrusion. They will represent responding to mother by "going in opposite

Table 8. Summary of interaction patterns associated with C (vs. B) and D (vs. B) attachment.

Interaction Pattern	Future C Dyads	Future D Dyads
Facial Mirroring/ Affective Correspondences	1. Infant higher Engagement coordination w M Engagement	1. M lower Engagement coordination w Infant Engagement 2. M smile/surprise to Infant distress
State Transforming	1. M less positive Touch 2. M Chase 3. Infant inhibition of coordination w M Touch	1. M lower Touch coordination w Infant Touch 2. Infant less access to Touch/Touch own skin
Spatial Misregulation	1. Chase and Dodge	1. Maternal Loom
Contingencies		
Self-Contingencies	1. M lower spatial 2. Infant lower Engagement	1. M lower Spatial, Gaze 2. Infant lower Engagement
Interactive Contingencies		
Infant	1. Infant higher Engagement coordination w M Engagement 2. Infant lower Engagement coordination w M Touch	–
Mother	–	1. M lower Engagement coordination w Infant Engagement 2. M lower Touch coordination w Infant Touch
Newly Identified Patterns		
M Unpredictable Spatial Frame	C	D
M Unpredictable Attentional Frame	–	D
I Destabilized Engagement Self-Contingency	C	D
I Tuning Out M Touch	C	–
I Lower Access to I Touch/ Touch Skin	–	D
I Discrepant Affect (same sec)	–	D
M Closed up Face	–	D
M Extensive Looking Away	–	D

Note: I = Infant, M = Mother.

directions,'' their own simultaneous activation and inhibition regarding maternal facial/visual engagement and touch, respectively. Thus, they vigilantly coordinate with maternal engagement while they ''tune out'' maternal touch. And they will have difficulty communicating what they ''like'' or do not ''like,'' a confusion in sensing their own affective and attentional state, and ultimately a difficulty in coming to know what they feel, in relation to maternal touch. However, two key arenas are intact. Because mothers showed no altered interactive contingency, infant interactive agency in this realm is not disturbed. And there are no difficulties in maternal facial mirroring or the more general arena of maternal affective correspondences.

The difficulties of future D dyads at 4 months are at a fundamentally deeper level than those of future C dyads. All central interaction patterns showed disturbance: maternal affective correspondence, infant state transforming, maternal spatial intrusion, and maternal lowered interactive contingency which disturbs infant interactive efficacy. The new interaction patterns identify disturbances in the spatial and attentional frame, which disrupt the very foundation of the face-to-face exchange. The new interaction patterns also identify infant discrepant affect, and maternal methods of managing her own state, such as extensive looking away and closing up her face, which create further distance from the infant.

The central feature of future D dyads is intrapersonal and interpersonal discordance or conflict, in the context of infants who are intensely emotionally distressed. We argued that *maternal withdrawal from distressed infants* compromises infant interactive agency and emotional coherence in future D (vs. B) infants. We characterized these infants as "frantic," not sensed or "known" in their distress, and relatively helpless to influence mothers with their distress. Infant attempts to manage distress become hierarchically organizing (Werner, 1948) for the future D infant. We interpreted the maternal withdrawal from distressed infants as the future D mother's difficulty with her own unresolved loss, mourning, or abuse, and presumably an inability to bear her own distress, as well as that of her infant. We understood these mothers to be preoccupied with regulating their own state (by looking way or closing up their faces).

Knowing and being known

In the arenas of being known by the mother's mind, knowing the mother's mind, and knowing one's own mind, we propose that although both future C and D infants will have difficulties in representing knowing and being known in these ways, these difficulties will be more modest in the future C infant, but extensive and serious in the future D.

(1) Being known by the mother's mind. The intact maternal interactive contingency safeguards the future C infant's interactive agency in this realm. However, the future C infant may have difficulty feeling sensed and known by his mother at moments of spatial/tactile intrusion. In contrast the future D infant, who is very distressed, will have serious difficulties representing being known by the mother's mind, as he encounters her difficulty in sharing his distress (through her "countering" of his distress, inscrutable closed up faces), her extensive and unpredictable looking away (generating a feeling of not being *seen*), her unpredictable looming, and his difficulty anticipating that she will follow him in the direction of his own changes in facial-visual engagement and touch. Compared to the future C infant, the future D infant will have great difficulty coming to represent an internal working model of, "you share my happiness when I am happy and you understand me when I am distressed; you know me; we are on the same wavelength; you are like me; we share the same states." Instead, infants come to expect that mothers do not sense and join their states, a working model of *not being known by the mother*, especially when distressed.

(2) Knowing the mother's mind. We propose that the future C infant will have difficulty knowing his mother's mind as he has difficulty predicting when mother will intrude (spatial/tactile). But he is also working too hard to know mother's mind, as

he vigilantly coordinates his facial-visual engagement with her facial-visual engagement. In contrast, the future D infant will have difficulty knowing his mother's mind across a broad range of arenas, especially her affective state. The future D infant will represent an internal working model of, "I don't know what you feel. You show me incomprehensible, indigestible smiling and surprised faces when I am upset; your face is inscrutable. I can't count on your attention. I don't know when you are going to loom into my face, I can't read your intent, and I feel threatened. I can't influence you to follow my facial-visual changes or my touch. I can't read you or predict you; you are not on my wavelength." Compared to the future C infant, these difficulties disturb the future D infant's internal working model of "I know you; you are mine."

(3) Knowing oneself. Both the future C and future D infant will have difficulty *knowing himself* as his own engagement self-contingency is lowered, making it more difficult to sense his own facial-visual action tendencies from moment-to-moment, and more difficult to develop a coherent expectation of his own body. Both future C and D infants showed an affective discrepancy, generating difficulty in sensing and representing a coherent state. The future C infant represents opposing expectations of how he responds to mother with his facial-visual engagement: vigilant to her engagement but inhibited to her touch. The future D represents opposing expectations of his own state in moments of discrepant affect, a more primal split in the organization of self experience. Moreover, as the future D infant has difficulty touching in general, touching his own skin, and getting "stuck" in states of no touch, all of which disturb his visceral feedback through touch, he will represent his own difficulty in being able to regulate his distress through touch. Although the future C infant has difficulty *using mother's* touch, the future D infant's difficulty *using his own touch* will accrue to difficulty sensing his own control over his own body. More generally, both future C and future D infants have difficulty in knowing the self, and generate representations that "my body is not my own, I can't sense myself." However, because of the numerous difficulties with his own touch, and his more primal affective split, we propose that the future D, as compared to C, infant experiences a more serious disturbance in the experience of agency with regard to his own states, and is more prone to represent himself as helpless to use his states in organizing his own behavior.

