A R T I C L E

SYSTEMS MODELS IN DEVELOPMENT AND PSYCHOANALYSIS: THE CASE OF VOCAL RHYTHM COORDINATION AND ATTACHMENT

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Our work owes a great intellectual debt to Louis Sander. Of his many publications, we were most influenced by the 1977 statement of his systems approach, where he suggested that ". . . organism, surround, and exchanges-between can be represented, or discussed, as a system . . . exchanges between interacting components in a system, through mutual modification, reach a harmonious coordination consistent with the conditions for enduring existence of each". (p. 138). A fundamental aspect of Sander's systems approach was his emphasis on timing as central to coordination: ". . . the domain of time and the temporal organization of events . . . provide the framework for . . . unscrambling the difficulties in conceptualizing the interface between two ongoing organizations" (p. 137). These two concepts, the systems approach, and the central importance of time in the coordination between two people, form the basis of work we present here.

Systems models of dyadic communication are potentially of great value to developmental psychology and psychoanalysis. They can provide organizing principles for interactive models of the dyad, of development, and of mind. This article illustrates systems concepts through

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research on vocal rhythm coordination, which has been extensively documented in both adult conversations and adult-infant interactions.

The coordination of vocal rhythms is applicable to psychoanalytic treatments conducted on the couch as well as face-to-face. Vocal rhythm coordination provides one underpinning of dialogue that is generally out of awareness of both patient and analyst. Whenever either person talks or makes any kind of vocal sound, some form of coordination of rhythms occurs. In addition, the degree of rhythmic coordination contributes powerfully to variations in emotional climate, across the lifespan. Throughout the article, we use a face-to-face videotaped interaction between a 12-month-old infant (Celia) and a stranger (first author), to illustrate various aspects of vocal rhythm coordination and systems models.

Our research on mother-infant, stranger-infant, and mother-stranger face-to-face vocal rhythm coordination (Beebe, Jaffe, Feldstein, Mays, & Alson, 1985; Beebe & Jaffe, 1992a; Beebe, Lachmann, & Jaffe, 1997; Jaffe, Beebe, Feldstein, Crown, & Jasnow, 1999) provides a rich illustration of concepts from two different systems theories: (l) a dyadic systems model of communication, and (2) nonlinear dynamic systems theory. The former was first introduced into infant research by Sander (1977, 1985, 1995), was influenced by Piaget (1954), Sameroff (1983), Von Bertalanffy (1968), Weiss (1969), and Werner (1948), was elaborated in infant research by Tronick (Gianino & Tronick, 1988; Tronick, 1989), and has generated interactive models of the dyad and of development (see Beebe, Jaffe, & Lachmann, 1992). The latter, as explicated by Edelman (1992), Fogel (1992a, b), Masterpasqua and Perna (1997), and Thelen and Smith (1994), among others, has generated an interactive model of how the brain works, which can contribute to an interactive model of mind for psychoanalysis (see also Shane, Shane, & Gales, 1997; Stolorow, 1997).

VOCAL RHYTHM COORDINATION

Timing and rhythm are basic organizing principles of all communication, and rhythms underlie all behavior (Lenneberg, 1967). Coordinating temporal patterns is thus one crucial way that social relatedness is organized. Timing refers, for example, to pausing, interruption and its outcome, turntaking, rate of speaking, and the switching pause at the end of one person's turn and the beginning of the partner's turn. In the research on vocal rhythm coordination, the durations of *on-off* sound-silence rhythms are examined. Other important paralinguistic phenomena such as prosody, pitch, melody, or contour are not addressed, nor is verbal content.

The process of relating to another person requires that each person have more or less continuous feedback about the subjective state of the other. Timing provides just such a continuous message system, displayed in all communicative behavior, giving each partner feedback about the state of the other (Byers, 1976; Lenneberg, 1967). It is a system generally out of awareness. Yet we respond to subtle changes in timing, such as a hesitation, or too long a switching pause between my turn and yours. These fluctuations alter our evaluation of the state of relatedness to the partner. Vocal timing may seem like a narrow slice of life, but it is synchronized with various kinesic features, such as facial expression, head movement, and gaze patterns, so that it potentially indexes the whole communicative "package". Stern (1994) argues that timing provides the "backbone" of all interpersonal representations. Timing is a perfect system to study in infancy because infants perceive time and estimate durations even in utero (DeCasper & Carstens, 1981; DeCasper & Fifer, 1980).

We are always coordinating our own vocal rhythms *in relation to* those of our partner. This is true both in adult-adult conversations and in adult-infant interactions, between mother and infant, as well as stranger and infant. Some interactive rhythms are experienced as "good vibes" (Byers, 1976), in the sense that they predict secure infant attachment outcomes at one year, and others are experienced as disturbing, predicting insecure attachment.

The idea for the vocal rhythm study presented in this article came from adult work by Jaffe and Feldstein (1970). Twenty-four unacquainted Barnard students were divided into six quartets. Members of each quartet recorded dialogues with each other for half an hour, on topics of their own choosing, in a round-robin design. The whole design was repeated eight times, each recording scheduled a day apart. Over the course of a conversation, these women came to match each other's pause durations. The more any pair correlated, the more they later reported experiencing each other as warm, similar, and someone they would invite to dinner. We have argued that interpersonal attraction and empathy, as in choosing a lover or a therapist, are associated with similarities in the timing of communicative behavior (Beebe, Jaffe, Feldstein, Mays, & Alson, 1985; Beebe et al., 1992; Crown, 1991; Feldstein & Welkowitz, 1978; Jaffe & Anderson, 1979).

One of the most startling findings of our research over the past decade is that the timing of preverbal dialogues (both vocal and kinesic) is remarkably similar to the timing of adult verbal dialogue. For example, both tend to be bi-directionally coordinated. In fact, infant-adult coordination is even more tightly contingent than that of adult partners (see Jaffe et al., 1999). In addition, the regulation of the turn exchange by coordinating the duration of the switching pause is similar in both (see Beebe, Alson, Jaffe, Feldstein, & Crown, 1988). This coordination of the switching pause duration is the major way in which each partner knows when it is their turn. Too short a switching pause in adult conversation is experienced as rudeness; too long a switching pause as being "out of it." Thus the coordination of timing in infancy is the *scaffolding*, the melody, on which verbal content is later superimposed: we are learning *how* to converse before we have words (Bloom, 1993). We are learning when to vocalize, when to pause, and for how long; we are learning whose turn it is, when to join in simultaneously (coactive speech), and how to exchange turns. This coordination of timing patterns operates through *expectancies*: the anticipation of the partner's pattern in relation to one's own. Learning the regulation of timing patterns constitutes learning nonverbal ways of *being with* the partner (see Stern, 1977, 1985).

