Early Socio-Emotional Development: Contingency Perception and the Social-Biofeedback Model

György Gergely
University College London

John S. Watson
University of California at Berkeley

The past century of theory about human development has placed much responsibility for normal socio-emotional development on the social interactions experienced in infancy (e.g., Bandura, 1992; Bowlby, 1969; Bruner, 1990; Freud, 1949; Skinner, 1948; Stern, 1985; Trevarthen, 1979; Watson, 1930). The reliance on nurture over nature in each of these theories may need to be tempered in light of some recent proposals about a variety of richly structured innate mechanisms to interpret social stimulation [e.g., Leslie's (1987, 1994) theory of mind module; Baron-Cohen's (1995) detectors for perceiving another person's intention and eye direction; Meltzoff's (Meltzoff & Gopnik, 1993; Meltzoff & Moore, 1977, 1989) neonatal imitation mechanism; or Gergely and Csibra's (1996, 1997; Csibra & Gergely, in press) teleological stance for interpreting another's action]. Even if incorporating one or more of these specific interpretive mechanisms, however, these diverse theories will surely continue to rely heavily on an assumption they share, at least implicitly, to the effect that human infants are sensitive to the existence of *contingencies between their behavior and environmental events.*

The capacity to accurately interpret stimulation as contingent or not could well be viewed as the most fundamental of an infant's arsenal of innate modules for interpreting early sensory stimulation. Whether as a means to establish a basis of conditioning (e.g., Bandura, Skinner) or a basis for building representations of social relations (e.g., Bowlby, Bruner, Trevarthen), an infant's capacity to detect contingency is taken for granted.

However, a definition of what constitutes a perceivable contingency is often only vaguely provided.

It has also been a common assumption of most developmental theories (including Freud, Bruner, and Stern) that early experience includes perceptual awareness of one's basic emotional states, at least initially (i.e., before any "repressive" mechanism). For example, even John B. Watson's (1930) extreme empiricism incorporated an assumption that an infant by nature experiences a set of simple emotions such as fear, love, and rage.

This chapter presents and extends a model of human socio-emotional development that we have recently proposed (Gergely & Watson, 1996). Our model gains its uniqueness by the fact that even though it embraces the common assumption that young infants are sensitive to contingency experience, at the same time, it rejects the general view that they are initially perceptually aware of their specific basic emotion states. Indeed, it is our contention that contingency detection is crucially involved in an infant's progressively developing awareness of his or her internal affective states. More specifically, our "social-biofeedback model" holds that the caregiver's contingent reflections of the infant's emotion expressive displays play a central causal role in the development of emotional self-awareness and control that is mediated by the contingency detection module.

We begin by trying to make very clear what we mean by *contingency perception, contingency seeking,* and its special limitation to *perceivable contingencies,* because we shall place considerable theoretical weight on these foundational constructs. We then consider the implications of this view of early contingency perception when conjoined with an assumption that an infant begins life with little or no awareness of his or her dispositional states. That leads us to our social-biofeedback model of how the infant progressively becomes aware of his or her emotional dispositions through the process previously identified as social mirroring. Our model includes an assumption about a change in the target magnitude of contingency seeking that appears to occur at about 3 months of age. The possible relevance of this for the understanding of the deviant developmental pattern in autism is also briefly considered.

THE CONTINGENCY DETECTION MODULE: BASES AND LIMITS OF CONTINGENCY PERCEPTION IN INFANTS

One of us (Watson, 1979, 1985, 1994, in press) has provided evidence for the very early existence of a complex perceptual contingency detection module that analyzes the conditional probability structure of the contingent relations between responses and stimulus events. Briefly, this analytic device

applies two independent mechanisms: one (called the *sufficiency index)* is looking forward in time, registering the conditional probability of an upcoming stimulus event as a function of an emitted response, and the other (called the *necessity index)* is testing backward in time, monitoring the relative likelihood that a given stimulus event was preceded by a given response. The two separate indices estimate two aspects of the contingency relation that can vary independently of each other providing a scale of different magnitudes of contingent relatedness. However, whenever the two indices provide different estimates of contingency, it is possible that this difference may signal the fact that the actual contingency is higher than the average of the two estimates. This is so because the device may be monitoring either a too narrow or a too broad class of responses. There is some evidence, however, that the contingency detection mechanism can discover the maximal degree of contingency (contingency maximizing, see Watson, 1979) by either reducing or expanding the sampled set of responses, eventually zeroing in on the correct response set and identifying the actual degree of contingent control (the details of the workings of the module are described in Gergely & Watson, 1996, pp. 1191-1192; see also Watson, 1979).

In a series of experiments, Watson (1979, 1985) examined infants' reactions to different magnitudes of response-stimulus temporal contingencies varying between less than 1 but greater than zero (in terms of conditional probability). He found that between 4 and 6 months of age, infants appear to have great difficulty with contingency magnitudes that are less than .5. Unexpectedly, they also appeared to fail to engage contingencies that approached a magnitude of 1 on both indices (i.e., on both necessity and sufficiency).

Though much of the supporting evidence has come from studies examining temporal contingency relations, a case has been made (Watson, 1984a) for there being at least three separate and independent bases of contingency: temporal, sensory relational, and spatial. In fact, we wish to argue that the contingency detection module can be conceived of as an analytic device that at its input end monitors for and registers all these three parameters of response-stimulus contingencies in parallel and provides as its output a value indicating the estimated degree of *causal relatedness* between responses and stimuli. Evidence of infants' use of these three informational bases in detecting contingency is available. The temporal variable has been investigated most, and the sensory relation variable has received the least amount of attention.

1. Temporal Contingencies

Many studies have shown infants to be sensitive to situations in which their behavior is followed in time by a stimulus event (e.g., a vocalization is followed by an auditory or visual stimulus, Bloom, 1979; Ramey & Ourth,

1971), or a leg movement is followed by movement of a mobile (Rovee-Collier, 1987; Rovee & Rovee, 1969; Watson, 1972). Under such circumstances, infants will rather quickly display a change in their pattern or rate of behavior. Even newborns will alter their sucking when it immediately affects what they see (Walton & Bower, 1993) or hear (De Casper & Prescott, 1984).

An infant's sensitivity to temporal contingency has limits, however. A delay of the contingent stimulus by as little as 3 seconds appears capable of blocking the detection of the contingency, at least for infants younger than 6 months of age (Millar, 1972; Millar & Watson, 1979, Ramey & Ourth, 1971). Whether or not the 3-second delay is an absolute barrier, however, it is clear that temporal delay has a profound affect on how well a contingency will be perceived, and it seems likely that longer delays would eventually make any temporal contingency undetectable (Watson, 1967; 1984b).

2. Sensory Relations

There is a further source of information about the contingent relatedness between events over and above their temporal contingency that is provided by sensory relations. There is no doubt that, as adults, we recognize the relationship between how much energy we put into an instrumental act and the amount of consequence we obtain. For example, we expect that a bell struck softly will produce a muted tone but one struck vigorously will produce a clanging one. In other words, we note the correspondence between the sensory effects of our behavior and the sensory consequences of the ensuing stimulus event that adds sensory relational information to the existing temporal one about their contingent relatedness.

Although sensory relational and temporal information about contingency often appear together, it is important to realize that sensory relations form an independent parameter that may provide information about contingency even in the absence of information regarding the temporal distribution of behavior and stimuli. Suppose that you have limited memory for the events that transpired in a certain situation. Your memory has a diminished quality such as you may have experienced in reflecting on a dream. The individual events are reasonably clear, but their temporal order is not. You recall being in a room watching a person making an impassioned speech. You recal his facial expressions. Among other events that transpired, you recall three instances in which he pounded his fist on the lectern while at the podium. One blow was hard, one soft, and one slightly softer yet. The order in which these occurred is not clear in your memory, however.

Now suppose you recall entering the room again sometime later. The room is empty except for the presence of three flowers. They differ only

in size. One is large, one is smaller, and one is yet slightly smaller. Assume that you are moved to ask how they came to exist. You consider the information available. You notice something that, although fantastic, is nonetheless to some degree compelling. The ratio of sizes of the flowers (2, 6, 14 inches) matches perfectly the ratio of sound intensities (10, 30, 70 decibels) you recall the speaker generating when at the podium. Note that even though one cannot compare absolute intensity levels of stimuli across modalities, it is quite possible to order and compare intensities within a modality, and the patterns thus generated can then be compared across modalities. Accordingly, it is the sensory relational correspondence between the ratios within the two modalities that forms the basis of our judgement of causal relatedness between the speaker's podium pounding and the appearance of flowers.

Of course, this example still retains an important reference to temporal sequence in our analysis of cause and effect. We have not wondered whether flowers may cause exuberant podium pounding. Our commitment to efficient causes requires that we distinguish this aspect of sequence in time between those events that may stand as causes from those that may stand as effects. Yet, clearly, in the process of sorting through our memories of the different things that have preceded the events we wish to explain (the appearance of the flowers), the evidence we have turned to is not temporal but sensory relational. For example, we have not worried whether each flower ag each strike to the lectern. Rather, we based our judgement on the correspondence between the ratios of flower sizes, on the one hand, and of the sound intensity of the strikes, on the other.

That infants are also sensitive to sensory relational information about contingency is highlighted, for example, by the work of Rovee-Collier and her colleagues (Fagen & Rovee, 1976; Rovee-Collier, 1987; Rovee & Rovee, 1969). These researchers have been studying the young infant's capacity to learn and remember response-reward contingencies under conditions employing what is termed *conjugate reinforcement.* This procedure involves placing the infant in a crib with a mobile overhead. A ribbon is tied to the infant's foot while its other end is attached to a mobile that is suspended overhead on a flexible rod. As a consequence of this arrangement, whenever the infant moves his or her leg, the mobile moves in a manner that is similar in frequency and intensity to the leg extensions. Thus, Rovee-Collier's subjects are receiving sensory relational contingency along with temporal contingency. Evidence that the infants are attentive to the sensory relational parameter is indicated by the fact that when a change in the magnitude of stimulus consequence is introduced, after an initial adaptation to a specific contingency, infants as young as 3 months of age readily detect the change (Fagen & Rovee, 1976).

3. Spatial Relational Information

To illustrate the role of spatial relational information about contingency, let us return to our fanciful example introduced previously. Suppose, however, that we do not remember the variation in intensity of the speaker's podium pounding, nor do we recall the relative size differences among the flowers. Instead, our limited memory provides us only with images of where things happened. We now note that the flowers reside at three places on the lectern. More than that, there is a flower at each place we recall the speaker hitting the lectern—one at the lower left corner, one in the center, and one midline at the top. We do not know the temporal order of the flowers' appearance nor do we have any evidence of correlated variation in the sensory quality of the flowers. Yet, despite the lack of temporal or sensory pattern information, it is clear that *the pattern of spatial positioning alone* provides a powerful implication for the attribution of causal relatedness between podium pounding and the presence of the flowers.