We propose that the level of dysregulation in future D dyads is of an entirely different order than that of future C dyads. The future D infant represents *not being sensed and known* by his mother, particularly in states of distress: "you are not on my wavelength"; he represents *not knowing the mother*: "I can't read you, influence you, or count on you, especially when I am upset"; and he represents *confusion in sensing and knowing himself*, especially at moments of distress; "I can't tell what I feel, I can't sense my self, I can't help myself." Thus the emerging internal working model of future D infants represents confusion about their own basic emotional organization, their mothers' emotional organization, and their mothers' response to their distress, setting a trajectory in development which may disturb the fundamental integration of the person.

Chapter 6. General discussion

We first note the unusual distribution of attachment classifications in our community sample, discuss associations of demographic variables with attachment, and comment on the sample. We then summarize the findings, and evaluate our hypotheses and conjectures, followed by a discussion of the findings of the study from the perspective of a dyadic systems view of communication. We then evaluate the role of different communication modalities in the patterns of results, and note the limitations of the study. Finally, we describe implication of the findings for clinical intervention, and provide a summary of the general discussion.

The sample

These participants are an unusual attachment group. The proportion of secure infants (56%) is similar to other samples. van IJzendoorn, Goldberg, Kroonenberg, and Frenkel (1992) found a secure rate of 55%; van IJzendoorn, Schuengel, and Bakermans-Kranenburg (1999) found a secure rate of 67%. However, the proportion of avoidant infants is unusually low (5%), compared to the rate of 15% reported by van IJzendoorn et al. (1999); and that of resistant (19%) is high compared to the rate of 9% reported by van IJzendoorn et al. (1999), or 7–15% by Cassidy and Berlin (1994). The proportion of disorganized (20%) is somewhat high compared to the rate of 15% reported by van IJzendoorn et al. (1999). The current sample was collected with the same criteria in the same hospital as the Jaffe et al. (2001) sample a decade earlier, but the proportion of C and D infants was higher, and the proportion of A was lower.

The participants are also unusual in the high level of education: 87.4% of mothers completed some college or more. The participants thus represent a high-risk attachment group, highly educated, in a selected low-risk community sample in the neighborhood of a large urban teaching hospital. Of the 132 dyads filmed at 4 months, there was a large drop-out rate in the 84 dyads who returned for attachment assessments at 12 months, but this rate is similar to our prior study using the same criteria in the same hospital (Jaffe et al., 2001). Dyads who dropped out did not differ in age, ethnicity, infant gender, or a global code of mothering style. The main reason mothers gave for not participating at 12 months was that they had returned to work.

Summary of findings and evaluation of hypotheses

Both *process* measures (contingency) and *content* measures (behavioral quality) were effective in examining the origins of attachment security. Process and content measures gave different, and complementary, kinds of information. Their integration was critical in understanding the contributions of both infants and mothers. Behavioral qualities assessed with the averages of ordinalized behavioral scales yielded little, whereas the behavioral extremes approach yielded a substantial number of findings, and was particularly informative for future D infants. Although maternal findings with the behavioral extremes approach were not extensive, they nevertheless identified very important contributions to the origins of C and D attachment.

Table 1 annotates the confirmation/disconfirmation of our hypotheses. In addition we summarize in Table 9 the results of contingency hypothesis (a), insecurity biases the 4-month mother–infant communication system toward both heightened and lowered contingency.

Table 9 summarizes associations of 4-month contingency with 12-month attachment. For each attachment contrast we ran 36 tests (9 modality-pairings ×

Table 9. Summary of associations of 4-month contingency with 12-month attachment.

		Non B (vs. B)						
			Poles of Regulation Hypothesis Confirmed	% of findings[a] NonB	C (vs. B)	D (vs. B)	Poles of Regulation Hypothesis Confirmed	% of findings[a] C + D
I	I → I	↓↑	nonB	2/10 = 20.00%	↓	↓↓↑↑	D	5/20 = 25.00%
	M → I	↓↑	nonB	2/8 = 25.00%	↓↓↑		C	3/16 = 18.75%
M	M → M	↓↓		2/8 = 25.00%	↓	↓↑↓	D	4/16 = 25.00%
	I → M			0/8 = 00.00%		↓↓		2/16 = 12.50%
I	IVQ → ITch	–			–	–		
	Itch → IVQ	–			–	–		
		6/36			5/36	9/36		

Note: Each arrow represents a finding of insecure (vs. secure) in a specific modality; ↓ = decreased contingency, ↑ = increased contingency, in insecure (vs. secure).
[a]% of equations run yielding significant findings for C (vs. B) and D (vs. B); denominator = possible findings across all C (vs. B) and D (vs. B) analyses. Per analysis (eg B vs. nonB), possible findings for infants = 10 self-contingency, 8 interactive contingency, 2 intrapersonal contingency; for mothers, 8 self- and 8 interactive contingency. Poles of regulation hypotheses: see Table 1, Hypotheses, Contingencies (a) 12-month insecurity will be associated with both heightened and lowered contingency in 4-month mother–infant face-to-face communication.

2 partners $\times$ self- and interactive contingency). The nonB (vs. B) contrast yielded 6 (of 36 possible) findings, the C (vs. B) yielded 5 (of 36 possible), and the D (vs. B) yielded 9 (of 36). Approximately 20% of the equations yielded significant findings. Table 9 shows that, within the nonB (vs. B) analyses, as well as across the C (vs. B) and D (vs. B) analyses, infant self-contingency, infant interactive contingency, and mother self-contingency each yielded comparable numbers of findings, approximately 20% to 25% of equations run. In contrast, mother interactive contingency yielded the least (0% in nonB and 12.5% across C and D analyses).

A dyadic systems view of the co-construction of attachment

Our results support a dyadic systems view of the co-construction of attachment processes by both mothers and infants. We began by asking whether associations with attachment would be found in our contingency measures for mothers, for infants, or for both. We also began by asking whether associations with attachment would be found in *self*-contingency, our intrapersonal measure of stability within the person's behavioral stream; in *interactive* contingency, our interpersonal measure of coordination between the two partners' behavioral streams; or both. Previous attachment research has emphasized mothers over infants and the interpersonal over the intrapersonal. We found that, over all 4-month contingency analyses, *mother interactive contingency* (mother's contingent coordination with infant behavior) predicted attachment with *the least* number of findings, opposite the literature's emphasis on the role of maternal responsiveness (see van IJzendoorn et al., 1992). Infant self- and interactive contingency and mother self-contingency predicted attachment with comparable numbers of findings. Thus the ways that infants regulated their own behaviors, and coordinated their behaviors with mothers, and the ways that mothers regulated their own behaviors, gave two to three times more information about future 12-month infant attachment status than the ways that mothers coordinated their behavior with the infant's prior behavior. Future attachment research should focus on infants as well as mothers, and on measures of self- as well as interactive contingency.