The similarity of patterns of timing coordination between preverbal and verbal dialogues argues for a concept of vocal timing as a "life-span" measure. This work provides a lifespan model of how the nonverbal aspect of communication works, in terms of patterns of interactive regulation. The fact that different patterns of vocal timing coordination predict different emotional climates, as indexed by different attachment outcomes, argues for the particular relevance of this work to psychoanalysis. It can be useful to analysts both in conceptualizing the emotional climates of their patients as children, and in conceptualizing one aspect of the way in which the analytic climate is dyadically constructed.

DIMENSIONS OF A DYADIC SYSTEMS MODEL

Communication is viewed as process, a continuous, moment-to-moment interactive sequence. Moment-to-moment variation is fundamental to communication: it provides an essential means of sensing the partner. Moment-to-moment process can be considered the smallest unit, nested within larger units that are more prolonged, such as "moods." Many approaches to psychological development treat moment-to-moment fluctuations as noise, or measurement error (Wolff, 1991). Instead, by shifting the lens to process, ongoing patterning over time is highlighted. In the history of psychoanalysis, this approach has been most evident in the careful tracking of the patient's process of associations. In the study of vocal rhythm coordination, however, what is carefully tracked over time is the interactive process, and particularly small ongoing variations in the durations of sound and silence. As we will see below, inner process is equally important (see Beebe & Lachmann, 1998).

Interaction is viewed as bi-directional. Within a dyad, there is a strong tendency for contingencies to flow in both directions, so that for example, the mother influences the infant and the infant influences the mother. Influence is defined in terms of probabilities that one person's behavioral stream can be predicted from that of the partner. Both partners experience influencing and being influenced, to varying degrees. We are using the terms contingency, coordination, and influence interchangeably, all operationally defined by time-series analysis (see Gottman, 1981). The Celia interaction, described in detail below, strikingly illustrates how active the infant can be in shaping the exchange. In translating the bi-directional model for psychoanalysis, it is important that we focus on *both* the patient's experience of being influenced by the analyst, as well as the patient's experience of influencing the analyst. Similarly, the bi-directional model gives equal weight to the analyst's experience of being influenced by the patient, as well as the the analyst's experience of influencing the patient. Because all our dialogic measures are defined symmetrically, the difference in roles can be quantified.

Interactive exchanges are a product of the integration of self- and mutual regulation processes. A theory of interaction must specify how each person is affected both by his own behavior, that is, self-regulation, as well as by the partner's behavior, that is, interactive regulation (Thomas & Martin, 1976; Thomas & Malone, 1979). Whereas bi-directional influences characterize the interactive process between two people, the integration of self and interactive regulation occurs within each person. Self- and interactive regulation are concurrent and reciprocal processes, each one affecting the success of the other (Gianino & Tronick, 1988). Fogel (1992b) beautifully described this system as *co-regulation*: all behavior is simultaneously unfolding in the individual while at the same time continuously modifying and being modified by the changing behavior of the partner.

Our method of evaluating interactive contingencies, time-series analysis, disembeds two different sources of variance in an interaction: (1) a person's sensitivity to his own prior behavior, that is, the degree to which a prior behavior influences the current behavior, termed "auto-correlation," a form of self-regulation; and (2) a person's sensitivity to the partner's prior behavior, that is, the degree to which the partner's prior behavior influences the person's current behavior, termed "cross-correlation," a form of interactive regulation. This latter dimension picks up consistently occurring moment-to-moment adjustments that each individual makes in response to changes in the partner's behavior. The time-series approach does not assess an individual's self-regulation as if he were in isolation, and thus does not address whether each partner brings something "independent" to the interaction. Instead, it assesses two aspects of how the interaction works: first, *within* the dyadic context, how much of the variance is attributable to each individual's self-regulation, and second, over and above the two partners' self-regulation, how the two partners affect each other.

This key role of self regulation in the mutual regulation exchange has been extensively described by Sander (1977, 1985, 1995). In his view, the infant is not seen as *activated* by the mother; instead, the infant brings primary endogenous activity, which must be coordinated with the partner (who also brings endogenous rhythms). One basic function of the brain is to process information, to detect pattern and order (see Basch, 1977; Schore, 1994). The infant has *intrinsic* motivation to order information, and is biologically prepared to engage in activity to stimulate his own brain. He is self-motivated to detect regularity, generate expectancies, and to act on these expectancies (Haith, Hazan, & Goodman, 1988). According to Sander (1995, p. 588), "the requirement that the infant as a living organism be self-regulating and self-organizing necessitates recognition in the system of the agency of the infant to initiate action toward these ends . . ." setting the stage for the "sense of the self as agent."

There is a potentially serious misunderstanding of "relational" and "systems" models in current psychoanalytic critiques. For example, Wilson (1995) critiques the relational mind as tilting too far toward environmental influences, one "enslaved by the environment," and insufficiently integrated with endogenous influences. However, in a systems model, every interaction pattern is co-constructed by both people, both in terms of how they influence each other, and in terms of the self-regulatory range and style, and previously established expectancies, that each brings. In the adult, this self regulation includes symbolic elaboration, fantasy, and projection. Inner process is organized by both self regulation and interactive regulation.

Patterns of expectation are generated by both partners. Patterns of expectation are constructed through the sequence of one's own actions in relation to that of the partner, and an associated self-regulatory range and style. This is one definition of "procedural knowledge" of the social environment. In previous work, we have used patterns of expectation to define presymbolic representation in the first year (Beebe et al., 1997; Beebe & Lachmann, 1988a&b, 1994; Beebe & Stern, 1977; see also Stern, 1977, 1985). Beebe and Lachmann (1994) identified three general patterns of expectation in infancy, three "principles of salience": ongoing regulations, disruption and repair of these regulations, and heightened affective moments. These three principles were also applied to an adult psychoanalytic treatment (Lachmann & Beebe, 1996). All three are visible in the two videotaped interactions that will be described below to illustrate vocal rhythm coordination. Although patterns of expectation are generated through time, space, affect, and arousal, in this study we illustrate only the timing dimension.

An example of disruption and repair occurs in the interaction of 12-month-old Celia and a stranger. [Quote from first author's notes]:

> "During the later portion of the interaction, Celia has been having a marvelous dialogue with me. But, toward the end of the interaction there are many cycles of disruption and repair (see Beebe & Lachmann, 1994; Tronick, 1989). In order to avoid a separation reaction, she was seated in her mother's lap. As she began to get tired, she arched away into her mother's body, and avoided me posturally and visually. But then she was able to keep coming back to me vis-a-vis, and to continue the rhythm of the vocal exchange. These movements away from me were her own self-regulatory efforts to manage her arousal within a comfortable range."