Recent work by Rochat & Morgan (1995) is the clearest demonstration of infants' sensitivity to spatial contingency. In a variation on a task previously used by Bahrick & Watson (1985), Rochat & Morgan presented 3.5- and 4.5-month-old infants with a choice between two views of a video image of their legs. In three experiments, they varied the choice presented. In one study, the infant was shown a normative view (wherein the image shows the legs projected upward and the right-left distribution of legs is correct in the visual field) versus a rotated image (wherein the legs projected downward and the left-right distribution was reversed). In the other two experiments, the comparison was between the normative view and a view in which only the orientation was reversed (keeping the left-right distribution normative) or only the distribution was reversed (keeping the orientation normative, i.e., projecting upward). Rochat & Morgan measured the degree of preferential looking and the amount of kicking while looking. They found that infants showed a selective preference for the images that presented a left-right inversion of the image. The infants also kicked more vigorously while looking at this image of their legs.

These results imply that the infants were sensitive to the spatial contingency between directional movement of their legs and the movement of the video image. Note that the two images were both perfectly matched in terms of temporal contingency and sensory relational dynamics with the infants' leg movements. It might seem odd that the infants showed a seeming preference for the less perfect contingency. However, this avoidance of the perfectly contingent image is consistent with the prior results of Bahrick & Watson (1985) and is consistent with Watson's (1985, 1994) hypothesis according to which the preferential target setting of the contingency detection device is "switched" around 3 months of age from seek-

ing out perfect respo-stimulus contingencies toward a bias for high but imperfect degrees of response-contingent stimulation (see further on).

Recently, Schmuckler (1996) has replicated Rochat & Morgan's findings in a task involving manual exploration of an object by 4- to 6-months-old infants. In three experiments, infants were given a visual choice between on-line video feedback of their hand movement or an alternative image. Again, in all three experiments the infants looked longer at the alternative image than at the on-line feedback representing the perfect contingency. Significant effects were found for the directionality (left-right inversion) but not for orientation (up-down inversion), paralleling Rochat's pattern of results. Without some comparative measure of the amount of motion the infants in these studies created in the two spatial dimensions, it is not yet clear whether these results indicate an intrinsic difference in the salience of the two dimensions of spatial variation. What is clear is that spatial contingency is detected at least for variation in the left—right dimension.

Meltzoff's work on the infant's sensitivity to being imitated (Meltzoff, 1990) also provides relevant evidence for an infant's use of spatial distribution as a source of information about contingency. (We consider this work again further on in the context of the infant's differential attraction to various levels of contingency.) Meltzoff used a preferential interaction paradigm in which 14-month-old infants were faced with two adult models, one of whom imitated as best as he or she could the child's object-related behaviors, whereas the other always performed a temporally contingent but dissimilar (spatially noncontingent) action. The infants looked and smiled more at the adult who mimicked them than at the one whose actions were only temporally contingent with theirs. As in the case of Rochat's study, the spatial (or *structural* as Meltzoff & Gopnik, 1993, call it) contingency was concurrent with very high temporal contingency. Under this condition, at least, it would seem that infants managed to detect differences in spatial contingency with ease and showed differential responsiveness on that basis.

DEVELOPMENTAL FUNCTIONS OF THE CONTINGENCY DETECTION MODULE

Watson (1972) has provided evidence that 2-month-olds increase their rate of leg kicking over a 2-week period when this response results in a contingent stimulus event (the movement of a mobile above their cribs) but not when they experience a similar but noncontingent event. Furthermore, after 3 to 5 days of contingent control over the mobile's movements, these infants exhibited what appear to be social smiling and cooing when the mobile was presented. These results indicate that very young infants are

able to detect contingent relations between their responses and external stimulus events and that the ensuing experience of causal control over an external event is generally positively arousing for them as well as potentially a triggering experience in filial imprinting (Watson, 1981).

Bahrick and Watson (1985; see also Rochat and Morgan, 1995, and Schmuckler, 1996) demonstrated in a preferential looking paradigm that both 3- and 5-month-olds are capable of differentiating between a perfectly contingent image (live video feedback) versus a noncontingent image (delayed feedback) of their own moving legs suggesting that *contingency analysis may be the underlying mechanism for early self-detection.* Interestingly, while 3-month-olds displayed a significant bimodal distribution of preference (i.e., about equally divided between preferring perfect versus preferring imperfect contingency of the image of their moving body), 5-month-olds showed a normal distribution of aversion to exploring such a perfect response-stimulus contingency. Similarly, in other studies (see Watson, 1985) it appears that after 3 months infants are most motivated to explore high but imperfect degrees of response-stimulus contingencies.

Watson (1994) argued that the initial target setting of the contingency detection device is to seek out perfect response-stimulus contingencies so as to identify the range of self-generated (perfectly response-contingent) stimuli. This presumably forms the basis of the *construction of the primary representation of the bodily self.* It is hypothesized that around 3 months the target value of the contingency analyzer in normal infants is "switched" to a preference for high but imperfect response-stimulus contingency. This change presumably serves the function of orienting the infant toward the external environment and thus supports the building of representations on the basis of stimulation provided by a responsive social environment.

THE SOCIAL-BIOFEEDBACK MODEL OF AFFECT-REFLECTIVE MIRRORING INTERACTIONS

We have argued so far that the contingency detection mechanism serves such central functions in development as self-other differentiation and orientation toward the social environment. In what follows we summarize our recent proposal (Gergely & Watson, 1996) concerning a further significant function that we believe is mediated by the contingency detection module; namely, *the development of emotional self-awareness and control* in infancy. Our model is based on two central assumptions: that in its initial state the human organism has no differential awareness of his or her basic categorical emotion states, and that affect-reflective parental *mirroring* interactions play a vital role in the development of perceptual sensitivity to the infant's internal affect states. We argue that this sensitization process

(similar to that of adult biofeedback training) is mediated by the mechanism of contingency detection and maximizing. In terms of our model, apart from sensitization, affect mirroring serves three further developmental functions as well:

1. It contributes directly to the infant's state-regulation.
2. It leads to the establishment of secondary representations that become associated with the infant's primary procedural affect states providing the cognitive means for accessing and attributing emotions to the self.
3. It results in the development of a generalized communicative code of "marked" expressions characterized by the representational functions of referential decoupling, anchoring, and suspension of realistic consequences.

INITIAL SENSITIVITY TO INTERNAL VERSUS EXTERNAL STIMULI

It is interesting to note that most classical as well as current approaches to infancy tend to adhere to the basic assumption that infants have conscious access to their internal basic emotion states from the beginning of life. For example, Meltzoff and Gopnik (1993) proposed that there are innate mechanisms that allow the infant to attribute emotions to other minds starting from birth. Based on evidence on neonatal imitation (Meltzoff & Moore, 1977, 1989) on the one hand and on the innate basis for primary emotions (Ekman, 1992; Ekman, Friesen, & Ellsworth, 1972; Izard, 1977, 1978) on the other, they proposed that by imitating the parent's facial emotion expression, the infant activates through prewired connections (see Ekman, Levenson, & Friesen, 1983) the corresponding physiological emotion state in himself or herself. The imitation-generated internal emotion state is then introspectively accessed, and the felt affect is attributed to the other's mind (but see Gergely & Watson, 1996, pp. 1183-1185, for a critical evaluation of this view). Similarly, proponents of differential emotions theory (Izard, 1977; Izard & Malatesta, 1987; Malatesta & Izard, 1984) also hold that "there is an innate expression-to-feeling concordance in the young infant" (Malatesta, Culver, Tesman, & Shepard, 1989, p. 6,). Stern (1985) also enumerates "categorical affects" as belonging to "the basic elements of early subjective experience" (p. 67).

In assuming that the infant's initial state is characterized by direct introspective access to internal emotion states, these modern authors follow the tradition of a long line of developmental theorists. For example, Freud and his followers (e.g., Mahler, Bergman, & Pine, 1975) have long held

the view that an infant is initially more sensitive to internal than to external stimuli. Bruner, Olver, and Greenfield (1966) also proposed that the infant moves from an initial reliance on internal, proprioceptive cues to a reliance on exteroceptive cues (see also Birch & Lefford, 1967; Gholson, 1980; for a review, see Rovee-Collier, 1987).

However, as Colombo, Mitchell, Coldren, and Atwater (1990) have pointed out, there are practically no empirical data to directly support this classical view. In contrast, in a series of experiments designed to test this assumption, these authors have demonstrated that 3-month-olds show discrimination learning on the basis of exteroceptive as well as interoceptive cues.[1] Moreover, in 6- and 9-month-olds, they actually found dominance of the *exteroceptive* over the interoceptive cues in learning.

In light of such evidence, we have proposed to explore the consequences of abandoning the classical assumption concerning the presumed dominance of internal stimuli in the initial state of the infant (Gergely & Watson, 1996). In contrast, we hypothesize that at the beginning of life *the perceptual system is set with a bias to attend to and explore the external world and builds representations primarily on the basis of exteroceptive stimuli.* In this view, then, the set of internal (visceral as well as proprioceptive) cues that are activated when being in and expressing an emotion state are, at first, not perceived consciously by the infant, or, at least, are not grouped together categorically in such a manner that they could be perceptually accessed as a distinctive emotion state.[2]

LEVELS OF REPRESENTATIONS OF SELF-STATES: AUTOMATIC VERSUS CONTROLLED PROCESSES

There are a number of dichotomies in cognitive theory such as the procedural-declarative, implicit-explicit, unconscious-conscious, or automatic-

[1]Note furthermore that one cannot rule out the possibility that the position cues in Colombo, et al.'s study, which were based on eye fixation, might have been computed on the basis of the position of the nose, which, in fact, is an *exteroceptive* cue (see Bower, 1974).

[2]As will become apparent, our proposal (although compatible with does not necessarily imply the more radical view that at the beginning of life infants are lacking any kind of awareness of their internal states). It is possible that infants have some awareness of the component stimuli that belong to the groups of internal state cues that are indicative of categorical emotions, but only as part of the "blooming, buzzing confusion" (James, 1890/1950) of internal sense impressions they may experience. Such state cues may also contribute to the overall (positive or negative) hedonic quality of infants' awareness. Our (less radical) suggestion is (a) that the groups of internal state cues that are indicative of dispositional emotion states are initially not perceptually accessible as distinct feeling states (see Lewis & Michaelson, 1983; Lewis & Brooks, 1978; and Kagan, 1992) and (b) that the perceptual system is at the start set with a bias to actively explore and categorize external rather than internal stimuli.

controlled distinctions (e.g., Karmiloff-Smith, 1992; Shiffrin & Schneider, 1977) that refer to qualitatively different levels of information representation in humans. *Automatized processes* refer to prewired or over-learned structures of behavioral organization in which information is represented implicitly, embedded in procedures, and is unavailable to other representational systems of the mind. Such automatisms are inflexible, perceptually driven, and operate outside consciousness. In contrast, *deliberative or controlled processes* refer to voluntary and conscious operations that are flexible and modifiable, can be governed by higher-order cognitive goals, and can override automatisms.