Our findings indicate that infant and mother *self*-contingency are important in the origins of attachment. The robustness of findings with our auto-correlation measure of self-contingency (stability of one's own behavioral rhythms) argues for its construct validity. The salience of self-contingency in analyses of attachment is paralleled by a similar salience in analyses of maternal depression, self-criticism and dependency (Beebe et al., 2007, 2008a).

In our dyadic systems view, we reiterate that our view of interaction as bi-directionally regulated does not assume symmetry. The mother obviously has a greater range, control, and flexibility of behavior than the infant. Instead, our systems view assumes that both partners actively contribute to the exchange. Thus, the lower salience of maternal contingent coordination with infant behavior does not imply that mothers are less important than infants in organizing the course of development. It does imply that we should look at forms of contingency in addition to maternal contingent coordination to find predictors of attachment status. Second, the behavioral extremes analysis complemented the contingency analysis in identifying important maternal contributors to the process of insecure attachment formation. Third, the number of findings is not the only index of the importance of the findings. For example, the fact that future D mothers are positive while their infants are distressed may be so salient and disturbing to the process of communication that it may be more "important" or "organizing" than other findings. This finding illustrates our "principle of heightened affective moments"; moments which are organizing out of proportion to frequency or duration.

Whereas affect regulation, particularly distress regulation, has been a central concern of the attachment literature (see Schore, 1994; Seifer & Schiller, 1995), we also began asking how various communication modalities of attention, affect, touch, and spatial orientation in mother–infant face-to-face communication may contribute to our understanding of the origins of attachment. All modalities were informative and worked together to specify further the nature of communication disturbances which predict insecure infant attachment outcomes. Furthermore, only through examination of separate modalities was it possible to identify discordant forms of communication, such as the simultaneous positive and negative discrepant affect of future D infants. Thus, we suggest that the study of the origins of attachment should be broadened to an examination of regulation through all possible communication modalities.

Our prior work (Jaffe et al., 2001) documented that interactive contingency of vocal rhythm was one mechanism of transmission of attachment security, and that insecurity biased 4-month mother–infant communication toward both excessive as well as insufficient contingency. The current findings partially replicate our prior findings for interactive contingency and extend them to self-contingency, in modalities other than vocal rhythm. We hypothesized that insecure attachment is associated with *both higher and lower* 4-month values of self- and interactive contingency than secure, as a function of partner and modality. This hypothesis was supported more for infants than mothers: (1) future nonB and D (vs. B) infants showed both higher self-contingency in touch, and lower in engagement; (2) future nonB and C (vs. B) infants showed higher engagement coordination with mother engagement, but lowered engagement coordination with mother intrusive touch; and (3) mothers of future D (vs. B) infants showed higher self-contingency in facial affect, but lower in gaze and spatial orientation. However, 5 of the 6 maternal self-contingency findings were lowered. Lowered maternal self-contingency is more prevalent in the origins of insecure attachment. Where consistent, *the hypothesis that distress biases communication toward both heightened and lowered contingency informs the origins of insecure attachment: higher self*- *or interactive contingency is not necessarily better*. This concept is an important antidote to the widespread assumption in the literature on mother–infant face-to-face interaction that more contingency is "more optimal" (see Cohn & Elmore, 1988; Jaffe et al., 2001).

Our results enhance an understanding of the *specificity* of the details of 4-month mother and infant face-to-face communication as it is relevant to the origins of 12-month C and D (but not A) attachment. The coding to a 1 s time-base, in specific modalities, with a sophisticated statistical approach to self- and interactive contingency, as well as exploratory analyses of behavioral extremes, allowed us to see a remarkable complexity and differentiation in the 4-month precursors of the C and D attachment categories. We note that the approach of *averaging* our behavioral scales to identify qualitative features of behaviors associated with attachment missed essential behavioral patterns that our subsequent study of behavioral extremes revealed.

The specificity of different components of the origins of attachment insecurity identified in this study illustrate Hofer's concept of component sub-processes of attachment formation. Hofer (1994, 2006) argues that the concept of attachment is a general one, referring to a cluster of behavioral and physiological sub-processes that maintain and regulate sustained social relationships. His own work examining the details of separation in mother–infant rat interactions identified critical component sub-processes. For example, an infant rat's response to separation from the mother is based on many subcomponents, such as nutrients, warmth, and tactile stimulation, which have different functions in the system. Hofer described these subcomponents as regulatory processes "hidden" within the mother–infant interaction. His work underscores the importance of carefully examining the details of how the more general concept of "attachment" might work. This is the focus of our work as well. Our results can be seen as examples of Hofer's concept of "hidden regulators," various forms of behavioral regulation in different subcomponents of the system: (1) partner (mother/infant), (2) type of measure (behavioral quality/contingency), (3) type of contingency (self-/interactive), and (4) modality of behavior (attention, affect, touch, spatial orientation).

Modalities of communication altered in relation to attachment

Although all modalities of communication examined (attention, affect, spatial orientation, and touch) were useful in articulating the 4-month origins of insecure attachment, in this section we are interested in which modalities were most salient. Examining patterns of modality use in the qualitative behavioral findings, and in the contingency findings, we conclude that facial-visual engagement and touch were the most salient modalities in detecting differences between future secure and insecure dyads. In assessing *qualitative behavioral* findings for future insecure infants (nonB, C and D vs. B), modalities of infant vocal affect, our combined measure of facial/vocal affect, and touch each yielded findings; infant facial affect (assessed alone), gaze, and head orientation did not. For mothers of future insecure infants, qualitative behavioral findings were evident in all modalities except facial affect: gaze, touch, spatial orientation, and the dyadic variables of chase and dodge, and mother smile while infant distressed, all yielded significant results.

Examination of the self- and interactive contingency findings reveals specific modality patterns. Although the modalities were not necessarily equally represented in the nine modality-pairings analyzed[9] (see Introduction), the pattern of findings did not mirror this distribution.[10] Summarizing across all contingency analyses, future insecurity (nonB, C, or D vs. B) was associated with altered 4-month contingency in the following rank order of modalities: engagement was represented in 11 findings (mother 3, infant 8), touch in 7 (mother 4, infant 3), mother spatial orientation in 3, mother gaze in 2, infant vocal affect in 1, and mother facial affect in 1. Thus for infant self- and interactive contingency, and mother interactive contingency, *engagement and touch* were the most salient modalities predicting infant attachment insecurity; for mother self-contingency, *spatial orientation and gaze* were most salient.