A systems model uses a constructivist view of perception and representation. This model addresses another potentially serious misunderstanding of relational and systems models. For example, Wilson (1995) argued that a theory of representation is not adequate to map the mind: that the use of representations alone will yield a model of the mind "enslaved as a mirror of nature". Wilson came to this conclusion because he used a "copy" theory of representation as a copy of the environment. This view derives from positivist, or "mechanistic" assumptions about the nature of perception. But a systems model uses "constructivist" assumptions of perception and representation. Contrary to the positivist assumption of a one-to-one correspondence between the world and what we perceive in it, in a constructivist view, there is no pure sensory event, independent of the "categories" we bring (see Kuhn, 1962; Lewis & Brooks, 1975; Reese & Overton, 1970). Examples of "categories" that the infant brings are perceptual preferences (see Bornstein, 1984), previously established expectancies and self-regulatory capacities. Thus, what we perceive and represent is a result of an interaction between the external world (the Kantian "sensuous manifold") and the categories we bring. We actively construct all information. Because we are always potentially re-organizing our representations, based on incoming information and past expectancies, our representations are in process rather than fixed.

This concept has been further developed by theorists of nonlinear dynamic systems, who conceptualize a mind that continuously re-assembles and "updates" its "maps," as a function of context and task (Fogel, 1992a,b; Freeman, 1987, 1991; Thelen & Smith, 1994; Tononi, Sporns, & Edelman, 1994). As we describe further below, this updating suggests that the concept of representations must radically change, to be reconceptualized as a continuously shifting process. We must therefore expand our concepts of bi-directional influence and co-construction to include the ideas of re-assembly and emergent organization. However the two partners are affecting each other, the patterning of this mutual influence changes a little on each sucessive encounter. Likewise, whatever the individual "brings" to an ongoing dyadic exchange, it is never exactly the same. In the hands of Thelen or Fogel, the concept of co-construction shifts to "co-assembly," pointing to the continuous transformational quality. Perhaps the term "co-creation" could cover these various meanings (see Beebe & McCrorie, 1999).

The role of context is critical to understanding how representations form, how the brain creates and updates its maps, how co-constructions re-assemble. The way behavior is organized, and the way two people co-construct their dyadic process, is very sensitive to context. But it is not possible to observe these variations unless contexts are altered. The data on vocal rhythm coordination that we present below show fascinating context sensitivities as a function of home vs. lab interactions, and the particular partner configuration. Thelen argued that it is context-sensitivity which allows behavior its enormous flexibility and allows for the possibility of change. She proposed that a representation is not something we "have" but something we assemble and re-assemble in the moment, according to context and task (Thelen & Smith, 1994). Psychoanalysis must translate the notion of context into its own terms, identifying its own critical contexts, for example, separations and reunions, disruptions and their repair, moments of shifting organization of affect, spatial orientation, or timing.

We distinguish between a symbolic representational level (discrete, categorical, declarative) and a perception-action level (nonsymbolic, continuous, implicit, procedural) in the organization of social behavior, and integrate the two. In previous work, we (Beebe & Lachmann, 1988a&b, 1994; Beebe, Lachmann, & Jaffe, 1997) have referred to the perception-action level in infancy as a sensory-motor form of "presymbolic representation." This form of representation can also be conceptualized as organized through implicit memory, procedural and emotional. A considerable literature articulates the infant's capacity for representation of action sequences and asociated emotions in a presymbolic, procedural mode (Emde, Biringen, Clyman, & Oppenheim,1991; Fagen, Morrongiello, Rovee-Collier, & Gekoski, 1984; Meltzoff, 1985; Meltzoff & Gopnik, 1993; Shields & Rovee-Collier, 1992; Stern, 1985, 1994). Whereas explicit (declarative) memory refers to symbolically organized recall for information and events, implicit includes emotional and procedural memory that is out of awareness. Procedural memory refers to skills or action sequences that are encoded nonsymbolically, become automatic with repeated practice, and influence the organizational processes which guide behavior (Emde et al., 1991; Grigsby & Hartlaub, 1994). The explicit and implicit memory systems are potentially dissociable. In adults, procedural memories are content-free, in the sense that they entail the learning of processes rather than information (Grigsby & Hartlaub, 1994). Four-month-old infants detect regularity in spatiotemporal events in their environment (Haith et al., 1988) and develop expectancies based on those events, implying some future-oriented mental process (DeCasper & Carstens, 1981; Fagen et al., 1984; Haith et al., 1988).

In a strict representational view, it is the symbolic (declarative) representations of other persons, their behavior, and their relationships to self, that guide social behavior (Newtson, 1990). This strict representational view is the traditional working assumption of most psychoanalysts. In contrast, a perception-action or "procedural" view argues that the control of social behavior is largely out of awareness, and lies in the organism-environment relation, such that the information sufficient to structure action is inherently present in the organism-environment relation (Fogel, 1992a; 1993; Gibson, 1979; Lewin, 1937; Newtson, 1990). This latter view is compatible with that of Thelen and Smith, (1994). In this latter view, actions contain information as an objective property, rather than viewing information as having no psychological reality until it is represented. The perception-action view sees actions as dynamical systems, as products of a dynamic organism-environment interaction, which is in continuous moment-by-moment re-organization, highly responsive to context (Newtson, 1990; Thelen & Smith, 1994). It is at this level that social behavior is regulated or coordinated on a split-second, moment-by-moment basis, largely out of awareness. The rapidity and density of information does not allow central cognitive control (Bernstein, 1976; Newtson, 1990).

Nevertheless, the information of the perception-action system can be symbolically represented, and herein lies the integration of the two levels of the organization of social behavior. We see these two levels as continuously affecting each other: the struggle to symbolize the perception-action level can be seen as one of the major goals of psychoanalysis (Bucci, 1985, 1997), and the nature of the symbolization can then potentially affect the perception-action level (see Beebe & Lachmann, 1998).

Bucci (1985, 1997) has also discussed the relationship between the action-perception and representation levels. She enriches the perception-action level by distinguishing two modes within it: a continuous, "subsymbolic" mode of processing and a nonverbal, presymbolic, but nevertheless categorical mode. Both of these modes are distinct from the symbolic mode of discrete categorized entities. The subsymbolic is based on sensory, visceral, somatic experiences which are "continuous" in the sense that infinite variations and gradations (such as the perception of continuously changing nuances of facial expressions) are encompassed. This is a lifelong mode of experience, usually out of awareness. Prior to symbolization, infants can also categorize events, objects, animals, spatial arrangements, patterns (see Bornstein, 1984; Bornstein & Sigman, 1986; Younger & Gotlieb, 1988), which is a nonverbal, but nevertheless categorical form of information processing, in which the continuous gradients of experience are "chunked" into discrete prototypic images. It is in this mode that Bucci believes we form "emotion schemas", similar to Stern's (1985) categorical "RIGS" (representations of interactions generalized), or Beebe and Lachmann's (1988b, 1994; Beebe, Lachmann, & Jaffe, 1997) "interaction structures". Bucci (1997) argues that the transformation of the continuous process into nonverbal categories provides the ultimate link to the symbolic mode.

The study of vocal rhythm presented below, an example of this perception-action, procedural level of social coordination, demonstrates that information flow between two partners (infant-adult or adult-adult) is significantly coupled. Recent reanalysis of our vocal data by Newtson (1993) characterized vocal turntaking as a behavioral wave flowing through the dyad, oscillating from one person's turn to the other, suggesting that our data supports the idea that ". . . interactants form a single unifed system . . ."