In this framework, infants' primary emotions can be conceived of as prewired, stimulus driven, dynamic behavioral automatisms over which they have no control at first. Affect-regulation is carried out mainly by the caregiver who, reading an infant's automatic emotion expressions, reacts with appropriate affect-modulating interactions. In this view, emotional self-control will become possible only with the establishment of *secondary control structures* that (a) monitor, detect, and evaluate the primary level dynamic affective state changes of the organism and (b) can inhibit or modify the emotional reaction if the anticipated automatic affective response would jeopardize higher-order cognitive plans.

Therefore, a precondition for the voluntary control and self-regulation of primary affective states is that the level of deliberative processes be informed about the on-going dispositional state changes of the organism that take place at the level of automatized processes. Within this framework, consciously felt emotions can be conceived of as *signals* that inform the level of deliberative processes about the automatic affective state changes of the organism.

This leads then to the question, How does an infant develop awareness of and come to represent the sets of internal state cues as indicating categorically distinct emotion states? We propose that the species-specific human propensity for the facial and vocal reflection of the infant's emotion-expressive displays during affect-regulative interactions plays a crucial role in this developmental process.

AFFECT-REFLECTIVE MIRRORING INTERACTIONS IN EARLY SOCIO-EMOTIONAL DEVELOPMENT

Historically, there are two traditions in developmental psychology that emphasize the formative importance of the role of the caretaker's inclination to behaviorally reflect the internal emotional and intentional states that she attributes to her infant. One is the social constructivist tradition, starting with Hegel and continuing with the work of Baldwin, Cooley, G. H.

Mead, and Bruner, which emphasizes the social origins of the development of the self. In this general view, the inferential basis for constructing the representation of the self is provided by the social reflections of the child's states and properties as those are perceived by the infant in the reactions of others. The second tradition is that of psychoanalytic object relations theories that have long identified the maternal mirroring function as an important causal factor in early emotional and personality development (e.g., Bion, 1962, 1967; Fonagy & Target, 1996; Jacobson, 1964; Kernberg, 1984; Kohut, 1971; Mahler et al., 1975; Mahler & McDevitt, 1982; Stern, 1985; Winnicott, 1967).

Recent empirical work on early mother-infant interactions (e.g., Beebe & Lachmann, 1988; Hains & Muir, 1996; Kaye, 1982; Murray & Trevarthen, 1985; Papousek & Papousek, 1987, 1989; Sroufe, 1996; Stern, 1985; Trevarthen, 1979; Tronick, 1989) has in general confirmed the traditional view that *facial and vocal mirroring of affective behavior* may be a central feature of parental affect-regulative interactions during the first year. The currently dominant biosocial view of emotional development holds that mother and infant form an affective communication system from the beginning of life (Beebe, Jaffe, & Lachmann, 1992; Bowlby, 1969; Brazelton, Koslowski, & Main, 1974; Hobson, 1993; Sander, 1970; Stern, 1985; Trevarthen, 1979; Tronick, 1989) in which the mother plays a vital interactive role in modulating the infant's affective states. Young infants do have some rudimentary means of affective self-regulation (such as turning away from over arousing stimuli or thumb sucking) (Demos, 1986; Malatesta et al., 1989), but there is agreement that the quality of maternal interactions exert a strong regulative influence on the infant's affective state changes (Field, 1994; Malatesta & Izard, 1984; Tronick, 1989; Tronick, Ricks, & Cohn, 1982). Mothers are generally rather efficient in reading their infants' emotion displays, and sensitive mothers tend to attune their own affective responses to modulate their infant's emotional states (Malatesta et al., 1989; Tronick, 1989).

Studies using the still-face procedure (Tronick, Als, Adamson, Wise, & Brazelton, 1978) or delayed feedback techniques (Murray & Trevarthen, 1985; see, however, Rochat, Neisser, & Marian, in press) indicate that young infants are sensitive to the contingency structure of face-to-face interaction and are actively searching to reestablish such a pattern of communication when being abruptly deprived of it. By using time-based microanalytic methods (e.g., Gottman & Ringland, 1981), several researchers provided evidence for the early existence of bidirectional influence of behavior and mutual regulation of affective communication between mothers and infants (Beebe & Lachmann, 1988; Beebe, Lachmann, & Jaffe, 1997; Cohn & Tronick, 1988; Tronick, Edward, Als, & Brazelton, 1977; Tronick, 1989). Imitative matching activity has been reported to be fre-

quent during mother-infant interactions (Uzgiris, Benson, Kruper, & Vasek, 1989), and mother-infant pairs have been shown to increase their degree of coordination in terms of matching and synchrony with infant age (Tronick & Cohn, 1989). Maternal imitative behavior was found to evoke more smiling and vocalization in $3^1/_2$-months old babies than nonimitative responses (Field, Guy, & Umbel, 1985). Mothers react with differential facial attunements to infants' emotion expressions producing contingent imitations more often to their baby's categorical emotion displays than to their more "random" facial movements (such as twitches or half smiles) (Malatesta & Izard, 1984; Malatesta et al., 1989). Infants' expressions of sadness and anger have been observed to produce affective responses of sadness and anger in their mothers (Tronick, 1989), and maternal reactions to negative affect include mock expressions of negative affect (Malatesta & Izard, 1984).

Research on the facial and vocal interaction between depressed mothers and their infants (Bettes, 1988; Cohn, Matias, Tronick, & Connell, 1986; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Tronick, 1989; Tronick & Field, 1986) have shown that there is a decrease in the amount of contingent affective interactions as well as more intrusiveness and more negative affect expression on the part of the mother. Furthermore, such infants' affective and regulatory reactions as well as their later security of attachment have been found to be related to the affect and behavior of their depressed mothers (Field, 1994; Field et al., 1988; Murray, 1992; Murray et al., 1996; Pickens & Field, 1993; Tronick, 1989; Tronick & Field, 1986).

In sum: It can be said that whereas theoretical, clinical, and empirical approaches all converge on the view that parental affect-reflective interactions play a central role in early emotional and self-development, the exact nature of the causal mechanisms mediating such effects has not yet been identified.

PARENTAL AFFECT-MIRRORING AS A MECHANISM OF EMOTION REGULATION

When we look at the structural relation between the stimulus features of the parent's mirroring expression and those of the infant's state-expressive behavior, it becomes clear that the term "mirroring" is a seriously misleading one. No matter how well attuned a mother is to the baby's state, her facial and vocal mirroring will never match perfectly the temporal, spatial, and sensory intensity parameters of her infant's behavioral expressions. Thus, by necessity, the degree of contingent relatedness between the infant's state expressive behaviors and the caretaker's reflective mirroring displays will be high but only imperfect. Earlier we discussed evidence indicating that the infant's contingency detection module is extremely sensitive to the distinction between perfect versus high but imperfect degrees of response-stimulus

contingencies, and a normal infant is preferentially biased to attend to and explore highly but imperfectly response contingent environmental stimuli after about 3 months of age (Bahrick & Watson, 1985; Watson, 1979, 1994). Since affect-reflective displays tend to provide relatively high contingency values on all three stimulus parameters (temporal, spatial, and sensory intensity) that are monitored by the contingency detection mechanism, they can be considered optimal naturalistic social target stimuli for the module, the detection of which will induce a sense of causal control and concomitant positive arousal in the infant.

This may, in fact, help us explain the soothing effect that emotion-reflective interactions seem to have on infants in negative affect. Imagine a helpless, whimpering or fearful baby who perceives his mother repeatedly presenting him with bouts of empathic affect-reflective displays in an attempt to sooth him. The infant's contingency detection device will automatically register the high degree of contingent relatedness between his emotion-expressive behavior and the parent's affect-reflective displays. This will result in an experience of causal efficacy in controlling and bringing about the parental mirroring behavior, which, in turn, will reduce the infant's feeling of helplessness. The high degree of perceived contingent control will also induce positive arousal in the infant (Watson, 1972) that, through reciprocal inhibition, can be expected to further decrease his negative affect state.

Note that an interesting additional feature of this process is that the infant will experience the ensuing emotional state regulation as an *active causal agent.* Apart from experiencing causal efficacy in controlling the adult's emotion-reflective displays, the infant will simultaneously register the ensuing positive modification of his negative affect state as well. Therefore, it can be hypothesized that successful emotion-regulative interactions involving parental affect mirroring may provide the experiential basis for the establishment of a *sense of self as self-regulating agent.* Thus, affect-regulative mirroring interactions may provide the original proto-situation in which infants can learn that by externalizing their internal emotion states, they can achieve successful regulation of their affective impulses (see Gergely & Watson, 1996, p. 1196, for more detailed arguments along these lines).

PARENTAL AFFECT MIRRORING AS A MECHANISM OF EMOTIONAL SENSITIZATION: THE SOCIAL-BIOFEEDBACK HYPOTHESIS

Above we hypothesized that the internal state cues that are activated when being in an emotion state are initially not perceived consciously or, at least, do not form a categorical group that could be perceptually accessed

as a distinctive emotion state. We have then proposed that the repetitive presentation of an external reflection of the infant's affect-expressive displays serves a vital teaching function that results in gradual sensitization to the relevant internal state cues as well as to the identification of the correct set of internal stimuli that correspond to the distinctive emotion category that the baby is in. As a result of this process, the infant will eventually come to develop an awareness of the differential internal cues that are indicative of categorical affect states and will become able to detect and represent his particular dispositional emotion states.

One, of course, may ask, In what way would the presentation of an external emotion display that is contingent on the baby's internal affect state lead to sensitization to and recognition of the internal state that was not consciously accessible before? Furthermore, is there any evidence that such externally induced sensitization to internal states is possible?

We believe there is at least one intriguing example of such a process that shows a high degree of family resemblance to the current proposal, namely, *biofeedback training procedures* (e.g., Dicara, 1970; Miller, 1969, 1978). In such studies, continuous measurements are made of the on-going state changes of some internal stimulus state to which the subject has no direct perceptual access initially (such as blood pressure). The internal state changes are mapped onto an *external* stimulus equivalent directly observable to the subject, the state of which covaries with that of the internal stimulus. Repeated exposure to such an externalized representation of the internal state eventually results in *sensitization to,* and in certain cases, subsequent *control over,* the internal state.

We hypothesize that the psychological mechanism involved in affect mirroring is the same process as that demonstrated in biofeedback training procedures. Thus, our proposal is that parental affect mirroring provides a kind of *natural social biofeedback training* for the infant. The internal emotional state cues are at first not consciously accessible to the baby, but the parent, who can read and interpret their automatic behavioral expressions, can provide a highly contingent external stimulus equivalent for them in the form of his or her affect-reflective displays that covary with the baby's internal affect state. We hypothesize that the contingency detection module, which has access to the (nonconscious) internal physiological state changes involved in an affective response as well as to the proprioceptive stimuli generated by their automatic expression, can identify the contingent relatedness between these internal cues on the one hand and the external affect-mirroring display, on the other. This leads to two consequences: (a) the infant will become gradually sensitized to the internal stimulus cues involved in the contingency relation, and (b) he will learn to group together those internal state cues whose combined presence correlates highly with the external affect-reflective display (and,

consequently, with the internal emotion sate reflected). As a result, eventually the infant will become sensitive to the set of distinctive internal state cues that indicate the onset of a dispositional emotion state and will be able to attribute such a state to himself or herself even in the absence of the external affect-mirroring biofeedback cue.

