Contingency Detection and the Contingent Organization of Behavior in Interactions: Implications for Socioemotional Development in Infancy

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In this report, the authors review studies addressing the issue of contingencies in social and nonsocial contexts during infancy. The review is divided into 4 groups of studies that suggest that (a) young infants detect contingencies unrelated to their behavior; (b) infants detect contingencies involving their behavior; (c) the study of contingency is pertinent for addressing behavioral organization within parent-infant interaction; and (d) there is a link between behavioral contingency in early infancy and global measures of socioemotional development that are predictive of social functioning at later points during childhood. Throughout the report, the pertinence of infant emotional responses during contingency-related tasks is emphasized. Finally, the authors delineate certain enduring questions regarding contingency experience in infancy and suggest ways of organizing research to address some of them.

The ability to detect contingencies between different environmental events is one of the quintessential features of adaptation throughout development (Alessandri, Sullivan, & Lewis, 1990; Canfield & Haith, 1991). Similarly, the learning of contingencies between one's own behavior and environmental events is also considered an important dimension of adaptation in childhood (Alessandri et al., 1990; Millar & Weir, 1992). Together, these aspects of learning permit individuals to predict events and organize their behaviors in coherent ways, either to avoid aversive consequences or to be subjected to desirable outcomes. A number of researchers, working within a range of theoretical perspectives, have proposed that such basic abilities are present either from birth (Flavell, 1985; Gewirtz & Palaez-Nogueras, 1992) or at least from a very young age (Canfield & Haith, 1991). As the building block on which future adaptive behaviors are based, these two aspects of learning are believed to contribute to various aspects of cognitive, social, and emotional development (Flavell, 1985; Gewirtz & Palaez-Nogueras, 1992; Sullivan, Lewis, & Alessandri, 1992; Symons & Moran, 1994; Watson, 1972; Wentworth & Haith, 1992).

The purpose of this article is to review the literature that has implicitly or explicitly been associated to the study of contingency detection and contingent behavioral organization in infancy. Specifically, we address four major themes. First, we examine studies that demonstrate that infants are able to learn contingencies between events that are independent of their own actions. Second, we review studies relating to the infant's ability to learn a contingency whose manifestation is dependent on his or her actions, that is, under his or her control. For the purposes of the present discussion, these two classes of contingency are referred to as environment-based and behavior-based contingencies, respectively. Researchers who have examined the behavioral organization of infants exposed to either type of contingency have documented the robustness and longitudinal stability of this basic mechanism across age groups (Millar & Weir, 1992; Sullivan, Lewis, et al., 1992), as well as the differences that exist between the abilities of infants subject to typical and atypical development (Millar, Weir, & Supramaniam, 1992). In addition, researchers have attempted to identify how certain characteristics of contingency detection may be related to the quality of affective responses in different contexts across development (Alessandri et al., 1990; DeCasper & Carstens, 1981; Fagen & Ohr, 1985; Gunnar, 1980; Watson, 1972).

A third subject we examine concerns the study of the contingent organization of behavior in social contexts, particularly within parent–infant interactions. Researchers in this area have often postulated that during infancy behaviors are gradually organized in coherent and temporally related manners around the behaviors of the social actors who provide the context for socioemotional development—most often this is the parents (Cohn & Tronick, 1983, 1988; Dunham & Dunham, 1990; Madewell & Haviland, 1982; Moran, Dumas, & Symons, 1992). Within this perspective, it is parents, rather than laboratory manipulations, who are viewed as the source of reinforcement for infant behaviors and emotional states. Consequently, it has often been speculated that parents who provide the most contingent, positive, and meaningful reinforcement create the optimal developmental environment for their infants (Dunham & Dun-
We examine the validity of this proposal. In addition, given that the domain of parent-infant interactions offers less methodological control to the observer than do nonsocial laboratory tasks, we give special attention to the different methods used to operationalize the notion of contingency in such contexts.