A systems model offers a perturbation theory of change based on transformation of patterns. Here we draw on Thelen and Smith's (l994) description of an optimal, flexible, open system as very variable. This variability is a source of new forms. If a system is flexible and variable, a perturbation can shake up old forms and shift the system into a new pattern. To illustrate from the interaction between 12-month-old Celia and the first author, [another quote from first author's notes]: "In the opening phase of the interaction with Celia at 12 months, I initially had a great deal of difficulty engaging her. She spent most of her time throwing toys on the floor. Nothing I did seemed to catch her interest or involvement. After about five minutes, however, she happened to make a "spit" sound, the first sound she uttered. I imitated it immediately. Suddenly, I had her attention. She offered another spit sound, and this time I roughly matched it, and then slightly elaborated it. She then offered her own elaboration, and we slowly moved into a vocal dialogue, which gradually took on increasingly rich and evocative variations." This stranger-infant interaction illustrates the dynamic systems idea that in an open, flexible system, a chance variation or perturbation can shift the system from one semi-stable pattern (attractor) into another.

THE DATA OF MOTHER-INFANT VOCAL RHYTHM COORDINATION AND THE PREDICTION OF ATTACHMENT

A study of vocal rhythm coordination evaluated 82 dyads at four and twelve months (Jaffe et al., 1999). When the infants were four months, face-to-face interactions between mother-infant, stranger-infant, and mother-stranger were recorded in the home. Fifty-three of these dyads were also seen in the lab, in the same three partner configurations. Bi-directional contingencies of vocal rhythm were used to predict infant attachment at 12 months (Ainsworth Strange Situation).

Definitions of Vocal States

The vocal states assessed were vocalizations, pauses, and switching pauses, illustrated in Figure 1. A turn rule is used to parse the dialogue into the vocal states of the two partners. A turn begins at the instant that either partner vocalizes alone, and it is held until the other partner vocalizes alone, at which point there is a speaker switch. A vocalization belongs to the partner who has the turn. A pause is a joint silence bounded by the vocalizations of the speaker who has the turn. A switching pause is a joint silence initiated by the speaker who has the turn, and terminated by a unilateral vocalization of the partner, who thereby gains the turn. For the purposes of this study we did not analyze simultaneous speech.

Vocal Rhythm Coordination at Four Months is Bi-Directional

Using time-series analysis to evaluate moment-to-moment interactive contingencies, our results showed a predominantly bi- directional system when the infants are four months (bidirectional is indicated by, for example, M $\leftrightarrow$ I; unidirectional by M $\rightarrow$ I or I $\rightarrow$ M). We evaluated a total of approximately 400 sessions of mother-infant, stranger-infant, and mother-stranger interactions, in the home and the lab, at 4 months. Based on an assessment of the patterns of influence *within each dyad*, there was a strong tendency for each partner to coordinate with (to be contingent upon) the other. However, the percent of dyads showing this bi-directionality varied dramatically with context.

The Importance of Context

Observation of behavior under uniform conditions elicits a restricted set of behavioral capacities (Thelen & Smith, 1994). Novelty and variation elicits a greater range of capabilities. In this study, we introduced novelty for the infant by varying the "contexts" of home/lab site and partner configuration (mother-infant, stranger-infant). We asked how the rhythmic structure of dialogue varied across these contexts which are everyday events in an infant's life. A remarkable sensitivity and flexibility of vocal rhythms was detected which organized around these interpersonal "contexts." The percent of dyads showing bi-directional contingent coordination of vocal rhythms at four months increased in a hierarchy (of constant linear increments)

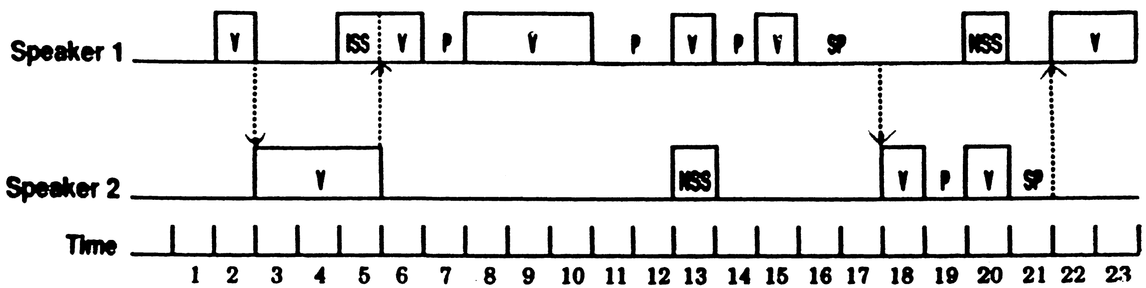

FIGURE 1. A diagrammatic representation of an interactional sequence. The number line at the bottom represents time in 250-msec. units. V, vocalization; P, pause; SP, switching pause; NSS, noninterruptive simultaneous speech; ISS, interruptive simultaneous speech. The arrows that point down denote the end of speaker 1's turns; those that point up denote the end of speaker 2's turns.

as a function of increasing novelty, or challenge, as the context varied from the most familiar situation of mother-infant at home, to the least familiar situation of stranger-infant in the lab.

Matching

Matching is not a good metaphor for vocal rhythm coordination at four months. Because the tendency for dyadic coupling (coordination) to be bi-directional systematically increased with these increments of novelty, vocal rhythm coordination was not well characterized by metaphors such as "matching," "attunement," or relatedness. An additional quality of "coping," possibly defensive, must be included. Degree of novelty or uncertainty alters the arousal level of each partner. We interpreted degree of bi-directional coordination as an index of the degree to which the two partners were making the interaction predictable. Heightened predictability is necessary under conditions of heightened arousal. The greater the degree of uncertainty, novelty, or challenge, the greater the need to make the interaction predictable. Thus, even with the same partner, we couple more tightly or more loosely, depending on context. Thelen and Smith (l994) proposed a generative theory of behavior in which each occurrence of a behavior is assembled anew to fit changing demands of task and context. Context sensitivity is what allows for the tremendous flexibility of behavior to reorganize.

12-Month Attachment Classifications

Using the Ainsworth (Ainsworth, Blehar, Waters, & Wall, 1978) attachment test based on separation and reunion with mother in the lab, the following infant classifications are defined at 12 months: avoidant infant attachment (A); secure (B); anxious-resistant (C); and disorganized (D).

The B infant in the Strange Situation can easily be comforted by mother and return to play, showing the optimum balance between being able to use mother as a secure base, and being able to explore the environment. The A infant shows little distress during separation from the mother, and avoids mother at reunion, turning away and refusing contact before returning to play. These infants have been described as minimizing responsiveness to fear by an organized shift of attention away from mother, toward the inanimate environment (Cassidy, 1994; Main & Hesse, l992). C infants respond to the separation from mother with great distress, but are unable to be comforted by her return, and cannot easily return to play, remaining preoccupied with mother (Main & Hesse (l992).