Elsewhere we have argued that the underlying information-processing mechanism that mediates the influence of both affect mirroring and biofeedback training is that of *contingency detection and contingency maximizing* (Gergely & Watson, 1996). The explication of the details of this process is beyond the scope of the present chapter (the interested reader can find a detailed account in Gergely & Watson, 1996, pp. 1190-1196). Suffice it to remind the reader here of the fact that the contingency detection module applies two independent mechanisms for analyzing the conditional probability structure of contingent response-stimulus events: The sufficiency index is looking forward in time and registers the conditional probability of stimulus events as a function of the monitored set of responses; the necessity index is testing backward in time, monitoring the relative likelihood that a given stimulus event was preceded by the responses in question. As mentioned previously, the estimated degree of control over the stimulus event, however, may not correspond to the actual degree of control. This is so because the device may be monitoring either a too narrow or a too broad class of responses. The contingency-detection mechanism can, however, discover the maximal degree of contingency (contingency maximizing, see Watson, 1979) by either reducing or expanding the sampled set of responses, eventually zeroing in on the correct response set and identifying the actual degree of contingent control.

THE REPRESENTATIONAL CONSEQUENCES OF PARENTAL AFFECT MIRRORING: THE "MARKEDNESS" HYPOTHESIS

One of the most intriguing and apparently paradoxical aspects of parental affect mirroring during state-regulative interactions is the fact that when a baby is in a negative state, the parent presents a reflection of a negative emotion display to the infant. This raises the potential danger of misattribution: How does the baby know that the affect-reflective emotion expression refers to his or her own state and not to that of the parent? Were the infant to misattribute the expressed negative affect to the parent, his or her own negative emotion state, instead of becoming regulated, would likely to escalate, as the sight of a fearful or angry parent is clearly cause for alarm (and, if occurring systematically, of possible trauma, see Main & Hesse, 1990; Fonagy & Target, 1997).

We have argued (see Gergely, 1995a, 1995b; Gergely & Watson, 1996, pp. 1196-1200) that this attribution problem is solved by a specific perceptual feature of the parent's affect-reflective emotion displays that we refer to as their *markedness.* It is proposed that mothers are instinctually driven to saliently *mark* their affect-mirroring displays to make them perceptually differentiable from their realistic emotion expressions. Marking is typically achieved by producing *an exaggerated version* of the parent's realistic emotion expression (similarly to the marked "as if" manner of emotion displays that is characteristically produced in pretend play). The marked affect display, nevertheless, remains sufficiently similar to the parent's normative emotion expression for the infant to recognize the dispositional content of the emotion. It is assumed that the infant has been adaptively discriminating parental dispositional displays (Watson, 1995). However, it is hypothesized that due to the markedness of the display during affect mirroring, the attribution of the perceived emotion to the parent will be inhibited. We call this process *referential decoupling,*[3] referring to the fact that in the interpretation of the marked affect display, the referential connection between the emotion expression and the corresponding dispositional state of the agent producing the display will be *suspended.* The perceived emotion display will be decoupled from its referent.

Note, however, that due to its markedness, the parental emotion display may become decoupled from its referent, but it still needs to be interpreted by the infant from a referential point of view as expressing *someone's* emotion. We suggest that this process of *referential anchoring* is determined by the *high degree of contingent relation* between the parent's affect-reflecting display and the infant's emotion-expressive behavior that is registered by the contingency detection module. On the basis of the perceived contingent relation, the infant will referentially anchor the marked mirroring stimulus as expressing his or her *own* self-state.

In this view, then, infants tend to experience the emotion displays of caregivers in two different forms over time: in their *realistic* and in their *marked* (affect-reflective) versions. We hypothesize that the infant will come to represent these two forms as qualitatively different variants of the emotion expression not only because of their marked differences in terms of perceptual features but also because of two further distinguishing characteristics.

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[3]The terms *"referential decoupling"* and *"referential anchoring"* originally were introduced by Alan Leslie (1987, 1994) to characterize the representational properties of communicative expressions produced in pretend play. We apply these terms in the current context to suggest a potential developmental and functional relationship between the markedness of affect-reflective expressions on the one hand and the markedness of expressions in the "pretend" mode of communication, on the other. The detailed exposition of this hypothesis, however, is beyond the scope of this chapter (see Gergely, 1995a, 1995b; Gergely & Watson, 1996).

First, the situational features and behavioral outcomes that will become associated with the realistic emotion expression (e.g., with the sight of an angry mother) will be qualitatively different from those that are characteristic of the corresponding marked display (i.e., the sight of an anger-reflecting mother). In other words, the *dispositional outcomes* associated with the realistic emotion will not hold for the case of the marked expression. Instead of the negative behavioral and emotional consequences typically accompanying a realistic anger expression, when faced with a marked anger-reflecting display, the infant is likely to experience positive outcomes in the form of successful affect regulation.

Second, the realistic and the marked emotion displays of caretakers will also become differentiated in terms of their *different contingency relation* to the infant's on-going behavior. Realistic emotion expressions are typically much less under the infant's contingent control than the marked emotion-reflective displays. A realistic expression of, say, fear on the mother's face, is more likely to be contingent on some external event or to be induced by some intrapsychic stimulus in the mother than to be under the control of the infant. The marked affect-reflective version of the emotion display is, however, under the contingent behavioral control of the baby, because it is produced as a mirroring response to the infant's corresponding emotion expression during affect-regulative interactions.

Furthermore, it can be hypothesized that in normal development, the behavioral transformations of a normative display that correspond to its marked form become established as a *generalized communicative code* associated with (a) referential decoupling of the expressed content from the agent producing the display, (b) with referentially anchoring the expressed content in an agent other than the one displaying the emotion,[4] and (c) with the suspension of the dispositional consequences of the realistic version of the expressed content (Gergely, 1995a, 1995b). Note that these features will become the central characteristics of the *'as if' mode of communication* as it first emerges in the ability to comprehend and to produce pretend play during the second year of life (see Fonagy & Target, 1996, 1997; Gergely, 1995a, 1995b; Gergely & Watson, 1996; Leslie, 1987, 1994).

The markedness of the affect-mirroring display is likely to have a further interesting effect as well. Since the mirroring display is differentiated from the corresponding realistic emotion expression by its perceptual markedness, its differential dispositional consequences, and its high degree of contingency with the baby's affective behavior, we hypothesize that the infant will construct a separate representation for it. Due to its contingent

[4]Note that although in affect-regulative interactions the marked emotion is anchored in the infant as a result of the experience of contingent control, later however—for example, in the use of the marked code in pretend play—the expressed content may be anchored in another (possibly imaginary) agent with whom the person producing the marked behavior identifies (see Leslie, 1987, 1994).

association with the infant's automatic affective reactions registered during the affect-regulative interactions, this representation will retain its associative link to the baby's primary level affective states. Therefore, the separately represented marked emotion display will come to function as a *secondary representational structure* that will become activated through associative routes whenever the set of internal state cues corresponding to the given dispositional emotion state are activated in the infant. Henceforth, the onset of an emotion state will result in the automatic activation of this proto-symbolic secondary emotion representation in the baby's awareness that will allow him or her to attribute the dispositional emotion state to himself or herself. As we argued earlier, the activation of such secondary representations mediate the signal function of felt affect states that forms the basis of emotional self-awareness and control.

In sum, we have argued that the instinctive inclination of parents to expose their infants to marked affect-reflective behavioral displays during emotion-regulative interactions results in three significant developmental consequences[5]:

1. The infant will come to detect and group together the sets of internal state cues that are indicative of his or her categorically distinct dispositional emotion states.
2. The infant will establish secondary representations associated with his or her primary level procedural affect states providing the cognitive means for accessing and attributing emotion states to the self.
3. The infant will acquire a generalized communicative code of "marked" expressions characterized by the representational functions of referential decoupling, anchoring, and suspension of realistic consequences.

SOME IMPLICATIONS

"Affect Attunement" From the Point of View of the Social-Biofeedback Theory

Stern (1984, 1985; Stern, Hofer, Haft, & Dore, 1985) has also proposed a theory concerning the role of parental affect-reflective behaviors in early social-emotional development. Similarly to our position, Stern believes that interactions involving emotion-reflective parental displays have a significant

[5]Our social biofeedback theory of affect mirroring and the markedness hypothesis also provide a new perspective on the potential pathological consequences of deviant mirroring styles or lack of parental mirroring. These implications for developmental psychopathology, however, are beyond the scope of this chapter and are treated elsewhere (see Gergely, 1995a; Gergely & Watson, 1996, pp. 1200-1205).

influence on self-development and affective self-regulation. His views on the developmental functions and mediating mechanisms involved in affect-reflective parental interactions, however, differ from ours in several important respects.

Stern's theory focuses on a specific type of affect-reflective interaction that he calls *affect attunements,* which he demonstrated to occur regularly in normal mother-infant interactions between 9 and 12 months (Stern et al., 1985). He noted that during free play, mothers periodically reflect some aspect of their infant's actions by providing a partial match of the baby's behavior in another modality. For example, he describes an $8^1/_2$-month-old boy reaching for a toy just beyond reach. As he is stretching his body in an obvious voluntary effort to achieve his goal, "his mother says, 'Uuuuuh . . . uuuuuh!' with a crescendo of vocal effort. . . . The mother's accelerating vocal-respiratory effort matched the infant's accelerating physical effort" (Stern et al., 1985, p. 250).

Stern (1984) makes several interesting points concerning the nature of such acts of behavioral attunements. Among other things, he emphasizes the fact that they are not simple acts of imitation because they involve only a partial match of the amodal (temporal, intensity, and shape) characteristics of the infant's target act rendered in a different modality. He also points out that "during the first half year of life it is our impression (as yet untested) that imitations predominate over attunements (the reverse is true after nine months)" (p. 11).

Stern proposes that the reason why around 9 months the mother (nonconsciously) chooses to "attune" to rather than simply provide an imitative replica of the infant's behavior is that she intends to refer to the internal affect state of the infant rather than to his or her surface behavior. In his view, the matched amodal characteristics correspond to the abstract representational form of affects that accompany the external behavioral act. Thus, the suggested function of such affect attunements is that of "interpersonal communion"—"to share" or "to participate in" the internal affective experience of the infant. Of course, for the infant to interpret affect attunements as indicating parental sharing of his or her internal mental state, he or she (a) must be aware of his or her affect state and (b) must understand that the parent also experiences internal mental states, which (c) can be either shared or different from the particular mental state of the infant. Stern argues for this view by pointing at a purported correlation between the emerging dominance of parental attunements (over imitations) starting at 9 months, on the one hand, and the emergence of the infant's "naive theory of interfaceable minds" (Bretherton & Bates, 1979) during the same period, on the other.