Finally, we consider the question of developmental outcome. By the end of the 1st year of life, infants possess behavioral characteristics that are related in coherent and meaningful ways to various facets of future functioning (see Kagan & Snidman, 1991; Pedlow, Sanson, Prior, & Oberklaid, 1993; and Stroufe & Fleeson, 1988). A number of constructs exist that address the issue of the quality of outcome from a variety of perspectives, such as infant-parent attachment (Ainsworth, Blehar, Waters, & Wall, 1978), temperament and other measures of infant behavioral characteristics (Brazelton, 1984; Pedlow et al., 1993; Rothbart, 1986), and certain aspects of cognitive (Rose, 1989) and emotional (Lewis, Sullivan, Ramsay, & Alessandri, 1992) development. Although the mechanisms underlying the contingent organization of behavior have been theoretically linked to the quality of development, empirical support is relatively meager. Very few researchers have attempted to document whether contingency detection or interactive contingencies in infancy are related to assessments of development, which do not directly address the issue of contingency. Basically, the question is, Does outcome, operationalized in social or nonsocial contingency-related tasks during infancy, relate to adaptation assessed using more global methods at later points of development? A number of researchers (e.g., Lewis et al., 1992) have made the suggestion that it might. We review studies that have addressed this issue and their implications for the study of developmental outcome.

Definitional and Conceptual Considerations

Before we enter into the core of the review, it is pertinent to address two issues, one definitional and one conceptual, regarding the notion of contingency. First, a contingency is defined as the presence of a temporal relationship between the occurrence of two events (Moran et al., 1992; Reber, 1985). Generally, a contingency is said to exist between Events A and B when the probability of occurrence of Event B, given the previous occurrence of A, is greater than that of B without A (Moran et al., 1992; Sackett, 1987; Watson, 1979). The relation between these events may or may not be causal because the existence of a contingency is a necessary, but not a sufficient, condition for inferring causality (Moran et al., 1992; Sackett, 1987). Moreover, the contingency may be either environment or behavior based (Watson, 1979). Environment-based contingencies are made up of events that are external to the individual and do not directly involve the individual's behavior. Behavior has no impact on the occurrence of any of the events involved, although behavior can be organized around contingencies that are detected, much like in a classical conditioning procedure. Consider the following example: A young boy, who enjoys reading in bed past his bedtime, has noticed that before coming in to check whether he is asleep, his father usually jingles his keys in his pocket as he walks down the hallway, signaling his impending arrival. The father's checking in on the child is contingent on the jingling of his keys in the hallway. The child, having made this observation, has detected an environment-based contingency between these two events. Not wishing to be caught reading past his bedtime by his father, the child turns off the light and hides the book as soon as he hears the keys jingle, thus organizing his behavior according to the environment-based contingency that he has detected.

A behavior-based contingency involves a behavior, or a set of behaviors, as the first event in the contingency. A behavior-based contingency is likened to a fixed-ratio, operant conditioning reinforcement schedule, in that the occurrence of an event is dependent on behavior. In the example above, in addition to the environment-based contingency that he has detected, the child has observed that some unwanted events (father's disapproval) are associated with his behavior (reading past bedtime). Thus, turning off the light and hiding his book is motivated by the jingling of keys, in the context of a behavior-based contingency that the child has been exposed to. Although this example is somewhat problematic because it involves an older child whose behaviors are willfully controlled, nevertheless it illustrates how both types of contingency can be used to anticipate events and organize behaviors to exert control over events (Haith, Hazan, & Goodman, 1988; Lewis et al., 1992). The behaviors and emotional manifestations associated with such expectations of events during infancy are at the center of research aimed at demonstrating the link between contingency in behavior organization and outcome (Seligman, 1975).

This statement leads to a perhaps more problematic conceptual issue. A number of researchers, working from a strong behaviorist framework, have questioned the scientific use of the terms expectation, expectancy, and anticipation, in relation to infant behavior when faced with contingent stimulation. The problem alluded to by these researchers may be summarized in the following manner: If an infant presses a button to see a colored picture and hear music, why must the "mentalist" notion of expectation be incurred? The fundamental principles of operant conditioning are more than adequate to explain such behavior. There is no need to seek more complex explanations, implying willful or conscious behavior on the part of the infant (Fagen, 1993; Gewirtz & Paláez-Nogueras, 1992, 1993; Schlinger, 1992, 1993).