When the attachment figure herself becomes frightening, none of the B, A, or C patterns of organization are consistently sustained. Whereas the B infant tracks shifts in caregiver location, the A infant shifts attention away from the mother, and the C infant shifts attention toward the mother, the D fails to exhibit a consistent pattern, and instead shows moments of "disorganization" (Main & Hesse, 1992). The D infant can be described as "in conflict" in the ethological sense of simultaneous activation of incompatible behavioral systems, both approaching and avoiding the mother, by contradictory behaviors such as opening the door for the mother at the reunion, and then sharply ignoring her. Because it is not possible to both approach and flee, many of these infants compromise by "freezing," "stilling," falling prone to the floor, or becoming "dazed" with blank stares or glazed, half-open eyes. Some infants exhibit apprehensive behaviors such as fearful facial expressions, oblique approaches, or vigilant postures (Lyons-Ruth, 1998; Main & Hesse, l992). The highest cortisol levels among insecure infants have been documented in the D infant (Spangler & Grossman, l993).

Vocal rhythm coordination at 4 months predicted infant attachment at 12 months. Predictions of attachment derived from all three dyad configurations at 4 months: mother-infant, stranger-infant, and mother-stranger. The findings further articulate why matching is not the right metaphor. Totally contrary to the idea that the highest degree of rhythm coordination would index the most well "matched" or well "related" dyads, the highest degree of vocal rhythm coordination predicted the most insecure infant attachments (disorganized and anxious-resistant), whereas the lowest degree of coordination predicted the avoidant. Thus, a midrange degree of coordination predicted secure attachment (B), and the high or low ends of the continuum of coordination predicted the insecure attachment classifications. Figure 2 illustrates this continuum of low, mid-range, and high coordination, in relation to attachment outcomes. We conceptualize the mid-range as optimum flexibility and variability, the low end as relative inhibition of engagement, and high end as vigilance.

Different patterns of vocal rhythm coordination at 4 months create different emotional climates. Because different degrees of vocal rhythm coordination predicted different patterns of attachment, we construe patterns of rhythmic coordination as ways of defining emotional climates, or different ways of "being with" the other, at four months. Thus, from vocal rhythms alone, complex patterns of interactive regulation can be differentiated. They powerfully predict one year attachment outcomes. Patterns of vocal rhythms organize the infant's experience of relatedness, and his development.

Different patterns of expectation of the coordination of vocal rhythms constitute one key aspect of the infant's presymbolic representation of self-in-relation-to-other (see Beebe & Stern, 1977; Beebe, Lachmann & Jaffe, 1997; Stern, 1985). Arnold Modell (l992) suggested that these preverbal interaction patterns form the basis of "nonconscious" memory structures. We emphasize that these patterns which are organized at the action perception (procedural) level are continuously being generated, "re-assembled," so that the nature of these presymbolic representations is in no way fixed or static. They are potentially open to continuous transformation.

Ernst Schactel (1959) hypothesized that the phenomenon of infantile amnesia is attributable to the fact that infantile experience is coded in a presymbolic mode that is not accessible once symbolic functioning develops. Neuroscientists have subsequently presented evidence for this mechanism in the phenomenon of procedural memory (Emde et al., 1991; Grigsby & Hartlaub, 1994). Because the details of our vocal timing codes predict later attachment types despite being similarly out of awareness, perhaps we have described an example of the behavioral code to which Schactel referred.

Optimum mid-range coordination of vocal rhythms is critical for attachment. A high degree of vocal rhythm coordination was our most salient risk factor for insecure infant attachment. We interpreted this high coordination as over-monitoring, indicating wariness or vigilance. At four months it may already be an attempt to counteract some disturbance in the interaction. We use nonlinear dynamic systems theory to interpret this high degree of rhythm coordination. In this theory, rigidity is one hallmark of pathology. The optimal, open system is more variable, more flexible, which is one way of describing the secure (B) attachment type. A very tightly coupled, highly predictable system is one where there is less flexibility, characteristic of the anxious-resistant (C) and disorganized (D) in our data. Similarly, at the other end of the continuum, too little predictability in the system may not provide enough coherence. This pattern was characteristic of the avoidant attachment (A) in our data. Insecure attachment outcomes were thus predicted from both the high and low ends of the continuum.

In mid-range coordination, there is both interpersonal coordination and correspondence in the dyad, and more room for uncertainty, variability, and unique initiative momentarily uncoupled from the dyad. This variability can be translated into the concept of "playfulness,"

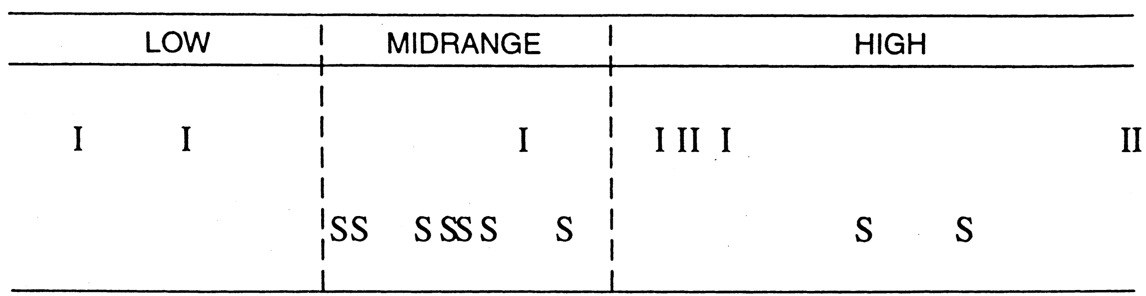

FIGURE 2. Rank ordering of low, midrange, and high vocal rhythm coordination ranges, yielding significant 12 month attachment predictions of secure (S) and insecure (I: A, C, D).

critical in mother-infant as well as analyst-patient interactions, and is illustrated by the Ceici interaction. Mid-range coordination provides the dyad more fluidity across the range of values, with more capacity to locate the varying partner. Flexibility across the range is the key issue.

Sander (1977) originally described the task of the mother-infant exchange as one of "co-ordination". We have come to endorse this metaphor as the most powerful in describing our data. Furthermore, the capacity of the dyad to be more "loosely coupled" has been continuously emphasized in Sander's writing (1977, 1985), as critical to the development of forms of self-regulation, such as being alone in the presence of the other, and agency. Sander (1995) has described the rigid coupling of less well functioning mother-infant dyads, such that any disruption shatters the system. An analogous concept can also be found in Stern's (1971) description of the difference in interactive regulation between a mother and her dyzygotic twins. The interaction between mother and Fred had an approach-avoid spatial organization with split-second bi-directional contingencies, and mother and Fred never became 'uncoupled' in time. Mother and Mark had an approach-approach pattern, and when either turned away, they both became uncoupled in time. This system between mother and Mark can be conceptualized as more loosely coupled than that between mother and Fred (First, 1998).