Engagement

Why is engagement such a productive variable in the contingency analyses? The unique aspect of engagement is that gaze and facial affect are "packaged" as a constellation.[11] In analyses of *interactive contingency*, gaze or facial affect as separate modalities were not significant in any of the contrasts of future B vs. nonB, C, or D dyads. Instead, there were many findings in the facial-visual engagement variable. Of the 11 engagement findings, 8 were infant. Thus, future insecure (vs. secure) infants showed robust differences in the ways they packaged the gestalt of gaze and facial/vocal affect in the process of self-predictability, and in the process of coordinating with mothers over time. In contrast, future secure infants coordinated with mother through gaze, facial and vocal affect as separate channels, but they did not coordinate facial-visual engagement with mother engagement. *Thus facial affect and gaze were not as tightly packaged in the process of interpersonal coordination for future secure* (vs. insecure) infants. Similarly, mothers of future secure infants coordinated touch patterns with infant vocal affect and touch, but not with infant engagement. Engagement was not a distinguishing variable in detecting differences in mother–infant communication patterns in our prior analyses of depressed, self-critical or dependent mothers; any engagement findings generally paralleled findings in facial affect and gaze analyzed separately (Beebe et al., 2008a). Thus, the constructed variable of engagement was unique in detecting differences in the origins of attachment insecurity.

Touch

Maternal and infant touch played important roles in the origins of attachment insecurity. Intrusive touch identified mothers of future nonB infants, and progressively less affectionate touch identified mothers of future C infants. Additionally the ways mothers used their touch patterns in the *process* of contingent coordination over time (for D dyads), and reciprocally the way infants coordinated with maternal touch (for C dyads), identified future infant attachment insecurity. Both qualitative features of infant touch (frequency, absence of touch, and touch skin), and the way infants used touch in contingent coordination, predicted attachment.

Maternal touch has long been recognized as essential to infant physical and social development (Ainsworth et al., 1978; Bowlby, 1953; Harlow, 1958; Spitz, 1946). In the past decade, however, research has shifted from considering touch as a unitary construct to considering it as a sophisticated medium of communication with subtle features (Downing, 2004; Hertenstein & Campos, 2001; Muir, 2002; Stack & Arnold, 1998; Stepakoff et al., 2000, 2008). For example, using the Still-Face paradigm, maternal touch can reduce or eliminate the still-face effect (Stack & Arnold, 1998; Pelaez-Nogueras et al., 1996). However, little work has documented the role of maternal touch *in the contingent process of mother and infant coordinating over time*, new to conceptualizing the origins of attachment insecurity.

Limitations of the study

Although we recruited subjects with the goal of obtaining a low-risk, ethnically diverse community group of first-born infants and their mothers in the vicinity of a large urban university hospital, we generated an unusual sample. The group was highly educated and had an attachment distribution with a low prevalence of avoidant attachment (5%), a high prevalence of C (19%), and a somewhat high prevalence of D (20%) attachment. This attachment distribution limits the generalizability of our findings, particularly to less educated samples, but facilitated our study of C and D classifications.

We used a new statistical approach, multilevel time-series modeling, which requires replication, although it yielded similar kinds of results for other analyses of maternal depression, self-criticism, and dependency. The number of results was modest (approximately 20–25% of equations run were significant for mother and infant self-contingency, and infant interactive contingency: see Table 9). A further limitation is that we have no way to assess effect sizes with this multilevel time-series modeling approach.

Examination of extremes of behaviors is currently advocated in relation to disorganized attachment (Lyons-Ruth et al., 1999; Tomlinson et al., 2005), but was relevant to other insecure classifications and would inform future research. Subtle differences in the precise definitions of variables were critical to finding associations with attachment. The behavioral extremes approach was exploratory and requires replication. However we note that averages of our behavioral scales missed essential patterns subsequently identified by behavioral extremes.

The study is limited by its exclusive examination of behavioral transactions between mothers and infants in the face-to-face encounter. Considerations of sleep-wake and feeding cycles; maternal states of mind, personality features, trauma history; and infant temperament lie outside the scope of the study. We take up the role of maternal depression in relation to attachment, and the role of infant temperament, in separate reports. Future research can directly examine whether our speculations of links between maternal behavioral forms of withdrawal and maternal trauma history hold up.

Implications for clinical intervention

The findings have rich implications for clinical intervention, with remarkable specificity for different kinds of mother and infant distress. Heightened and lowered self- and interactive contingency, in different modalities, as well as the specific behavioral qualities identified, provide the clinician a more differentiated set of concepts and perceptions. With therapeutic viewing of the videotape, mothers can be sensitized to the ‘‘nonverbal language’’ of both mother and infant (see Beebe, 2003, 2005; Beebe, Cohen, Bergman, Moskowitz, Sossin, Reiswig, et al., in press; Cohen & Beebe, 2002).

Mothers of future C infants

A critical background to clinical intervention with C mothers is their history of not being able to trust attachments, and their need to be sure that their infants need them (Cassidy & Berlin, 1994). Maternal ‘‘chasing’’ of the infant can be reframed as her need for her infant, and her worry about whether her infant is ‘‘with’’ her. These mothers can be sensitized to the concept that their infants are watching them carefully, coordinating with mothers’ own emotional states, thus reassuring mothers that their infants are indeed ‘‘with’’ them. Future C mothers can be helped to pay more attention to the stability/instability of infant rhythms in infant self-contingency patterns of vocal affect and facial-visual engagement. The progressive use of more active and less affectionate maternal touch in future C mothers can alert clinicians to this way that the mother may make an effort to be sure her infant is ‘‘with’’ her, as the clinician attends to the mother’s own history of being touched and her attachment history.

Mothers of future D infants

A critical background to clinical intervention with D mothers is their unresolved loss, mourning or abuse, and difficulty with their own distress. Addressing the mother's possibly dissociated distress will be a critical context for helping mothers to notice, become curious about, and tolerate their infants' vocal and facial distress, and ambivalent positive and negative facial/vocal signals. The mother can be helped to allow herself more facial-emotional response to the infant's facial-visual-vocal engagement shifts, while the clinician remains alert to maternal emotional withdrawal out of feelings of inadequacy and rejection, fears of intimacy, or fear or anger regarding infant distress, while unable to bear her own distress. Clinicians can remain alert to any maternal tendency to confuse the infant's distress with their own, or with negative feelings toward a childhood attachment figure. The clinician can inquire about what it might mean to the mother if she allowed herself more emotional response, and to help the mother with her need for, and potential fear of, engagement with her baby. These mothers can be helped to notice their own look-look away cycles, and to understand the importance of providing predictable rhythms of visual attention, as the clinician attends to the mother's potential difficulties with the intimacy of mutual gaze. Future D mothers can be sensitized to infant touch patterns as a source of infant comfort, while clinicians remain sensitive to potential maternal difficulties in their own self-comforting. The mother can be helped to pay attention to her own touch patterns, her history of being touched, and how her own touch patterns are affected by her infant's touch patterns.

Summary of general discussion

Our central contribution is a greater specification of mother–infant communication processes that predict 12-month resistant and disorganized attachment (see Demos, 2001).