Rather than become entangled in this philosophical and paradigmatic question, we choose to state our perspective on the data presented throughout this report. The central issue concerns an infant's capacity to organize behavior as a function of environmental events which are linked to other events or behavior. There is no implication that infant expectations are on the conscious level, although the issue of consciousness is clearly different whether one addresses it with neonates or with 2-year-olds. Even if consciousness were implied in expectation, this would have no bearing on the prediction of behavior. There is no functional difference with regard to the behavioral consequences of expectations, regardless of the behaviorist or cognitivist (or even meta-cognitivist) flavor that the term takes on. Our perspective is that cognitive processes, conscious or unconscious, are involved in the learning of contingencies, and that expectations, conscious or unconscious, are an essential feature of behavioral organization, and may well provide, in infancy,
one of the building blocks to the development of cognitive representations and socioemotional development (Canfield & Haith, 1991; Lewis et al., 1992).

The Detection of Environment-Based Contingencies

In this section, we are concerned with reviewing research demonstrating that infants are able to detect contingencies between events whose occurrence are not related to their behavior. Some of the most significant work in this area has been conducted by Marshall Haith et al. (1988) who have developed the visual expectation paradigm (VEP). The VEP is a 2-min laboratory procedure specifically devised to assess the ability of infants to anticipate the occurrence of stimuli. Within this procedure, infants, while lying on their backs, are exposed to patterned sequences of visual images, rapidly alternating between their left and right visual fields (L–R sequencing). Haith et al. assessed two dimensions of their behavior believed to represent their learning of the sequence and their expectation of stimuli occurrence. The first type of behavior consists of anticipatory visual fixations, where infants shift their gaze from one field to the other before the occurrence of the stimulus in that field. Second, infants may manifest that they have learned the pattern by showing faster reaction times during periods of contingent stimulation than during random stimuli presentation. Both characteristics of infant responses to the VEP are interpreted as indicating some element of expectation related to the detection of an environment-based contingency and reflect a form of behavioral organization.

With the VEP, Haith and colleagues have obtained data suggesting that contingency detection is characterized by a number of features that testify to the detailed processing abilities of infants. Infants as young as 6 weeks have demonstrated both anticipatory fixations and faster reaction times when exposed to simple L–R patterns of stimulus sequencing, suggesting that contingency detection abilities are present very early in infancy (Robinson, McCarty, & Haith, 1988). Haith and McCarty (1990) have shown that for 3-month-olds anticipatory behavior was stable over a 7-day span. In addition, 2- and 3-month-olds were able to anticipate and show faster reaction times to more complex patterns of stimulus sequencing (e.g., L–L–R or L–L–L–R; Canfield & Haith, 1991; Wentworth & Haith, 1992). Wentworth and Haith’s (1992) findings, infant visual preferences for film stimuli were linked to substance characteristics of the sound and images presented. Infants did not fixate either film stimuli if the sound was temporally contingent to the events in one film, but they did not match the attributes of the events (e.g., sound of blocks colliding presented with colliding sponges).

The results of such studies raise a number of questions concerning the features of environment-based contingencies that render them salient for infants. Studies that examine the relative contribution of the temporal and stimulus facets of infant response to contingency have yet to be carried out. How do infants respond in anticipation of the repeated exposure of a stimulus that occurs irregularly? Moreover, for understandable reasons, in all of the studies that have been encountered in this area researchers have used stimuli which infringe on infant attention in positive ways (lights, colors, images, etc.). These types of stimulation are appealing to infants and elicit the behaviors on which learning is inferred. How would infants respond, how-
ever, in similar situations involving other types of stimulation? Although it would be undesirable, and in some cases unethical, to conduct studies involving negative stimulation, it remains necessary to understand the contribution of stimulus valence to infant response to environment-based contingencies.

In summary, researchers in the area of perceptual development have extensively used infant ability to detect contingencies to illustrate that from a very young age children are actively involved in organizing behavior around environmental events. The degree of coherence in their behavior is dependent on the temporal characteristics of contingencies, as well as on the consistency, and thus predictability, of the physical features of the stimuli involved.