Before contrasting Stern's ideas with ours, let us call attention to some aspects of his proposal that seem to us questionable. First, central to Stern's

argument is the contention that around 9 months of age there is a shift in the mother's reflective behaviors from intramodal, faithful imitations to cross-modal attunements of amodal properties rendered in a different modality. However, it should be pointed out that in the technical sense, all imitative behaviors are (at least partially) cross-modal: If a tongue protrusion is faithfully imitated by a tongue protrusion, the infant experiences an intermodal (motor-visual) correspondence between his own behavior and the imitative act of the parent. It is also well known that even newborn infants are able to appreciate cross-modal correspondence as shown by phenomena such as neonatal imitation (Kaye & Bower, 1994; Meltzoff & Borton, 1979; Meltzoff & Moore, 1977, 1989; Stern, 1985). Obviously, then, what Stern has in mind is not so much the question of intra- versus intersensory modality but rather the fact that the attunement behavior, although showing a partial match in terms of amodal properties, is a different act than the target behavior of the infant.

Second, whether Stern's impression about a qualitative shift around 9 months from imitations to attunements can be empirically substantiated remains to be seen. Certainly, mothers do engage in attunement behaviors even much earlier (as in the prototypical theme-variation games proposed by Watson, 1972). However, even if we assume with Stern that there is a statistical tendency to engage in more attunements than imitations after 9 months, there seems to be a more mundane reason for this than Stern's account in terms of the emerging mentalism of the infant. At the end of the first year, infants become more mobile, and the previous dominance of face-to-face interactions are superceded by object-oriented joint activities (Stern, 1985; Trevarthen & Hubley, 1978). This imposes a pragmatic constraint on the mother's choice of behavior when she intends to reflect the infant's target act in a way that is accessible to the infant. For example, if the baby is visually orienting toward a toy that he or she is reaching for rather than toward the parent, the mother may be forced to attune to the baby's motor effort vocally.

Third, while the momentous changes in an infant's competence after 9 months (such as joint attention, pointing and gaze following, or social referencing) have been interpreted by some researchers as indicating the emergence of understanding intentional mind states (Bretherton, 1991; Bretherton & Bates, 1979; Stern, 1985), others have resisted this temptation and proposed nonmentalistic interpretations for the same phenomena (Barresi & Moore, 1996; Gergely, Nádasdy, Csibra, & Bíró, 1995; Gewirtz & Pelaez-Nogueras, 1992; Moore & Corkum, 1994). For example, as one of us has argued in detail elsewhere (Gergely & Csibra, 1997; Csibra & Gergely, in press), the emerging new competencies at the end of the first year can be understood in terms of a "naive theory of rational action" that is an as yet nonmentalistic teleological interpretational system. Further-

more, while the 9-month-old may not have an appreciation of mind states as yet, mothers certainly attribute intentionality and mentalizing to their infant even at a much earlier age (as shown by the work on cognitive scaffolding by Bruner, Stern, and others). In terms of Stern's hypothesis about the function of attunements being that of signaling the sharing of attributed internal affect states, this would predict that caretakers engage in affect attunements even before their infant is 9 months of age.

In our minds, these arguments raise enough doubts concerning Stern's interpretation of the function and nature of affect attunements that it may be worthwhile to explore an alternative approach to this intriguing developmental phenomenon. Such an alternative is provided by our contingency-based social biofeedback model of affect-reflective parental behaviors.

Note first of all that the three amodal features (time, intensity, and shape) identified by Stern as the abstract stimulus properties matched in affect attunements correspond to the three sources of contingency that the contingency-detection module monitors. Therefore, even if an attunement behavior is presented only on a single occasion, the combined value of the three contingency parameters can be sufficient to indicate a highly but imperfectly contingent external stimulus that is controlled by the infant's preceding behavior. In other words, the contingency detection device will categorize the parent's attunement behavior as a causal consequence of the infant's on-going activity, resulting in a momentary sense of causal efficacy and the concomitant induction of positive arousal. The ensuing fleeting sense of causal control and instrumentality will become associated with the particular act that the infant is engaged in while being attuned to. This leads to our first proposal concerning the developmental function of reflective attunements. By momentarily attuning to them, the parent can selectively reinforce those affective, voluntary, or playful acts of the infant's that she would like to see continued or repeated in the future. In other words, reflective attunements are an efficient tool of early nonverbal socialization whereby the parent can selectively reinforce and shape the infant's emerging voluntary, goal-oriented, or playful social activities.

In a somewhat more speculative vein, we also would like to propose that selective attunements may serve an additional sensitizing and representation-building function as well. Recall that, unlike Stern's, our model assumes that the infant initially lacks awareness of his or her internal affective and proprioceptive states that accompany his or her behaviors. By providing a partial rendering of some of the amodal features of the target act in a different behavioral format, the attunement behavior presents the infant with a nonidentical but highly contingent externalized version of his or her procedural behavioral routine. As a result, the infant will form a representation of the reflected amodal features that will become

associated, due to their high degree of perceived contingency, with the nonconscious, primary, procedural representation of his or her on-going activity. In this way, reflective attunements result in the establishment of secondary representations of primary procedural states that will be more cognitively accessible and more subject to conscious awareness.

This hypothesized secondary representation building process can be conceived of as a special case of what Annette Karmiloff-Smith (1992) called *representational redescription.* She argued that the human mind has the capacity to access and re-represent in a more explicit and cognitively accessible form the implicitly represented structural information embedded in nonconscious, automatic procedural routines. Although Karmiloff-Smith's theory postulates an innate endogenous epistemic drive that carries out such a process of self-discovery of one's own mind, our social biofeedback model identifies the contingent reflective externalizations provided by social partners as the informational basis for re-representing the amodal internal structure of nonconscious primary representations.

But do affect attunements serve the function of interpersonal communion or internal state sharing as well, as suggested by Stern? Our guess is that initially this may not yet be the case, especially in so far as the infant has not yet been sensitized to his or her internal categorical affect states as a result of the social biofeedback training provided by affect-reflective interactions. We agree, however, that communicating the sharing of internal states may become a secondary function of attunement behaviors later in life. In verbal behavior, paraphrasing often serves the function of informing the other that the underlying meaning of his or her surface utterance has been correctly encoded. Nonverbal reflective attunements are likely to come to serve a similar communicative function as well later in life.

Meltzoff and Gopnik's "Like Me" Hypothesis

Meltzoff and Gopnik (Gopnik & Meltzoff, 1997; Meltzoff, 1990; Meltzoff & Gopnik, 1993) have proposed that imitative interactions between caregivers and infants can provide a basis that could lead babies to pay special attention to fellow human beings. This arises in specific regard to the times that the caregivers imitate their infants as opposed to when the babies imitate the caregivers. Meltzoff and Gopnik propose that an infant may use his or her innate cross-modal capacity to map the caregiver's visual movements onto the proprioceptive feelings of his or her own movements that the parent is imitating. The caregiver's movements become attractive (attention capturing) because they are perceived (via the mapping) to be very much like the baby's own. Meltzoff and Gopnik hypothesize that it is this *"like me" experience* that explains the infants' preferential attention and

smiling to the mimicking adult model over the only temporally contingent one in the in Meltzoff's (1990) preferential interaction study described earlier.

Since our contingency-based social biofeedback theory also generates specific predictions for the infant's attraction to parental mirroring acts, we would like to make explicit two important differences between our position and that of Meltzoff and Gopnik. First, Meltzoff and Gopnik (1993) assume that infants have direct introspective access to their internal feeling states from the beginning of life. By contrast, we are assuming that, initially, much of infants' state transitions are outside of their perceptual awareness. We assume this to be so both for the visceral and physiological state cues that accompany basic emotion states and for much of the proprioceptive consequences of facial muscular movement. Indeed, a central aspect of our model is that such internal state cues only become liminal after a period of biofeedback sensitization brought about as a result of parental mirroring interactions. This difference in assumption about what is and what is not felt by an infant is not likely to be resolvable empirically, however. The reason for this pessimism is that we, and very likely Meltzoff and Gopnik as well, are using the term *felt* in the sense of a state of conscious awareness. For example, we do not contend that the infant has no functional use of proprioceptive feedback from facial muscle movement before social mirroring experiences. What we contend is that whereas such feedback exists and is used in various motor control systems, it does not enter conscious awareness. As adults, many motor events are subliminal until we attend to them; for example, eye movement, head rotation, chest diaphragm expansion, and even limb motion. But it is not easy to think of how to measure such a distinction in relation to the subjective experience of an infant.

The second point of difference between our model and Meltzoff and Gopnik's "like me" hypothesis about the attractiveness of social mirroring is far more assessable empirically. The "like me" hypothesis seems to clearly predict that theative mirroring reproduces the infant's behavior, the more attractive it will be for the baby. By contrast, we assume (see Bahrick & Watson, 1985; Watson, 1994) that after about 3 months, the target setting of the contingency detection module of the normal human infant is switched toward seeking out high but imperfect degrees of contingency. This predicts a preference for high but imperfectly contingent mirroring displays over perfectly contingent ones, whereas the opposite prediction follows from the "like me" hypothesis.

Our explanation for the looking pattern in Meltzoff's (1990) study is that the mimicking model provides a high but nevertheless only imperfectly contingent action that is preferred as such over the simply temporally

contingent model that produces a much lower degree of contingency. We agree with Meltzoff and Gopnik that the infants appear to use the spatial (or structural) information in differentiating between the two models. Somewhat tautologically, however, we propose that the preference for the temporal plus spatial (the mimicking adult) over the just temporal (the alternative model) contingency simply indicates that the imitating model provided a contingency magnitude that was closer to the target criterion of best (high-but-not-perfect) contingency of the contingency detection module than was the alternative model.

The "Nearly, but Clearly Not, Like Me" Hypothesis

In contrast to Meltzoff and Gopnik's "like me" hypothesis, however, we predict that if given a choice between a perfectly contingent versus the highly but only imperfectly contingent imitative display used by Meltzoff, the infant (after 3 months) would preferentially attend to the latter. In other words, we predict that the infant would be attracted to the "nearly, but clearly not, like me" versus the "like me" display. The infant would do so, because rather than preferentially orienting toward a self-like (perfect) contingency, the infant is committed to engage contingencies that are specifically not self-based (i.e., not perfect).