(1) Whereas attachment research has focused on maternal antecedents, analysis of infant as well as maternal behavior was critical in generating a dyadic view of these early disturbances.
(2) Contingency measures of self- and interactive regulation were successful in predicting attachment outcomes. But the behavioral extremes approach was an essential complement. The behavioral extremes approach was exploratory, and results must be taken with caution and require replication. Exact method of measurement will affect replication.
(3) In contingency analyses, maternal interactive contingency (contingent coordination with infant behavior) was least successful in predicting attachment, contrary to the literature, although maternal interactive contingency was important in the origins of future D dyads. Mother and infant self-contingency, and infant interactive contingency, were more robust with comparable results. However, these findings do not imply that mothers are any less important in the infant's development. They do underscore the importance of self- as well as of interactive contingency, and of the roles of both partners, in early communication disturbances.
(4) Rather than the more usual hypothesis that more contingency is "more optimal," we partially supported our hypothesis that 12-month insecurity is associated with *both higher and lower* 4-month self- and interactive

contingency values than secure, as a function of mother vs. infant and communication modality. Thus, in the origins of attachment security, more contingency is not necessarily more optimal. Both lowered interactive contingency ("withdrawal") and heightened ("vigilance"), and both lowered self-contingency ("destabilized rhythms") and heightened (overly stabilized rhythms), characterized insecure (vs. secure) dyads. These results partially replicate our prior findings for interactive contingency (Jaffe et al., 2001) and extend them to self-contingency, in modalities other than vocal rhythm.

(5) Whereas much attachment theory emphasizes emotion, all communication modalities made unique contributions to an understanding of the origins of insecure attachment: attention, touch, and spatial orientation, as well as facial and vocal affect, and facial-visual engagement. The analysis of separate modalities identified striking intermodal discrepancies or conflict, both intrapersonal and interpersonal, that characterized future C and D dyads.

(6) Future C (vs. B) and D (vs. B) dyads showed remarkable differentiation and complexity in their patterns of findings. Aspects of the phenomena of 12-month C and D attachment are thus *already in place at 4 months*. We argued that the different patterns of 4-month interaction disturbances in future C (vs. B) and future D (vs. B) dyads generate different emerging infant internal working models of attachment.

(7) From these different patterns of interaction disturbances in future C and D infants, we inferred different kinds of difficulties in emerging infant abilities to know and be known by the mother's mind, as well as to know one's own mind. Although disturbances in affective correspondences, leading to infant difficulty in sensing shared states, is usually considered to be the central feature affecting infant ability to know and be known by the mother's mind, we found that disturbances in spatial, touch, and attention patterns were also critical.

(8) Our findings confirm the proposition that regulation of distress is a key issue in the origins of attachment insecurity (see Cassidy, 1994; Kobak & Sceery, 1988; Sroufe et al., 2005; Schore, 1994), but it was far more relevant to future D than C infants. Because only future D infants were intensely emotionally upset, we proposed that emotional distress is hierarchically organizing for future D, but not C, infants, a central differentiating feature of internal working models.

(9) We argued that the difficulties of future D dyads at 4 months are at a fundamentally deeper level than those of future C dyads. Maternal emotional withdrawal from intensely distressed infants compromises infant interactive agency and emotional coherence in future D (vs. B) infants. Both future C and D infants will likely have difficulties in creating internal working models of knowing, and being known by, the mother's mind, and knowing one's own mind, but these difficulties will be more serious in the future D infant. The future D infant represents *not being sensed and known* by the mother, and *confusion in sensing and knowing himself*, especially at moments of distress. Thus the emerging internal working model of future D infants includes confusion about their own basic emotional organization, their mothers' emotional organization, and their mothers' response to their distress, setting a trajectory in development which may disturb the fundamental integration of the person.

In conclusion, the specificity and complexity of our findings expand the paradigm for studying the origins of attachment. We document a dyadic systems view of the roles of both partners, the roles of both self- and interactive contingency, and the importance of attention, touch, and spatial orientation as well as facial and vocal affect, and facial-visual engagement, in the co-construction of different forms of attachment insecurity. The remarkable specificity of our findings has the potential to lead to more finely-focused clinical interventions.

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Notes

1. The current data set is entirely different from that reported in Jaffe et al. (2001).
2. Global codes of mothering style were coded midrange ("good-enough"), intrusive, and mixed midrange/intrusive. No mothers scored withdrawn. Reliability on 22% of dyads, randomly drawn, coded in three waves to prevent coder drift, produced a mean kappa of

.90. For the current analysis, codes were collapsed to midrange ("good-enough") vs. all others. The 84 subjects with attachment classifications did not differ from the 48 without, in "good-enough" vs. "not good-enough" mothering ($\chi^2 = .188$, 2 df, $p = .665$). "Good enough" (vs. not good-enough) mothers showed little disruptive behavior (ANOVA $F = 16.399$, df = 3127, $p < .001$) (Lupi, 2009).

3. Because multilevel models have so many covariates, we used correlations (or chi-square or ANOVA) to test associations between attachment and the ordinalized behavioral scales, thus yielding results more comparable to those of the literature.
4. A "random effect" is the term used for identifying the differences in a variable (function, or association) among the study subjects. These always include variation in the mean of the dependent variable across the observations, and variation in the variance of the dependent variable across the observations; they usually include variation in the linear change in the dependent variable over time, and in our case it includes between-dyad variation in the auto-regressive effect. A "fixed effect" is the average association across study units (in our case, dyads), just as it would be in an ordinary regression analysis. These average effects will account for some fraction of the random effects, just as ordinary regression analysis predictors account for some fraction of the variance in the dependent variable.
5. Preliminary analyses estimated the number of seconds over which lagged effects were statistically significant. For each dependent variable, measures of prior self or partner behavior, termed "lagged variables," were computed as a weighted average of the recent prior seconds, based on these analyses. Typically the prior 3 s sufficed to account for these lagged effects on the subsequent behavior. Across the interpersonal modality-pairings studied, mother (M) was significant at 2–3 lags (2–3 s) for both self- and interactive contingency; evaluation of longer lags yielded non-significant results. Significant infant lags varied: for self-contingency, 5 lags (engagement), 4 (vocal affect), 3 (facial affect, gaze), 2 (touch), and 1 (head orientation); for interactive contingency, 6 lags (M gaze $\rightarrow$ I gaze), 5 (M facial affect $\rightarrow$ I facial affect), and 3 (M facial affect $\rightarrow$ I vocal affect, M engagement $\rightarrow$ I engagement), and 0 (M spatial orientation $\rightarrow$ I head orientation). Although some of the above modality-pairings show lags longer than 3 s, the amount of variance accounted for was very small. In the analyses, no more than 3 lags were used, to maintain a consistent sample size; no fewer than 2 lags were used, regardless of significance.
6. Across all dyads (secure and insecure), in this M spatial orientation – I head orientation pairing, there is a significant bi-directional pattern. The infant interactive contingency carries a positive sign: as mothers move from sitting upright toward forward or loom, infants orient away, from enface toward arch (and vice-versa: as mothers move from loom toward upright, infants orient toward enface). The maternal interactive contingency carries a negative sign: as infants orient away from en face toward arch, mothers sit back, moving from loom toward forward or upright (and vice-versa). But maternal interactive contingency reduces to zero in more educated mothers. In future B mothers, maternal interactive contingency is not significant.
7. An alternative "slope" measure of intrusive maternal touch was reported in Beebe et al. (2003). By fitting semi-parametric group-based mixture models using SAS Proc TRAJ (Nagin & Tremblay, 2001), we estimated two developmental trajectory groups (high and lower) for maternal touch. We calculated the posterior probabilities of group membership for each individual in the sample, estimating the probability of the individual belonging to each trajectory group. This differentiated mothers whose touch behavior remained relatively stable across the session (86.4%), from those who showed decreasing slope (13.6%), a progressively less affectionate touch. Decreasing slope was associated with nonB ($p = .04$) and with C ($p = .006$).
8. There are two exceptions to this generalization in the infant data: (1) "average" infants across the group did not significantly coordinate engagement, vocal affect and touch with mother touch, and the secure subset is similar, differing only in the presence of significant coordination of infant engagement with mother touch; (2) whereas average infants across the group coordinated engagement with mother engagement, future secure infants did