Behavior-Based Contingencies

Perhaps the most studied contingencies have been those where infant behavior formed one of the contingent events. Numerous researchers have documented that early in development, perhaps from birth, infants are sensitive to the manner in which their behaviors are related to environmental events in experimental and natural settings (Alessandri et al., 1990; Bahrick & Watson, 1985; DeCasper & Carstens, 1981; Fagen & Ohr, 1985; Fagen, Morrongiello, Rovee-Collier, & Gekoski, 1984; Gunnar, 1980; Lewis, Alessandri, & Sullivan, 1990; Millar, 1988; Millar & Weir, 1992; Millar et al., 1992; Rovee & Rovee, 1969; Sameroff, 1971; Sullivan & Lewis, 1989; Sullivan, Lewis, et al., 1992; Watson, 1972, 1979). Typically, these researchers have relied on paradigms that are composed of the following two elements: (a) The possibility exists for the infant to emit a behavior that will lead to the occurrence of a reinforcing event. This may be a naturally occurring behavior which, through some manipulation, is linked to an external event (e.g., tying the infant's foot to a ribbon, which is tied to a mobile, so when the infant kicks, the mobile moves; Rovee & Rovee, 1969) or a more traditional operant response, where the infant learns that pushing a button, pulling a string, or some other such behavior triggers an event (Millar & Weir, 1992). (b) A second characteristic of these studies consists of the contingency detection paradigm itself. Infants are first exposed to a baseline phase, where emitting the observed behavior is not reinforced. During the second phase, the behavior is reinforced; finally during the third phase, the behavior is extinct. The infant is said to have detected the contingency when responding during the second phase which follows a learning curve, different from the response rate in the first phase. Researchers who have used this traditional framework have illustrated that neonates to 10-month-olds quickly and efficiently learn both simple and complex relationships between an aspect of their behavior and an environmental consequence, or reinforcer.

Researchers have also used other procedures, stimuli, and responses to investigate how infants of various ages organize behavior as a function of external events. For example, Bahrick and Watson (1985) tested 3- to 5-month-olds to see if they could discriminate between the live and recorded movement of their leg on a television monitor. Within this particular design, Bahrick and Watson noted that the contingency is perfect—there is no delay between the behavior and the environmental event (i.e. the video image of the moving leg). The dependent variable, which operationalized contingency detection, was the difference in the duration of infant visual fixation between the monitors that showed the ongoing and recorded leg movements. Infants also wore bibs, which prevented them from simultaneously seeing the television monitors and their leg. They reported convincing results, indicating that infant fixation of the monitors clearly differentiated between the presence and absence of contingency (for examples of other types of procedures, see Julien, Pomerleau, Feider, & Malcuit, 1983; and Walton & Bower, 1993).

In general, and regardless of the design used, studies concerned with behavior-based contingencies have provided consistent support for the idea that infants quickly learn the link between certain aspects of their behavior and specific environmental consequences. Several researchers have proposed that this particular dimension of competence may be involved in the development of other behaviors throughout infancy (DeCasper & Carstens, 1981; Gewirtz & Palaez-Nogueras, 1992; Lewis et al., 1992; Seligman, 1975; Watson, 1979).

The traditional contingency detection paradigm has permitted researchers to observe infant behavior within the context of the violation of a learned contingency because some researchers have included an additional extinction phase, generally not present in other procedures. Infants learn that a relation exists between a behavior and an environmental event, and then abruptly, this relation is no longer present. How do they react? Among the researchers who have devoted attention to this question are Fagen and his colleagues (Fagen et al., 1984; Fagen & Ohr, 1985), Millar and colleagues (Millar, 1972; Millar & Weir, 1992; Millar et al., 1992), and Lewis, Sullivan, Alessandri, and their coworkers (Alessandri et al., 1990; Lewis et al., 1990, 1992; Sullivan, Lewis, et al., 1992). The results of these studies are highly convergent: When the learned contingency is violated, an infant's first usual response is an immediate increase in the observed behavior, followed by a decrease until the behavior occurs no more frequently than during baseline levels. The immediate increase in behavior has been likened to a frustration response on the part of the infant because the expected outcome to behavior no longer occurs (Alessandri et al., 1990). Such behavior supports the notion that infants build expectations as they organize their behavior in accordance with environmental consequences and that they show behavioral reactions when events no longer take place in accordance with these expectations (Alessandri et al., 1990; DeCasper & Carstens, 1981; Fagen et al., 1984).