Revision of the Mutual Regulation Model

The field of micro-analysis of mother-infant face-to-face interaction began in approximately 1970 (Brazelton, Kozlowski, & Main, 1974; Stern, 1971; Trevarthen, 1974). Child development research at that time was undergoing a major theoretical shift from a "one-way influence model" (the parent affects or molds the child) to a bi-directional model of interactive exchange (see Bell, 1968; Lewis & Rosenblum, 1974; Thomas & Martin, 1976). In the days when we were heady with the increasing abilty to document the very existence of bi-directional contingencies in mother-infant interaction, we thought of bi-directional regulation per se as the hallmark of an optimal developmental process. We had expected that the very presence of a bi-directional pattern per dyad in the four month vocal rhythm data would predict the more secure attachments. But there were no significant differences in relative preponderance of bi-directional influences in the four attachment classifications.

Now we must refine the mutual regulation model in relation to the prediction of attachment. The presence of a bi-directional regulation process alone does not help us differentiate risk patterns in our data. At four months, all four attachment classifications showed relatively similar bi-directional influences, assessed per dyad. Instead, *degree* of coordination (influence) predicted 12 month attachment. Mutual regulation can be excessive, because the highest degrees of coordination predicted the most risk (anxious-resistant and disorganized attachment), or inhibited (illustrated by the avoidant infants). These predictions were based on mother's (and/or stranger's) coordination with infant, the infant's coordination with mother (and/or stranger), as well as the mother's coordination with the stranger (see Jaffe et al., 1999).

We conceptualize a systems model of pathology as a relative balance between simultaneous interactive regulation and self regulation (see also Beebe & McCrorie, 1999; Tronick, 1989). In an optimal system there is a shifting foreground/background balance, with maximum flexibility to shift back and forth, as to which is more salient. A loss of flexibility at either pole defines pathology. One pole is defined by excessively high coordination, as exemplified especially in the disorganized attachment pattern. We hypothesize that these infants compromise their access to the monitoring of inner state (Sander, 1977, 1985). At the other pole, described by Tronick (l989) in the study of maternal depression, infants withdraw into a preoccupation with the self-regulation of distress states, following the failure of the mutual regulation exchange. Similarly, the Avoidant attachment infants in this sample, who used extremely low degrees of coordination, have been shown by Koulomzin (Koulomzin, Beebe, Jaffe, & Feldstein, 1993) to look less at the mother, and to use self-comfort strategies (self-touch, finger strap or clothing) far more than the secure.

INTEGRATION OF THE ACTION-PERCEPTION (PROCEDURAL) AND SYMBOLIC-NARRATIVE LEVELS

The research on vocal rhythm coordination in infancy illustrates the action-perception, procedural level of organization. One approach to an integration with the symbolic level derives from research on the adult's attachment history, based on the in-depth interview of Main and Goldwyn's (1988, 1993) "Adult Attachment Interview" (AAI). Each of the infant attachment classifications has a comparable adult category. Actual degree of difficulty in childhood is not the determining factor for the assessment of adult security using the AAI; rather, the logical coherence and integration of the narrative is the key criterion.

Fonagy, Steele, and Steele (1991) showed that the AAI given to mothers during their pregnancy predicted the infant's own attachment classification at 12 months. Fonagy et al. thus predicted from the coherence of the mother's symbolic narrative prior to the infant's birth, to the infant's and mother's action-perception level of organization in the separation-reunion test when the infant was 12 months. Other work has also shown correlations between adult and infant attachment types (Benoit & Parker, l994; Main & Hesse, l990; Main, Kaplan, & Cassidy, l985; Radojevic, l992; Ward & Carlson, l995). Our data in the vocal rhythm study was limited to infant attachment outcomes, without AAI data on the mothers. Nevertheless, on the basis of the correlations in the literature, we suggest that our secure infants were likely to have had secure mothers, and likewise the insecure infants, insecure mothers.

Combining our results with the AAI literature, a parallel is suggested between the coherence of the AAI narrative and the consistency of the pattern of vocal rhythm coordination observed among the mother-infant, stranger-infant, and mother-stranger dyads. The following parallels characterize the secure (B = 55) and insecure (A = 16 & D = 7) categories (we omit the C because the mother did not appear in the prediction, which was based on the stranger-infant interaction).

The secure mother typically has a coherent narrative, so that her examples from her childhood history illustrate her assertions about her development. In our vocal rhythm data, both she and her baby (M $\leftrightarrow$ I) were midrange coordinators with each other. Likewise, stranger and infant (S $\leftrightarrow$ I), and mother and stranger (S $\rightarrow$ M) were also midrange coordinators. Thus, coherent narrative in AAI, at the symbolic level, goes with a consistent pattern of coordination among our three partner configurations, at the procedural level.

The narrative of the avoidant mother is typically dismissive of attachment. In the vocal rhythm data, her baby showed low coordination with stranger (S $\rightarrow$ I). However, she herself showed high coordination with the same stranger (S $\rightarrow$ M). Here we see an inconsistent pattern of coordination in the partner configurations of S-I and M-S. Thus incoherence of narrative at the symbolic level goes with inconsistency of coordination patterns among partners at the procedural level. Here the inconsistency at the procedural level is within the mother-infant dyad, in the sense that mother and infant coordinate at opposite extremes with the same person.

The disorganized mother lacks coherence in her narrative, has lapses in reasoning, and has a history of unresolved trauma or loss. In our vocal rhythm data, both mother and infant were high coordinators with each other (M $\leftrightarrow$ I). However, mother was an extremely low tracker of the stranger (S $\rightarrow$ M). Here we see incoherence of narrative at the symbolic level, and inconsistency of pattern of coordination among the partner configurations of M-I and M-S at the procedural level. This inconsistency is also seen within the mother herself: the disorganized mother is a very high coordinator with her infant and a very low coordinator with the stranger. At the narrative level, the disorganized mother can be seen as suffering from unresolved loss or trauma, and she relies on dissociative defenses (Main & Hesse, 1992). Conceptualizing the stranger in the vocal rhythm study as somewhat comparable to the interviewer in the AAI, the mother reacts to the adult interviewer with dissociation at the narrative level, and to the stranger with inhibited coordination at the procedural level.

Although incoherence of the narrative interview and inconsistency of patterns of rhythm coordination across different partners are rather different kinds of inconsistencies, nevertheless the parallels are striking and suggest intriguing relationships between procedural and narrative levels of functioning. This may be one central way that psychoanalysis works: the verbal narrative accesses aspects (here, the dyadic rhythms) of the patient's earlier procedural organization.