not. Maternal interactive contingency findings are identical with one exception: whereas average mothers across the group coordinated touch with infant engagement, future secure mothers did not.

9. Infant (I) vocal affect was represented 3 times (pairings 3, 6, 9); I engagement and touch 2 times each (pairings 4, 5; and 7, 9 respectively); I gaze, facial affect and head orientation 1 each. Mother (M) touch had 3 (pairings 5, 6, 7); M facial affect 2 (pairings 2, 3), M gaze and engagement 1 each.
10. For infant (I) self-contingency across all 3 attachment contrasts, engagement was represented in 4 findings, touch in 3 (although both variables were equally represented in the modality-pairings). For I interactive contingency, infant engagement coordination with mother (M) engagement yielded 2 findings, I engagement coordination with M touch 2 findings, and I vocal affect coordination with mother touch one. Of infant (I) interactive contingency findings, I engagement was represented in 4 (of 5), M touch in 3, M engagement in 2. For M self-contingency, spatial orientation yielded 3 findings: gaze 2, and facial affect 1, although facial affect was represented twice in the 9 modality-pairings, and gaze and spatial orientation once. For M interactive contingency (exclusively in the D analysis), M engagement coordination with I engagement, and M touch coordination with I touch, each yielded 1 finding.
11. Pearson correlations show that M engagement is correlated with component items of facial affect ($r = .873$) and gaze ($r = .671$). Infant engagement is correlated with component items of gaze ($r = .664$), facial affect ($r = .516$), vocal affect ($r = .479$) and head orientation ($r = .454$), all $p < .001$. Thus for mothers, face leads slightly over gaze in the constellation, whereas the reverse is true for infants.

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Appendix A

Coding of ordinalized behavioral scales

Modality		Definition		
Mother facial affect[a]		*Mouth widen (MW)*	*Mouth open (MO)*	*Other*
90	mock surprise	MW 0 (1)	MO 3 (4)	eye brows raised
85	smile 3	MW 2	MO 3 (4)	
80	smile 2	MW 2	MO 2	
70	smile 1	MW 1	MO1 (2)	
67	oh face } Interest	MW 0	MO 1 (2)	
60	positive attention } Interest	MW 0	MO 1 (0)	[kiss/ purse]
50	neutral	MW 1	MO 0	
45	2 = woe face	MW 0	MO 0	empathic pout and/or frown
40	1 = negative face	grimace and/or compressed lips		
Infant facial affect[b]		*MW*	*MO*	*Other*
5	medium high/ high positive	MW 2	MO 3 (4)	
4	low/medium positive	MW 1	MO 1 (2)	
3	interest/neutral	MW 0 (1)	MO 0	
2	mild negative	grimace	MO 0 (1)	[and/or frown]
1	negative	squared anger mouth/pre-cry/cry-face (partial/full display)	MO 2 (3)	[and/or frown]
Mother/Infant gaze				
1 = on partner's face				
0 = off partner's face				
Infant vocal affect[c]				
6	high positive		rising intonations, peals, laughter	
5	neutral/positive		includes gurgles, coos, neutral sounds	
4	None			
3	fuss/whimper			
2	angry protest		distinct angry quality	
1	Cry		full-blown cry	
For data analysis, codes were combined:				
4	positive/neutral			
3	None			
2	fuss/whimper			
1	angry protest/cry			

Infant Head Orientation[d]		**Infant Touch**[e]	
6	en face	0	None
5	enface/head down	1	touch/suck own skin
4	30–60 degree minor avert	2	touch/suck own clothing, strap, chair
3	30–60 degree avert+head down	3	touch/suck mother's skin, clothing
2	60–90 degree major avert	*For analysis, codes were ordinalized:*	
1	Arch	3	more than one code within one sec
		2	any one code
		1	None

(*continued*)

Appendix A. (*Continued*).

Mother Spatial Orientation[f]		
3	upright	torso/shoulders perpendicular to floor
2	forward	torso bent 45 degrees, minimum 12 inches from infant's face
1	loom	torso bent 80 degrees, within 12 inches of infant's face

Dyadic Mother "Chase"- Infant "Dodge"[f] : Coding Rules

1) The infant may initiate the chase and dodge sequence with a "dodge" that consists of at least a 30-degree lateral head aversion from the vis-à-vis orientation with the mother.
2) A maternal "chase" requires that mother is already in a forward or loom spatial orientation, and that she alters the position of her head or body in the direction of the infant's head aversion. The mother must begin chasing within 1 sec of the infant's head aversion.
3) If more than 1 sec elapses between the infant's head aversion and the mother's movement, then the chase and dodge sequence is said to be initiated by the mother's movement.
4) Chase and dodge movement focuses only on lateral movement. This refers to movement away from the vis-à-vis position toward the side from which the infant has just moved.
5) Chase and dodge is present as long as movement by at least one partner continues within 2 secs (e.g. the infant turns his head from side to side). Even if the infant's head is averted or the mother is in a "chasing" position, chase and dodge is not considered present if there is no movement for 2 seconds or more.
6) Chase and dodge is no longer coded when either the mother or the infant are in the vis-à-vis position for 1 sec.
7) A minimum of 2 sec duration is required to code chase and dodge.