Judit Magyar, in her Ph.D. research, has specifically contrasted the effect on young children's behavior of the availability of perfect versus imitative feedback of their manual activity (see Magyar & Gergely, 1998). Magyar tested 32 normal subjects (between 18 and 36 months of age) who sat in front of two TV monitors each displaying the moving image of a schematic hand. The subjects moved a small metal bowl (with a computer mouse hidden inside) freely on the surface of the table in front of them. On one of the screens, they saw the perfectly response-contingent movements of the schematic hand generated by a computer program controlled by the subjects' manual manipulation of the bowl. The second screen displayed a highly but imperfectly response-contingent image of the schematic hand that was generated by the imitative efforts of a human experimenter. This person attempted to faithfully copy the subject's manual behavior by moving a mouse under the visual guidance of the subject-generated movements of the schematic hand (the perfect feedback display) viewed on a separate monitor in another room. This procedure was used in an attempt to provide the normal lag and imperfection of a human act of direct imitation. Magyar found (see Fig. 5.1, Panel A) that normal children attended more to the imitation-based (highly but imperfectly) contingent image than to the perfectly contingent one ($p < .05$). This, then, provides support for our hypothesis that normal children are selectively attracted to response-con-

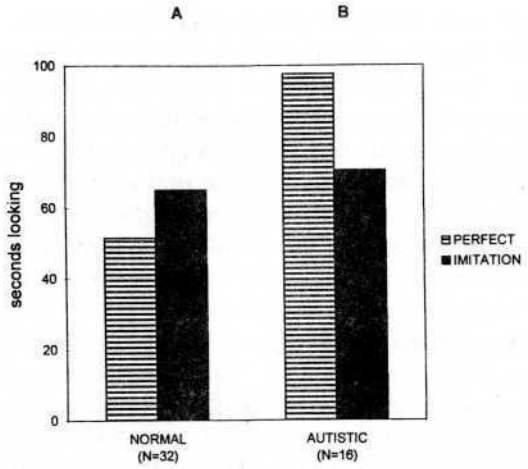

FIG. 5.1. Looking times at video monitors containing "imitative" versus "perfect" computer simulation of image movement contingent on hand movement for 32 normal children (Panel A) and for 16 autistic children (Panel B).

tingent stimuli that are "nearly, but clearly not, like me" rather than being "just like me."

CONTINGENCY DETECTION AND CHILDHOOD AUTISM: A HYPOTHESIS

Finally, we would like to briefly further sketch a hypothesis initially developed by one of us (Watson, 1994) that considers the aetiology of childhood autism to be related to a genetically based dysfunction of the contingency detection module. In recent years, a number of new hypotheses have been offered concerning the primary causes of autism. These have ranged from global deficits such as "a missing drive for global coherence" (Frith, 1989); to specialized modular deficits such as a missing "theory of mind module" (Baron-Cohen, Leslie, & Frith, 1985; Leslie, 1994); a deficient "eye tracking module" (Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997); a deficient "attention switching mechanism" (Courchesne et al., 1994); an "executive function deficit" (Ozonoff, Pennington, & Rogers, 1991; Russell, 1996); or a deficient "imitation mechanism" (Meltzoff & Gopnik, 1993)—each concentrating on some subset of the complex symptom cluster of this pervasive developmental disorder. This is not the occasion to compare the relative merits of these proposals; neither shall we contrast them in any detail to the alternative view we are offering. Our present aim is simply to add to the list of these intriguing theories a conceptually different approach that we believe sheds new light on a number of the central symptoms that characterize childhood autism.

Earlier in this chapter we argued on the basis of a set of infant learning studies (Watson, 1979, 1985) and a set of studies on preferential looking

at visual feedback of body motion (Bahrick & Watson, 1985; Field, 1979; Papousek & Papousek, 1974; Rochat & Morgan, 1995; Schmuckler, 1996) that there is a biologically based transition around 3 months of age in the preferred target setting of the contingency detection module. During the first 2 to 3 months, infants are preferentially engaging perfect response-stimulus contingencies typically provided by cyclic repetitions of body-centered activities (which Piaget, 1936/1952, described as primary circular reactions). We hypothesized that the self-generated perfect contingencies provide an important source of self-calibrating information (Watson, 1994) leading to the progressive differentiation of the self and the construction of the primary representation of the body schema. In the long run, however, selective evolutionary pressure is for adaptation to the external environment. In service of this requirement, infants must shift orientation from self-based perfect contingencies to environment-based contingencies. This shift is accomplished by resetting the target magnitude of the contingency detection module from perfect to something discriminably less than perfect at about 3 months of age. By doing that, an infant's preference shifts from engaging self-stimulation to engaging stimulus consequences of action on the environment that, for a variety of reasons, typically provide less than perfect contingent effects. As a result, in normal infants, after 3 months of age the preferential engagement in primary circular reactions is progressively replaced by producing and attending to secondary circular reactions; that is, by exploring the external stimulus consequences of acts on the environment. We also argued that the infant-induced reactions of responsive social objects, such as affect-reflective mirroring interactions or repetitive gamelike interactions (Watson, 1972), provide optimal, highly but imperfectly response contingent stimulation that approximates best the preferential target value of the contingency detection device after 3 months. This functions as the basis for the infant's emerging orientation toward and exploration of the social environment and forms the basis for the establishment of the representations of object relationships with primary attachment figures.

Our proposal concerning the aetiology of autism is a simple one. We hypothesize that in autistic individuals the normal shift at around 3 month (as triggered by maturation or experience) in the genetically based target value of the contingency detection module does not take place (or not by enough) and, as a result, autistic children continue to invest in perfect contingencies throughout their life. This tragic devotion to life-long perfection seeking can be seen as underlying a wide range of the symptoms characteristic of autism, as we shall try to briefly indicate here.

1. *Stereotypies.* Autistic children often exhibit characteristic behavioral rhythmicities and stereotypic motor activities as well as an intolerance of

variation in routines. These central features of the disorder can be seen as a direct consequence of the fact that the target setting of the contingency detection module remains in its original position of seeking out perfect contingencies. The preference for invariance and the repetitive engagement in primary circular reactions generate close to perfect response-stimulus contingencies, whereas the high but imperfect contingencies provided by responsive social interactions remain too low in contingency value to positively engage the autistic child's attention.

2. *Executive function problems.* Perseveration with habitual routines and a difficulty in inhibiting circular reactions may contribute to the difficulties that autistic children show in carrying out complex, planned, goal-directed activities. They can also be expected to be less motivated and efficient in engaging in planning action outcomes involving conditional (less than perfect) contingencies, especially when competing habitual action alternatives with clearly predictable perfectly contingent outcomes are available.

3. *Aversion to social objects.* To be able to predict the behavior of social objects, one needs to learn about the significance of dispositional behavioral cues, which, however, are displayed in a contingency matrix that is by necessity lower than perfect. By hypothesis, autistic children show a deficit in attending to and processing the facial and gestural dispositional cues produced by their social environment. This will render the behavioral variation of social partners largely unpredictable to autistic children, which will be anxiety provoking and will lead to aversion to and avoidance of social interaction.

4. *Inattention to faces and lack of social responsivity.* Whether or not there exists an innate bias to orient toward faces (see Morton & Johnson, 1991), there is reasonable evidence that the power of faces to attract attention and elicit smiling increases markedly at around 3 to 4 months in the life of a normal infant. Watson (1972, 1981) proposed that the face acquired special ethological potency for eliciting smiling and drawing attention by virtue of its association with high but not perfect contingency as exemplified in repetitive gamelike face-to-face interactions. In this view, the failure of an autistic infant to modify contingency seeking from a target of perfect to high but not perfect undermines the infant's capacity to engage the early interactional games that normally would generate the special social potency of the face to capture attention and elicit smiling.

5. *Lack of social understanding.* Inferring actions of others based on attributed dispositional and intentional mental states implies a sensitivity to the behavioral cues (such as facial expressions or gaze direction) that indicate such internal states in others. Note that such discriminative cues enter into conditional probability relations with consequent actions that are typically less than perfect and, therefore, may be missed by autistic children. This fact, together with the inattention to facial cues discussed

earlier, may help explain the profound difficulties autistic children have in reading other peoples' minds.

6. *Emotional impulsivity and abnormal sensitivity to internal stimuli.* Autistic children have serious problems in impulse control, showing uncontrollable tantrums and irritability. This may be related to the fact that parental affect-reflective mirroring interactions, which as we have argued, play a central causal role in the development of emotional self-awareness and control, are by necessity high but imperfect in contingency. Therefore, due to the setting of the target value of the contingency detection module to seek out only close to perfect contingencies, autistic children may simply not register the less than perfectly contingent relation between the parent's mirroring displays and their own affect-expressive behaviors. As a result, they will not anchor the representations of marked affect-reflective displays to their own internal self states, and so they will not establish secondary representations for their dispositional emotion states. This predicts a consequent deficiency in being perceptually aware of internal affect states as well as an inability to anticipate and control emotional impulses. Furthermore, due to their 'blindness' to lower than perfect contingencies, the hypothesized sensitization to internal state cues that results from the social biofeedback effects of affect mirroring is also likely to be impaired. This may explain the characteristically abnormal thresholds to internal stimuli (such as pain) found in autistic individuals.

7. *Lack of pretense.* If the availability of secondary representations and an understanding of 'markedness' as a generalized communicative code associated with decoupling (see previous and Gergely, 1995a, 1995b; Gergely & Watson, 1996) are cognitive prerequisites for understanding and producing pretense (Leslie, 1987, 1994), the inability to process marked affect-mirroring displays may contribute to an autistic child's deficient ability to comprehend and produce pretend play. This could be so in so far as the repeated encounters with marked forms of emotion displays during affect-regulative mirroring interactions are causally involved in the acquisition of markedness as a cue of decoupling and suspension of dispositional outcomes (Gergely, 1995a, 1995b; Gergely & Watson, 1996). Since marked affect-reflective displays are characterized by less than perfect degrees of contingency, autistic infants, due to their dysfunctional obsession with only perfectly contingent stimulation, are likely to show deficiency in processing and producing marked transforms of behavioral expressions and will lack understanding of the representational implications of such expressions.

This brief account of autism as 'blindness' to less than perfect contingencies is admittedly highly speculative. One obvious reason for caution has to do with the fact that the supporting evidence concerning the contingency switching hypothesis at 3 months comes from studies with normal

infants only. Until now, we had no direct evidence to indicate that autistic children remain seekers of perfect contingencies. Judit Magyar's Ph.D. research, however, has changed this situation by providing the first indication that autistic children react to response-stimulus contingencies significantly differently than normals. We have briefly described her study (Magyar & Gergely, 1998) which showed that normal children preferentially orient toward a highly but imperfectly contingent (imitative) feedback of their manual actions when compared to a perfectly contingent computer-generated feedback. Magyar has also tested 16 autistic children on the same task and found the opposite effect. The autistic children spent significantly more time ($p < .02$) looking at the perfectly contingent computer-generated feedback than at the imitative, human-generated feedback display (see Fig. 5.1, Panel B).

CONCLUSION

Our discussion has been primarily a theoretical venture. The theory we have advanced, regardless of its degree of validity, is clearly a product of its time. It is basically a story in the tradition of nurture over nature, but it recruits some basic guidance for nurture in the form of our proposed contingency seeking module. Modules are, of course, a way of patching nurture with nature; and although we hesitated to add another member to the growing modularity family, it was a temptation we could not resist. Our theory of early socio-emotional development is also of its time in that it draws heavily on recent conceptual advances regarding mental representation. The theory also embraces the classic but still current assumption about the important causal role of affect-mirroring in human socio-emotional development. The potential virtue of our theory, as we see it, is that it provides a relatively precise story as to how this uniquely human form of early caregiving behavior might be responsible for an infant's development of emotional awareness and emotional control behavior.