CONTRIBUTIONS OF NONLINEAR DYNAMIC SYSTEMS THEORY

To this point we have relied on a version of systems theory that was introduced into infant research by Louis Sander, and elaborated by Beebe et al. (1992), Sameroff, (1983), Stern (1971, 1977), Tronick (1989), among others. Now we turn to another version of systems theory, nonlinear dynamic systems. Although there are many sources for these ideas, we draw primarily from the work of Thelen and Smith (1994) and Fogel (1992a,b, 1993). These systems concepts can further enrich as well as alter some of the central concepts in psychoanalysis:

(1) a redefinintion of psychopathology: the flexible mid-range as a definition of optimal, with pathology at either end of the range, which we illustrate with our findings on vocal rhythm and attachment;

(2) a perturbation theory of change, which we illustrate with the videotaped interaction of a rich vocal rhythm dialogue between12-month-old Celia and the first author;

(3) an interactive model of how the brain perceives, contributing to an "interactive model of mind."

Redefinitions of Psychopathology

Nonlinear dynamic systems theory was pivotal in the interpretation of our finding that mid-range coordination predicted secure attachment, leading us to conceptualize an optimum, mid-range degree of interpersonal coordination. To interpret our finding that the highest coordination predicted the most insecure attachment (anxious-resistant and disorganized), we drew on concepts from nonlinear dynamic systems theory indicating that rigdidity is one hallmark of pathology. We thus proposed that our highest rhythm coordination was an index of loss of flexibilty, such that the system had become too tightly coupled. These mothers and infants were too "hooked in", too vigilant, too predictable (contingently responsive), presumably as a way of coping with stress or threat (Main & Hesse, 1990, 1992; Moore, 1994). At the very low end where coordination was low or inhibited, the two partners were acting relatively independently of each other (too loosely coupled). We inferred that the dyadic system had lost its coherence and the partners became too variable in relation to each other.

The concept of optimal midrange coordination of vocal rhythms, which predicted secure attachment, is enhanced by an analogous process identified in research on rhythmic communication between sets of neurons in the forebrain. Tononi et al. (1994) used a measure of complexity that indicated how information was transmitted in a system of neural networks, by computer simulation. If two subsets (populations) of neurons were relatively independent, the measurement of complexity was low, indicating relatively little information transmission. If the subsets were highly dependent, complexity was also low, because they were all doing approximately the same thing. But if connectivity was midrange, the complexity measure was highest, indicating the maximal transmission of information. By analogy, the Tononi et al. finding suggests one conceivable mechanism for explaining why midrange rhythmic coupling might be optimal for certain aspects of social communication, in this case, attachment security. That is, the transmission of information is optimal with midrange coupling of rhythms.

A Perturbation Theory of Change

Dynamic systems theorists pose the question, how do complex, self-organizing, open systems create patterns and change patterns? What would move a system out of a temporarily stable state? Why would a system become more variable and more open and responsive to perturbations? These are the premier developmental questions (see Thelen & Smith, 1994), but they are equally critical for psychoanalysis, which is similarly concerned with individual's development and change, and mechanisms of therapeutic action.

Dynamic systems theory begins with the assumption that all action and knowledge is process: patterns of activity in time arise in a certain context, inherently dynamic and changeable (see Thelen & Smith, 1994, Thelen, 1995, 1998). Development is conceptualized as a series of patterns of changing stability and instability. Some patterns are fairly stable in certain contexts, and others are unstable, easily disrupted, as a function of history, current status, context and task. In an optimally open system, there is a continual flow of information in and out, with the creation of temporarily stable patterns. But because an open system is flexible, and variable, it is open to exploration, and responsive to perturbations with new solutions. *Variability is a source of new forms.* For a pattern to change, some part of the system must disrupt the current stable pattern. New patterns then form, as emergent properties of the system. These patterns are nonlinear: they cannot be predicted from what went before. When components are not too tightly coordinated, the system can explore and change. However, when coordination is too tight, it is harder for the system to shift and to explore new solutions. In this case, if the system is perturbed, variability can emerge, and the overly stable patterns can be pulled apart. In the study of vocal rhythm coordination, the tightest coupling was seen in the most insecurely organized attachments (anxious-resistant and disorganized), and presumably the tightly coupled dyads lose variability and flexibility.

Using the well-known "A not B" error in Piagetian cognitive testing, Thelen (1996) gave an example of loss of flexibility, where an overly tightly coupled system loses variability and becomes "stuck". A system that cannot explore new cooperative solutions is one definition of pathology. In this testing, the experimenter hides an object on the infant's left side (A). The infant becomes accustomed to looking for it there. Then the experimenter hides it on the right side (B). But the baby is "stuck" in looking for the object in A. How did the infant get stuck, and how can she become "unstuck"? Adaptive behavior requires a balance between stability and change (flexibility). Thelen demonstrated that by changing the particular conditions of the experiment, this error no longer occurred. She increased the visual distinctness of the target, and decreased the delay between hiding the object and the infant's reaching for it. Thelen noted that traditionally discussions of the "A not B" error have focused on what the infant either had or did not have in her head, as a trait, capacity, representation, or deficit. Instead, Thelen focused on what the infant is doing, has done, and could do, if the context of the task were slightly changed, emphasizing action and action history. Thus, in Thelen's view, variability is the source of new forms. If the system is too stable, it cannot explore new solutions. When Thelen disrupted the infant's habit (of looking at A not B), perturbing the system to introduce variability, then the system could shift.

These ideas hold the promise of influencing our concepts of representation, as well as health and pathology. They contain a perturbation theory of transformation of pattern that can enrich psychoanalytic concepts of modes of therapeutic action. Much further exploration would be required to explicate the poles of the continuum where pathology lies, as systems which are too stable or too unstable. Presumably trauma interferes with the variability and flexiblity of the open system. But, assuming the system remains open and flexible, the "perturbation theory of change" can be a powerful model. Thelen & Smith (1994) have described an open system as "messy," variable, sensitive to different contexts, and capable of taking advantage of inherent fluctuations around temporarily stable patterns. These variations are the source of new patterns. At some point, fluctuations increase, and the variability of the system will amplify fluctuations. At a critical point, the system shifts. Systems can shift into new forms only if the system is sufficiently variable and flexible that perturbations can shake up old forms. The openness of the system leads to "preparedness" to pick up on perturbations. Change happens only when there is sufficient variability to explore options, and there is the opportunity to find new patterns. A small change can build on itself, exponentially, in a nonlinear way.

The videotaped vocal dialogue between the first author and Celia at 12 months can be used to illustrate the perturbation theory of change. We hypothesize that the first author's imitative elaboration of Celia's spit sound shifted the system from one relatively stable state (Celia throwing toys on the floor and impossible to engage) to a new relatively stable state of a rich and varying turntaking dialogue. The perturbation consisted of "echoing" Celia's spit sound in an elaborative imitation. The preparedness of the system can be found in the adult partner's readiness to coordinate vocal rhythms, to elaborate patterns, to experiment and to "play". The preparedness is equally found in Celia's responsivity to the coordinations, and her own willingness to elaborate on the jointly formed patterns, that is, to play as well. Celia was extremely active in initiating new forms of elaboration as the dialogue proceeded. The adult partner's vocal coordination and elaboration acted to re-organize the variability in the system, jolting the system into a new dyadic rhythm (Thelen, 1995).