Note: Codes within each modality coding scheme are mutually exclusive. Coding rules for multiple codes within the same sec follow Tronick and Weinberg (1990). If two codes occur in the same sec, the code occurring in the first half of the sec is attached to that sec; the code occurring in the second half of the sec is attached to the following sec. For vocalization, this coding rule was adapted as follows: if two vocalizations occur in the same sec, code the most intense one; if they are of equal intensity, code the second one. Vocalizations are scored in the sec they occur even if they occur in the second half of the sec (consistent with Weinberg & Tronick, 1990).

[a]Mother Facial Affect coding follows Beebe and Gerstman (1980). Two degrees of mouth widen (MW) were distinguished: MW1 = sideways lip stretch (without zygomaticus retraction); MW2 = lip-corner raise (zygomaticus retraction). Four degrees of mouth open (MO) were distinguished, from lips slightly parted to maximal display of mouth open ("gape"). Reliability was evaluated based on configurations (levels 40 - 90).

[b]Infant Facial Affect coding follows Koulomzin et al. (2002) and Marquette (1999). Two degrees of mouth widen and four degrees of mouth open were distinguished, definitions identical to that of *mother facial affect*. Reliability was evaluated based on configurations (levels 1–5).

[c]Infant Vocal Affect coding follows Demetri-Friedman (2005), adapted from Tronick and Weinberg (1990).

[d]Infant Head orientation coding follows Koulomzin et al. (2002) and Marquette (1999).

[e]Infant Touch coding follows Koulomzin et al. (2002); see also Hentel et al., (2000); Marquette (1999).

[f]Mother Spatial Behavior coding follows Kushnick (2002) and Demetriades (2003); Mother Chase – Infant Dodge coding follows Kushnick (2002).

Appendix B

Ordinalized maternal touch scale: from affectionate to intrusive.

	Scale category	Type	Location	Intensity (intense)	%	Cat%
11	Affectionate Touch	(3) stroke, caress (6) kiss, nuzzle (21) pat	(4) hands, arms, (5) feet, legs	(1) mild or moderate	0.8	32.9
10	Static Touch	(1) hold, (2) provide hand or finger for infant to hold	(4) hands, arms, (5) feet, legs	(1) mild or moderate	24.6	
9	Playful Touch	(4) tap, (8) tickle, (9) rub, (11) large movements with arms or legs	(4) hands, arms, (5) feet, legs	(1) mild or moderate	7.5	
8	No Touch	(0) no touch	n.a.	n.a.	38.9	38.9
7	Caregiving	(5) caregiving	(4) hands, arms, (5) feet, legs	(1) mild or moderate	0.4	8.4
6	Jiggle / Bounce	(13) jiggle, bounce	(4) hands, arms, (5) feet, legs	(1) mild or moderate	8.0	
5	Oral Touch	(14) infant-directed oral touch	(1) face	(1) mild or moderate	1.3	1.3
4	Object Mediated	(19) object-mediated touch	(1) face, (2) body, (3) head, neck, (4) hands, arms, (5) feet, legs	(1) mild or moderate	2.7	2.7
3	Centripetal Touch	(1) hold, (3) stroke, (4) tap, (5) caregiving, (6) kiss, nuzzle, (8) tickle, (21) pat	(1) face, (2) body, (3) head, neck	(1) mild or moderate	9.0	9.0
2	Rough Touch	(10) scratch, (15) pull, (16) push, (17) pinch, 18 (poke)	(1) face, (2) body, (3) head, neck, (4) hands, arms, (5) feet, legs	(1) mild or moderate	3.0	6.9
1	High Intensity Touch (Intrusive)	Any	(1) face, (2) body, (3) head, neck, (4) hands, arms, (5) feet, legs	(2) high intensity	3.9	

Note: Category = Categories of the scale, from affectionate touch to high intensity intrusive touch; Type = Numeric entries refer to specific types of touch (taken from Appendix Web 1: Maternal Touch Codes) defining the category; Location = Location on Infant's Body: (1) face, (2) body, (3) head, neck, (4) hands, arms, (5) feet, legs; Intensity = 1 = mild or moderate; 2 = high rapid, abrupt, intrusive.

The Mother Touch Scale is comprised of 11 ordinalized categories of 21 types of touch behaviors, defined in Web Appendix 1 (Stepakoff, 1999; Stepakoff, Beebe & Jaffe, 2000). Each category describes the type of maternal touch, intensity, and location of maternal touch in relation to the infant's body.

The most intuitively positive mode of touch is "affectionate touch," which occurs less frequently in depressed mothers (Stepakoff, 1999). "Static touch" refers to holding or gently squeezing (legs/feet or arms/hands), resting mother's hand or palm on infant (legs/feet or arms/hands), or providing the mother's hand or finger for the infant to hold (arms/hands). This category of touch is intuitively gentle. "Playful touch" refers to tap/graze, tickle, rub, or flex/extend or lift/circle (legs/feet or arms/hands). This form of touch is more active, and overtly "playful," often involving games. All three of these categories occur exclusively in the location of arms/hands or feet/legs. We followed Stepakoff's hypothesis that touch to the periphery of the body was less stimulating than touch to the center of the body. These three categories account for approximately one third of the data. The category of "no touch", which accounts for 38.9% of the data, is next in the ordinalization. At this point of the scale, almost 72% of the data is accounted for.

The next two categories, "Caregiving", which accounts for very little data, and "Jiggle/Bounce," a substantial category (8%), both occur exclusively in the location of arms/hands or feet/legs. They differ from the first three categories in that they are more active. "Oral touch", a relatively rare code (1.3% of the data), is defined as mother putting her finger in the infant's mouth. "Object mediated touch" (2.7%) involves mother touching the infant with an object in between her body and the infant's body, such as mother dangles toy on infant's chest. Depressed mothers use more "object mediated touch" (Stepakoff, 2000). "Centripetal touch" (9%) is defined both by central body location (face, body, head and neck, excluding hands, arms, feet and legs) and by mild intensity. Touch to the central body was considered more stimulating (Stepakoff 2000). The final two categories can be considered intrusive. "Rough touch" (3%) includes scratch, pull, push, constrain, force, or control infant movement (such as force infant's foot into infant's face, or force infant's hand down), pinch or poke/jab, in any location on the infant's body. The final category "high intensity touch" (3.9%) was by definition intrusive, involving "rapid, abrupt or intrusive touch," irrespective of the type of touch.

Appendix C

Mother and Infant Engagement Scales

Beebe and Gerstman (1980) developed an ordinal scale of degree of infant and mother facial-visual engagement. By three to four months, an extensive range of interpersonal affective play is present in the infant. Observations of infants sustaining or disrupting the face-to-face play encounter led to the development of an infant engagement scale describing the various ways that infants combine their orientation to the mother, their visual attention to her, and subtle variations in their facial expressiveness (Beebe and Stern, 1977; Beebe and Gerstman, 1980, 1984). This scale was influenced by the concept that nuances of affective quality occur on a continuum of gradations, rather than only as discrete on-or-off categories.