We believe our theory has some unique heuristic value. Magyar's study of contingency preference should at least illustrate the degree to which certain assumptions of the theory are empirically testable. We would note as well that the theory's specific prescription for marked affect reflection introduces the basis for empirical predictions about developmental outcome when this process is deficient or disorganized (see Gergely & Watson, 1996, for some examples). We also are hopeful that this theory may offer some fruitful perspective on patterns of deviant development resulting from specific faults in the contingency-seeking module. Our attempt to consider autism as one such case is a tentative step toward that goal.

REFERENCES

Bahrick, L. R., & Watson, J. S. (1985). Detection of intermodal proprioceptive-visual contingency as a potential basis of self-perception in infancy. *Developmental Psychology, 21,* 963-973.

Bandura, A. (1992). Social cognitive theory of social referencing. In S. Feinman (Ed.), *Social referencing and the social construction of reality in infancy* (pp. 175-208). New York: Plenum Press.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind.* Cambridge, MA: MIT Press.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21(7),* 37-46.

Barresi, J., & Moore, C. (1996). Intentional relations and social understanding. *Behavioral and Brain Sciences, 19,* 107-154.

Beebe, B., Jaffe, J., & Lachmann, F. M. (1992). A dyadic systems view of communication. In N. Skolnick & S. Warshaw (Eds.), *Relational perspectives in psychoanalysis* (pp. 61-82). Hillsdale, NJ: Analytic Press.

Beebe, B., & Lachmann, F. M. (1988). The contribution of mother-infant mutual influence to the origins of self- and object representations. *Psychoanalytic Psychology,* 5, 305-337.

Beebe, B., Lachmann, F. M., & Jaffe, J. (1997). Mother-infant interaction structures and presymbolic self- and object representations. *Psychoanalytic Dialogues,* 7(2), 133-182.

Bettes, B. A. (1988). Material depression and motherese: Temporal and intonational features. *Child Development, 59,* 1089-1096.

Bion, W. R. (1962). *Learning from experience.* New York: Basic Books.

Bion, W. R. (1967). A theory of thinking. In *Second thoughts* (pp. 110-119). London: Heinemann.

Birch, H. G., & Lefford, A. (1967). Visual differentiation, intersensory integration, and voluntary control. *Monographs of the Society for Research in Child Development, 32* (Serial No. 110).

Bloom, K, (1979). Evaluation of infant vocal conditioning. *Journal of Experimental Child Psychology, 27,* 60-70.

Bower, T. G. R. (1974). *Development in infancy.* San Francisco: W. H. Freeman.

Bowlby, J. (1969). *Attachment and loss: Vol. 1. Attachment.* New York: Basic Books.

Brazelton, T. B., Koslowski, B., & Main, M. (1974). The origins of reciprocity: The early mother-infant interaction. In M. Lewis & L. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 49-76). New York: Wiley.

Bretherton, I. (1991). Intentional communication and the development of an understanding of mind. In D. Frye & C. Moore (Eds.), *Children's theories of mind: Mental states and social understanding* (pp. 49-75). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bretherton, I., & Bates, E. (1979). The emergence of intentional communication. In I. C. Uzgiris (Ed.), *Social Interaction and Communication during Infancy* (pp. 81-100). San Francisco: Jossey-Bass.

Bruner, J. S. (1990). *Acts of meaning.* Cambridge, MA: Harvard University Press.

Bruner, J. S., Olver, P. R., & Greenfield, P. M. (1966). *Studies on cognitive growth.* New York: Wiley.

Cohn, J. F., Matias, R., Tronick, E. Z., & Connell, D. (1986). Face-to-face interactions of depressed mothers and their infants. *New Directions for Child Development, 34,* 31-45.

Cohn, J. F., & Tronick, E. Z. (1988). Mother-infant face-to-face interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology, 24,* 386-392.

Colombo, J., Mitchell, D. W., Coldren, J. T., & Atwater, J. D. (1990). Discrimination learning during the first year: Stimulus and positional cues. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 98-109.

Csibra, G., &: Gergely, G. (in press). The teleological origins of causal mentalistic explanations: A developmental hypothesis. *Developmental Science.*

De Casper, A. J., & Prescott, P. A. (1984). Human newborns' perception of male voices: Preference, discrimination, and reinforcing value. *Developmental Psychobiology, 17,* 481-491.

Demos, V. (1986). Crying in early infancy: An illustration of the motivational function of affect. In T. B. Brazelton & M. W. Yogman (Eds.), *Affective development in infancy* (pp. 39-73). Norwood, NJ: Ablex.

Dicara, L. V. (1970). Learning in the autonomic nervous system. *Scientific American, 222,* 30-39.

Ekman, P. (1992). Facial expressions of emotion: New findings, new questions. *Psychological Science, 3,* 34-38.

Ekman, P., Friesen, W. V., & Ellsworth, P. (1972). *Emotion in the human face.* New York: Pergamon Press.

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes between emotions. *Science, 221,* 1208-1210.

Fagen, J. W., & Rovee, C. K. (1976). Effects of quantitative shifts in a visual reinforcer on the instrumental response of infants. *Journal of Experimental Child Psychology, 21,* 349-360.

Field, T. (1979). Differential behavioral and cardiac responses of 3-month-old infants to a mirror and peer. *Infant Behavior and Development, 2,* 179-184.

Field, T. (1994). The effects of mother's physical and emotional unavailability on emotion regulation. *Monographs of the Society for Research in Child Development,* 59(23).

Field, T., Guy, L., & Umbel, V. (1985). Infants' responses to mothers' imitative behaviors. *Infant Mental Health Journal, 6,* 40-44.

Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., Zimmerman, E. A., & Kuhn, C. (1988). Infants of depressed mothers show "depressed" behavior even with nondepressed adults. *Child Development, 59,* 1569-1579.

Fonagy, P., & Target, M. (1996). Playing with reality: I. Theory of mind and the normal development of psychic reality. *International Journal of Psycho-Analysis, 77,* 217-233.

Fonagy, P., & Target, M. (1997). Attachment and reflective function: Their role in self-organization. *Development and Psychopathology, 9,* 677-699.

Freud, S. (1949). *An outline of psycho-analysis* (Rev. ed., J. Strachey, Trans.). New York: Norton. (Original work published 1940)

Frith, U. (1989). *Autism: Explaining the enigma.* Oxford: Basil Blackwell.

Gergely, G. (1995a, March). *The role of parental mirroring of affects in early psychic structuration.* Paper presented at the International Psychoanalytic Association's Fifth Conference on Psychoanalytic Research: "Advances in Our Understanding of Affects: Clinical Implications," London.

Gergely, G. (1995b, March). *The social construction of self-awareness and first-person authority.* Paper presented at the Twelfth SRCD Conference, Indianapolis.

Gergely, G., &: Csibra, G. (1996, April). *Understanding rational actions in infancy: Teleological interpretations without mental attribution.* Paper presented at the Symposium on "Early Perception of Social Contingencies" at the Tenth Biennial International Conference on Infant Studies (ICIS), Providence, RI.

Gergely, G., & Csibra, G. (1997). Teleological reasoning in infancy: The infant's naive theory of rational action. A reply to Premack and Premack. *Cognition, 63,* 227-233.

Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition, 56,* 165-193.

Gergely, G., & Watson, J. S. (1996). The social biofeedback theory of parental affect-mirroring: The development of emotional self-awareness and self-control in infancy. *International Journal of Psycho-Analysis, 77,* 1181-1212.

Gewirtz, J. L., & Pelaez-Nogueras, M. (1992). Social referencing as a learned process. In S. Feinman (Ed.), *Social referencing and the social construction of reality in infancy* (pp. 151-173). New York: Plenum Press.

Gholson, B. (1980). *The Cognitive-Developmental Basis of Human Learning: Studies in Hypothesis Testing.* New York: Academic Press.

Gopnik, A., & Meltzoff, A. (1997). *Words, thoughts, and theories.* Cambridge, MA: MIT Press.

Gottman, J. M., & Ringland, J. T. (1981). The analysis of dominance and bidirectionality in social development. *Child Development,* 52, 393-412.

Hains, S. M. J., & Muir, D. W. (1996). Infant sensitivity to adult eye direction. *Child Development, 67,* 1940-1951.

Hobson, R. P. (1993). *Autism and the development of mind.* Hove, UK: Lawrence Erlbaum Associates.

Izard, C. E. (1977). *Human Emotions.* New York: Plenum Press.

Izard, C. E. (1978). Emotions as motivations: An evolutionary-developmental perspective. In H. E. Howe, Jr. (Ed.), *Nebraska Symposium on Motivation* (Vol. 26, pp. 163-199). Lincoln: University of Nebraska Press.

Izard, C. E., & Malatesta, C. Z. (1987). Perspectives on emotional development. I. Differential emotions theory of early emotional development. In J. D. Osofsky (Ed.), *Handbook of Infant Development* (2nd ed., pp. 494-554). New York: Wiley.

Jacobson, E. (1964). *The self and the object world.* New York: International Universities Press.

James, W. (1950). *The principles of psychology.* New York: Dover. (Originally published 1890)

Kagan, J. (1992). The conceptual analysis of affects. In T. Shapiro & R. N. Emde (Eds.), *Affects: Psychoanalytic perspectives* (pp. 109-129). Madison, WI: International Universities Press.

Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective on cognitive science.* Cambridge, MA: MIT Press.

Kaye, K. L., & Bower, T. G. B. (1994). Learning and intermodal transfer of information in newborns. *Psychological Science,* 5(5), 286-288.

Kaye, S. (1982). Psychoanalytic perspectives on learning disability. *Journal of Contemporary Psychotherapy, 13,* 83-93.

Kernberg, P. F. (1984). Reflections in the mirror: Mother-child interactions, self-awareness, and self-recognition. In J. D. Call, E. Galenson, & R. L. Tyson (Eds.), *Frontiers of infant psychiatry, vol. II* (pp. 101-110). New York: Basic Books.

Kohut, H. (1971). *The analysis of the self.* New York: International Universities Press.

Leekam, S., Baron-Cohen, S., Perrett, D., Milders, M., & Brown, S. (1977). Eye-direction detection: A dissociation between geometric and joint attention skills in autism. *British Journal of Developmental Psychology,* 75, 77-95.

Leslie, A. M. (1987). Pretense and representation: The origins of "theory of mind." *Psychological Review, 94,* 412-426.

Leslie, A. M. (1994). ToMM, ToBy, and Agency: Core architecture and domain specificity. In L. Hirschfeld & S. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 119-148). New York: Cambridge University Press.

Lewis, M., & Brooks, J. (1978). Self-knowledge and emotional development. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect* (pp. 205-226). New York: Plenum Press.

Lewis, M., & Michaelson, L. (1983). *Children's emotions and moods: Developmental theory and measurement.* New York: Plenum Press.