An Interactive Model of Mind

Dynamic systems theory has a critical contribution to make to an interactive model of mind for psychoanalysis through its emphasis on the question of how the brain perceives, drawing on the work of Edelman (1987, 1992; Tononi et al., 1994), Freeman (1987, 1991) and others. Equal emphasis is placed on both sides of an interactive model: the brain influences behavior, but experience alters the brain. Tremendous neural diversity, with variability in sizes, shapes, types and connections of cells, ensures that every brain is different. Therefore the connections between cells, the "wiring", is dependent on experience (see Schore, 1994; Thelen & Smith, 1994). These connections among cells are continuously re-written, re-mapped, as a function of ongoing experience. One implication of this model is that there is no fixed schema or representation of a stimulus. The representation of a stimulus is always being updated, "reassembled", as a function of arousal level, context, experience.

An example of this process of updating can be found in research on how the brain of a rabbit creates a "map" of the smell of sawdust (Freeman, 1987, 1991; see also Thelen & Smith, 1994). EEG patterns were recorded from 60 sites all over the olfactory bulb. The identity of the sawdust odor was found in the pattern of amplitude of EEGs from all 60 sites. To study the updating process, the rabbit was then exposed to the smell of a banana. Then the same sawdust was returned, and EEG patterns were again recorded. It was found that the sawdust "map" had changed, had been modified, as a function of the interposed banana smell. Presumably this same process could be demonstrated if the stimulus were another rabbit and a banana, or just another rabbit.

This kind of research suggests that the mind is inherently relational. It provides an interactive model of how the brain creates perceptions, maps, and how these maps are continually updated by experience. This work has tremendous implications for the nature of representations. Many theorists have emphasized the "process" rather than static nature of representations (Beebe & Stern, 1977; Beebe & Lachmann, 1988b, 1994; Fogel, 1992a,b; Stern, 1977, 1985, 1994; Werner, 1948; Piaget, 1954). However, in the hands of Thelen and Smith (1994), representations take on more of a purely process character, in the sense that they are continually updated as a function of experience. However, there are quasi-stable states of the system, modes or attractors which we would translate into the familiar concept of expectancies (repetitive sequences, procedural knowledge). This work provides a model for the transformation of representations, thus a model of therapeutic action for psychoanalysis. Nevertheless, much work is needed to explicate the conditions which interfere with the updating process. Presumably trauma substantially alters the flexibility of the brain to update perception and representation (see van der Kolk & Greenberg, 1987).

CONCLUSION: RELEVANCE OF SYSTEMS THEORIES FOR PSYCHOANALYSIS

Rhythm is a fundamental organizing principle of social communication. The work on vocal rhythm coordination in infancy has shown that many aspects of these rhythms can be coordinated in different ways, and to different degrees, to predict infant social outcomes. In adult conversation, aspects of these same rhythms have been shown to predict social adaptations such as perceived similarity, warmth, attraction, and empathy (Crown, 1991; Feldstein & Welkowitz, 1978; Jaffe & Feldstein, 1970).

Our work on vocal rhythm coordination in mother-infant, stranger-infant, and mother-stranger dyads (Jaffe et al., 1999) can be applied to the analytic dyad. We are not recommending a concrete translation, such that optimum coordination in psychoanalytic dyads should be in the midrange. Such questions await empirical research. Instead, we suggest that, out of awareness, analyst and patient do create different patterns of vocal rhythm coordination, continuously, moment-by-moment, organized at the perception-action (procedural) level. The perception-action coordination system is a central mode through which the patient comprehends the analyst, and vice-versa. Different patterns will contribute to different emotional climates, and potentially unconscious fantasies. By paying attention to the details of what either partner is doing at the action-perception level, each has a way of getting "in" to the other's experience. And each can further comprehend, question, and "deconstruct" (Slavin, 1998) the symbolic level through elaborations, alterations, or discrepancies at the perception-action level.

Our concepts of therapeutic action are shifted by this research. We are sensitized to look beyond the verbal content to the perception-action level of the interaction for a fuller understanding of the moment-by-moment relatedness being jointly constructed. In our illustration of vocal rhythm coordination, nonverbal temporal dimensions powerfully enhance or disturb the structure of relatedness. For example, the analyst's failure to participate in vocal rhythm coordination (through sounds, not necessarily words), may disturb the relatedness (which the analyst may or may not want to do). Any model of therapeutic action must include these issues.

Essentially, psychoanalysis needs a theory of interaction that integrates both verbal and nonverbal, explicit and implicit communication (see also Pally, 1998). We need to conceptualize how the nonverbal system (in time, space, affect and arousal), at the action-perception level, provides a continuous background to the regulation of the interaction at the declarative, symbolic level, where the verbal system is usually in the foreground. The organization of each potentially impacts on that of the other. Both the dyadic systems view of communication, and nonlinear dynamic systems theory are in a position to make an essential contribution to this endeavor. The distinction between the cognitive symbolic representational level and the perception-action or procedural level (see Bucci, 1985, 1997; Newtson, 1990; Thelen & Smith, 1994) provides a powerful way of conceptualizing the integration of these two modes of processing our experience. Psychoanalysis now has the challenge of using concepts from various systems theories to further conceptualize the perception-action level of transactions in psychoanalytic treatment, and their integration with the symbolic narrative.

Psychoanalysis itself is increasingly an "open" and changing field of ideas. One of the most exciting developments is that psychoanalysis is seeking a theory of interaction, essentially, a systems theory (see Beebe & Lachmann, 1998). Systems models conceptualize the relation of the individual to the dyadic interaction, for example in Sander's (1977, 1995) and Tronick's (1989, 1998) formulations of the intimate inter-relation between self- and mutual regulation, thus avoiding either of Wilson's extremes of a mind enslaved by the environment, or a mind enslaved by endogenous pressures. Systems models, particularly those developed in infant research on face-to-face interaction, conceptualize the complexity of the different patterns of the moment-by-moment dyadic interactive process, and their implications for affective climate and attachment security, in adults as well as children. This research also provides more subtle as well as more specific ways of talking about the adult patient's experience of disturbed parenting, for example, in terms of altered timing, extremes of interpersonal contingencies, or disturbed turn-taking. More adequate theories of change, such as Thelen's perturbation theory of change, and the contribution of nonverbal factors to therapeutic action (see Beebe & Lachmann, 1998; Clyman, 1991; Grigsby & Hartlaub, 1994; Kiersky & Beebe, 1994; Knoblauch, 1997; Lachmann & Beebe, 1996; Pally, 1998; Rustin, 1997; Sorter, 1994, 1996; Tronick et al., 1998) can potentially result from applying systems ideas to psychoanalysis. Finally, systems approaches can help us develop an interactive model of mind. Particularly the empirical research of Edelman, Freeman, Schore and others, on how the brain processes information and updates its maps or representations, points to an inherently "relational brain".

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