Although our previous versions of the infant engagement scale used infant gaze, facial affect, and head orientation, in this study we also integrated infant vocal affect into the ordinalization of the multimodal infant engagement scale. Thus the construction of the infant engagement scale underwent extensive revision. The mother engagement scale was not changed. The mother engagement scale is ordinalized consistent with the mother facial affect scale (see Appendix A). Mock surprise is the highest mother engagement level based on ordinalizing by degree of mouth opening; as such it carries the fullest degree of display of the positive expressions.

The entire data set was run through a series of successive versions of the engagement scale, and frequency analyses were performed to see what percentage of the total seconds of data was accounted for by the engagement categories in each of the versions of the scale. Any engagement levels that accounted for less than 2% of the data were regrouped with other similar levels. Any large proportion of seconds unaccounted for by the existing categories led to the creation of new levels, until 92% (infant) and 94% (mother) of the data set was included in each engagement scale, and no single level of engagement represented less than 2% of the entire data set (with the exception of two levels of infant distress). These percentages can be found in the final column of the engagement scales.

INFANT ENGAGEMENT SCALE

ENG	GAZE (On/Off)	HEAD ORIENTATION	FACIAL AFFECT	VOCAL AFFECT	DESCRIPTION	%
POSITIVE ON						
18	ON (1)	En Face (6)	Hi Positive (85)	Hi (6) / Neut (5) / No Voc (4)	Hi Positive Engagement	3.7
17	ON (1)	En Face (6)	Mild Positive (70)	Hi (6) / Neut (5) / No Voc (4)	Mild Positive Engagement	6.2
16	ON (1)	En Face (6)	Neutral (55)	Hi (6) / Neut (5)	Positive / Neutral Engagement	2.1
15	ON (1)	En Face (6)	Neutral (55)	No Voc (4)	Neutral / Interest	19.9
NEGATIVE ON						
14	ON (1)	En Face (6)	Neutral (55)	Fuss (3)	Negative Engagement (Voc)	3.4
14	ON (1)	En Face (6)	Negative (40)	Neut (5)/No Voc (4)/ Fuss (3)	Negative Engagement	
LOOK ANGLED-ESCAPE						
13	ON (1)	Any except En Face (1–5)	Any except Cry (40–85)	Any except Protest or Cry (3–6)	Look Angled for Escape	2.2
POSITIVE OFF						
12	OFF (0)	Any	Hi Pos (85)/ Mld Pos (70)	Hi(6) / Neut (5) / No Voc (4)	Neutral Face / No Voc	2.2
11	OFF (0)	Any	Neutral (55)	Hi Pos (6) / Neut Pos (5)	Neutral Face / Pos Voc	3.2
NEUTRAL OFF						
10	OFF (0)	En Face (6)	Neutral (55)	No Voc (4)	En Face	16.5
9	OFF (0)	Head Down, vis a vis (5)	Neutral (55)	No Voc (4)	Head Down, vis a vis	3.5
8	OFF (0)	30–60 Avert (4)	Neutral (55)	No Voc (4)	30–60 Avert	7.8
7	OFF (0)	30–60 + Head Down (3)	Neutral (55)	No Voc (4)	30–60 + Head Down	4.6
6	OFF (0)	60–90 (1) / Hd Up & Back (2)	Neutral (55)	No Voc (4)	60–90/Head Up & Back	3.0
INF GAZE AT OBJECT						
5	Look at Object	Any	Any	Any	Object Engagement	6.2
NEG OFF/ EN FACE						
4	OFF (0)	En Face (6)	Neutral (55)	Fuss (3)	Off En Face - Negative	2.9
4	OFF (0)	En Face (6)	Negative (40)	No Voc (4) / Fuss (3)	Off En Face - Negative	

(continued)

INFANT ENGAGEMENT SCALE (*Continued*).

ENG	GAZE (On/Off)	HEAD ORIENTATION	FACIAL AFFECT	VOCAL AFFECT	DESCRIPTION	%
NEG OFF/ AVERT						
3	OFF (0)	Any (except En Face) (1–5)	Neutral (55)	Fuss (3)	Gaze Avert-Negative	2.2
3	OFF (0)	Any (except En Face) (1–5)	Negative (40)	No Voc (4) / Fuss (3)	Gaze Avert-Negative	
DISTRESS						
CRY FACE						
2	ON/OFF	Any	Cry Face (20)	No Voc (4) / Fuss (3)	Cry Face	1.6
ANGRY PROTEST						
2	ON/OFF	Any	Neutral (55) / Neg (40) Cry Face (20)	Angry Protest (2)	Angry Protest	
DISCREPANT AFFECT						
2	ON/OFF	Any	Negative (40)	Neutral Positive (5)	Low Discrepancy	
2	ON/OFF	Any	Mild Positive (70)	Fuss (3)		
2	ON/OFF	Any	Negative (40)	Hi Positive (6)	Medium Discrepancy	
2	ON/OFF	Any	Hi Positive (85)	Fuss (3)		
2	ON/OFF	Any	Cry Face (20)	Hi Positive (6) / Neut Pos (5)	High Discrepancy	
2	ON/OFF	Any	Hi Pos (85) / Mild Pos (70)	Angry Protest (2)		
2	ON/OFF	Any	Hi Pos (85) / Mild Pos (70)	Cry (1)		
CRY						
1	ON/OFF	Any	Cry Face (20)	Cry (1)	Cry	1.0

MOTHER ENGAGEMENT SCALE

	GAZE (On/Off)	FACIAL AFFECT	%
GAZE AT INFANT			
9	ON	Mock Surprise (90)	2.0
8	ON	Smile 3 (hi) (85)	3.2
7	ON	Smile 2 (med) (80)	15.5
6	ON	Smile 1 (lo) (70)	22.7
5	ON	Oh Face (67)	1.1
4	ON	Positive Attention (60)	38.0
3	ON	Neutral (50) / Woe (45) / Negative Attention (40)	2.2
GAZE OFF INFANT			
Positive Off			
2	OFF	Oh (67)/Sm1 (70)/Sm2 (80)/Sm3 (85)/ Mock Surprise (90)	3.8
Neutral / Negative Off			
1	OFF	Neg Attn (40)/Woe (45)/Neut (50)/Pos Attn (60)	6.9

Note: For details of Mother facial affect coding and ordinalization, see Appendix A. "Oh Face" = Mouth open midway, no smile; "Positive Attention" = Gaze on with slight mouth widening and / or opening without smile; "Woe Face" = Slight down-turned corners of mouth with pursed out lips; "Negative Attention" = Gaze on, with mouth corners turned down in grimace and / or frown and / or mouth drawn in tightly in "compressed lips".