Magyar, J., &: Gergely, G. (1998, April). *The obscure object of desire: "Nearly, but clearly not like me": Perception of self-generated contingencies in normal infants and children with autism.* Poster, ICIS, Atlanta, GA.

Mahler, M., Bergman, A., & Pine, F. (1975). *The psychological birth of the human infant: Symbiosis and individuation.* New York: Basic Books.

Mahler, M., & McDevitt, J. B. (1982). Thoughts on the emergence of the sense of self, with particular emphasis on the body self. *Journal of the American Psychoanalytic Association, 30,* 827-848.

Main, M., & Hesse, E. (1990). Parents' unresolved traumatic experiences are related to infant disorganized attachment status: Is frightened and/or frightening parental behavior the linking mechanism? In M. T. Greenberg, D. Cicchetti, & E. M. Cummings (Eds.), *Attachment in the preschool years: Theory, research, and intervention* (pp. 161-182). The John D. and Catherine T. MacArthur Foundation series on mental health and development. Chicago: University of Chicago Press.

Malatesta, C. Z., &: Izard, C. E. (1984). The ontogenesis of human social signals: From biological imperative to symbol utilization. In N. A. Fox & R. J. Davidson (Eds.), *The psychobiology of affective development* (pp. 161-206). Hillsdale, NJ: Lawrence Erlbaum Associates.

Malatesta, C. Z., Culver, C., Tesman, R.J., & Shepard, B. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development, 54* (Serial No. 219).

Meltzoff, A. N. (1990). Foundations for developing a concept of self: The role of imitation in relating self to other and the value of social mirroring, social modeling, and self practice in infancy. In D. Cicchetti & M. Beeghly (Eds.), *The self in transition: Infancy to childhood* (pp. 139-164). Chicago: University of Chicago Press.

Meltzoff, A. N., & Borton, R. W. (1979). Intermodal matching by human neonates. *Nature, 282,* 403-404.

Meltzoff, A. N., & Gopnik, A. (1993). The role of imitation in understanding persons and developing a theory of mind. In S. Baron-Cohen, H. Tager-Flusberg, & D.J. Cohen (Eds.), *Understanding other minds: Perspectives from autism* (pp. 335-365). Oxford: Oxford University Press.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198,* 75-78.

Meltzoff, A. N., & Moore, M. K. (1989). Imitation in newborn infants: Exploring the range of gestures imitated and the underlying mechanisms. *Developmental Psychology, 25,* 954-962.

Millar, W. S. (1972). A study of operant conditioning under delayed reinforcement in early infancy. *Monographs for the Society for Research in Child Development,* vol. 37, no. 2, Serial No. 147.

Millar, W. S., & Watson, J. S. (1979). The effect of delayed feedback on infant learning reexamined. *Child Development, 50,* 747-751.

Miller, N. E. (1969). Learning visceral and glandular responses. *Science, 163,* 434-445.

Miller, N. E. (1978). Biofeedback and visceral learning. *Annual Review of Psychology, 29,* 373-404.

Moore, C., & Corkum, V. (1994). Social understanding at the end of the first year of life. *Developmental Review, 14,* 349-372.

Morton, J., & Johnson, M. (1991). The perception of facial structure in infancy. In G. R. Lockhead & J. R. Pomerantz (Eds.), *The perception of structure: Essays in honor of Wendell R. Garner* (pp. 317-325). Washington, DC: American Psychological Association.

Murray, L. (1992). The impact of postnatal depression on infant development. *Journal of Child Psychology and Psychiatry, 33,* 543-561.

Murray, L., Fiori-Cowley, A., Hooper, R., & Cooper, P. (1996). The impact of postnatal depression and associated adversity on early mother-infant interactions and later infant outcomes. *Child Development, 67,* 2512-2526.

Murray, L., & Trevarthen, C. (1985). Emotional regulation of interactions between two-month-olds and their mothers. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 177-198). Norwood, NJ: Ablex.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 32,* 1081-1105.

Papousek H., & Papousek, M. (1974). Mirror-image and self-recognition in young human infants: A new method of experimental analysis. *Developmental Psychobiology, 7,* 149-157.

Papousek, H., & Papousek, M. (1987). Intuitive parenting: A dialectic counterpart to the infant's integrative competence. In J. D. Osofsky (Ed.), *Handbook of infant development* (pp. 669-720). New York: Wiley.

Papousek, H., & Papousek, M. (1989). Forms and functions of vocal matching in interactions between mothers and their precanonical infants. *First Language, 9,* 137-158.

Piaget, J. (1952). *Origins of Intelligence.* New York: Norton. (Original work published 1936)

Pickens, J., &: Field, T. (1993). Facial expressivity in infants of depressed mothers. *Developmental Psychology, 29,* 986-988.

Ramey, C. T., & Ourth, L. L. (1971). Delayed reinforcement and vocalization rates of infants. *Child Development, 42,* 291-297.

Rochat, P., & Morgan, R. (1995). Spatial determinants in the perception of self-produced leg movements in 3- to 5-month-old infants. *Developmental Psychology, 31,* 626-636.

Rochat, P., Neisser, U., & Marian, V. (in press). Are young infants sensitive to interpersonal contingency? *Infant Behavior and Development.*

Rovee, C. K., & Rovee, D. T. (1969). Conjugate reinforcement in infant exploratory behavior. *Journal of Experimental Child Psychology, 8,* 33-39.

Rovee-Collier, C. K. (1987). Learning and memory in infancy. In J. D. Osofsky (Ed.), *Handbook of infant development* (2nd ed., pp. 98-148). New York: Wiley.

Russell, J. (1996). *Agency: Its role in mental development.* Hove: Lawrence Erlbaum Associates.

Sander, L. W. (1970). Regulation and organization of behavior in the early infant-caretaker system. In R. Robinson (Ed.), *Brain and early behavior.* London: Academic Press.

Schmuckler, M. A. (1996). Visual-proprioceptive intermodal perception in infancy. *Infant Behavior and Development, 19,* 221-232.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review, 84,* 127-190.

Skinner, B. F. (1948). *Walden two.* New York: Macmillan.

Sroufe, L. A. (1996). *Emotional development: The organization of emotional life in the early years.* New York: Cambridge University Press.

Stern, D. N. (1984). Affect attunement. In J. D. Call, E. Galenson, & R. T. Tyson (Eds.), *Frontiers of infant psychiatry, vol. II* (pp. 3-14). New York: Basic Books.

Stern, D. N. (1985). *The interpersonal word of the infant.* New York: Basic Books.

Stern, D. N., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: The sharing of feeling states between mother and infant by means of inter-modal fluency. In T. M. Fields & N. A. Fox (Eds.), *Social perception in infants.* Norwood, NJ: Ablex.

Trevarthen, C. (1979). Communication and cooperation in early infancy. A description of primary intersubjectivity. In M. Bullowa (Ed.), *Before speech: The beginning of human communication* (pp. 321-347). Cambridge: Cambridge University Press.

Trevarthen, C., & Hubley, P. (1978). Secondary intersubjectivity: Confidence, confiding and acts of meaning in the second year. In A. Lock (Ed.), *Action, gesture and symbol: The emergence of language* (pp. 183-229). New York: Academic Press.

Tronick, E. Z. (1989). Emotions and emotional communication in infants. *American Psychologist, 44,* 112-119.

Tronick, E. Z., Edward, M., Als, H., & Brazelton, T. B. (1977). Mutuality in mother-infant *interaction. Journal of Communication, 27,* 74—79.

Tronick, E. Z., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's responses to entrapment between contradictory messages in face to face interaction. *Journal of the American Academy of Child Psychiatry, 16,* 1-13.

Tronick, E. Z., & Field, T. (1986). *Maternal depression and infant disturbance.* San Francisco: Jossey-Bass.

Tronick, E. Z., & Cohn, J. F. (1989). Infant-mother face-to-face interaction: Age and gender differences in coordination and the occurrence of miscoordination. *Child Development, 60,* 85-92.

Tronick, E. Z., Ricks, M., & Cohn, J. F. (1982). Maternal and infant affective exchange: Patterns of adaptation. In T. Field & A. Fogel (Eds.), *Emotion and early interaction* (pp. 83-100). Hillsdale, NJ: Lawrence Erlbaum Associates.

Uzgiris, I. C., Benson, J. B., Kruper, J. C., & Vasek, M. E. (1989). Contextual influences on imitative interactions between mothers and infants. In J. J. Lockman & N. L. Hazen (Eds.), *Action in Social Context: Perspectives on Early Development* (pp. 103-127). New York: Plenum Press.

Walton, Gail E., Bower, T. G. (1993). Newborns form "prototypes" in less than 1 minute. *Psychological Science, 4,* 203-205.

Watson, J. B. (1930). *Behaviorism* (Rev. ed.). Chicago: University of Chicago Press.

Watson, J. S. (1967). Memory and "contingency analysis" in infant learning. *Merrill-Palmer Quarterly, 13,* 55-76.

Watson, J. S. (1972). Smiling, cooing, and "the game." *Merrill-Palmer Quarterly, 18,* 323-339.

Watson, J. S. (1979). Perception of contingency as a determinant of social responsiveness. In E. Thoman (Ed.), *The origins of social responsiveness* (pp. 33-64). Hillsdale, NJ: Lawrence Erlbaum Associates.

Watson, J. S. (1981). Contingency experience in behavioral development. In K. Immelmann, G. W. Barlow, L. Petrinovich, & M. Main (Eds.), *Behavioral development: The bielefeld interdisciplinary project* (pp. 83-89). New York: Cambridge University Press.

Watson, J. S. (1984a). Bases of causal inference in infancy: Time, space and sensory relations. In L. P. Lipsitt & C. Rovee-Collier (Eds.), *Advances in infancy research, vol. 3* (pp. 152-165). Norwood, NJ: Ablex.

Watson, J. S. (1984b). Memory in learning: Analysis of three momentary reactions of infants. In R. Kail & N. Spear (Eds.), *Comparative perspectives on the development of memory* (pp. 159-179). Hillsdale, NJ: Lawrence Erlbaum Associates.

Watson, J. S. (1985). Contingency perception in early social development. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 157-176). Norwood, NJ: Ablex.

Watson, J. S. (1994). Detection of self: The perfect algorithm. In S. T. Parker, R. W. Mitchell, & M. L. Boccia (Eds.), *Self-awareness in animals and humans: Developmental perspectives* (pp. 131-148). New York: Cambridge University Press.

Watson, J. S. (1995). Mother-infant interaction: Dispositional properties and mutual designs. In N. S. Thompson (Ed.), *Perspectives in ethology, vol. 11* (pp. 189-210). New York: Plenum Press.

Watson, J. S. (in press). Contingency and its two indices within conditional probability analysis. *The Behavior Analyst.*

Winnicott, D. W. (1967). Mirror-role of mother and family in child development. In P. Lomas (Ed.), *The predicament of the family: A psychoanalytical symposium* (pp. 26—33). London: Hogarth Press and the Institute of Psycho-Analysis.