To test the suggestion that behavioral response to contingency violation is related to infant frustration, Lewis, Sullivan, Alessandri, and their colleagues (see Alessandri et al., 1990; Lewis, Sullivan, & Brooks-Gunn, 1985; Lewis et al., 1992; Sullivan & Lewis, 1989; Sullivan, Lewis, et al., 1992) have published a number of reports where infant facial expressions during baseline, contingency detection and extinction were coded using the maximally discriminative facial coding system (MAX; Izard, 1983). This measure assesses patterns of facial movements, representing emotions frequently observed during infancy. Assessing emotional and behavioral responses simultaneously is of interest because of the close relationship between these two di-
mensions of development at this age (Izard, 1991). These researchers have found that, overall, for infants aged 2 to 8 months, manifestations of positive emotions (interest, joy, and surprise) predominate for infants during the acquisition phase, and that indices of negative emotions (anger, sadness, and fear) increase in frequency during the extinction phase. Sullivan, Lewis, et al. (1992) found stability in these results when infants were reassessed 2 months later. Infants who were not able to learn the contingency at all during the acquisition phase showed no changes on the level of behavioral response or facial expression (Sullivan & Lewis, 1988). Other researchers have obtained similar data by using global indices of affect during the learning and extinction phases with both younger and older infants (e.g., crying, Fagen & Ohr, 1985; cooing, Watson, 1972; and global activity, Decasper & Carstens, 1981). These results support the proposal that the detection of a contingency is associated with positively valenced affect, which is linked to the behavioral organization of the infant in the context of predictably occurring environmental events. When the contingency no longer exists between the behavior and the event, thus going against the anticipations of the infant, negatively valenced affect is associated with an immediate increase in the observed behavior.

As with the literature on environment-based contingencies, the role of stimulus characteristics remains relatively understudied. However, Gunnar and her colleagues (Gunnar, 1980; Gunnar, Leighton, & Peleaux, 1984; Gunnar-vonGnechten, 1978; for a review, see Parritz, Mangelsdorf, & Gunnar, 1992), who conducted several studies with 12-month-olds, suggest that the interpretation of certain stimuli as being positive or negative may depend on the nature of the contingencies in which they are involved. In all of these studies, the stimulus was a noisy toy monkey, perceived as potentially threatening to the infants. The onset of this toy was linked to a behavior-based contingency where it was preceded by the occurrence of a tone. In other conditions considered in these studies, the tone and the activation of the toy occurred randomly or the monkey was activated at regular intervals without prior warning. Two sets of results are noteworthy regarding the issue of contingency: First, when the onset of the toy was involved in a behavioral contingency, more frequent positive affect (smiling and laughing) and less frequent negative affect (full-blown crying and fussing) were observed in comparison with other conditions, including when the toy was regularly activated and when the monkey was activated at regular intervals without prior warning. This result is worth underlining in that the stimulus was originally selected because of its potentially threatening qualities. The behavior-based contingency that allowed the infant to control the activation of the toy monkey appeared to influence infant interpretation or appraisal of stimulus valence.

Second, the condition which elicited the most negative behavior and affect for boys was the environment-based contingency, where toy activation was preceded by a tone (Gunnar et al., 1984). For boys, this condition elicited greater levels of crying, fussing, and searching for proximity to mother. For girls, the condition where the toy monkey was regularly activated elicited greater levels of negative behavior and affect. In both cases, we interpreted negative behavior and affect as fear reactions on the part of the infant. Although the facial expressions linked to fear are not specifically coded (Lewis et al., 1990), the use of an aversive stimulus and the coding of approaches to the mother following its activation appear to provide a context in which it is legitimate to label extreme manifestations of negative affect as expressions of fear.

Thus, the same stimulus, originally considered as somewhat aversive to infants, was linked to positive behavior and affect in the context of behavior-based contingencies and to expressions of fear when presented as part of an environment-based contingency. Additionally, Gunnar (1980) found that the positive effects of behavior-based contingencies seem to be absent in younger children as observed in 12-month-olds, but not in 6- and 9-month-olds, underlining the importance of conducting contingency research with older infants. Both Lewis et al. (1990) and Millar et al. (1992) had underlined the influence of age in infant contingency detection ability in the context of positive stimulation. The use of aversive stimulation more saliently emphasizes the role played by age. Therefore, both infant age and gender appear to play a role in the behavioral and affective organization of infants exposed to contingencies involving a negative stimulus. Gunnar's research provides one of the rare instances in which both types of contingencies were examined in the context of a negatively valenced stimulus.

Lewis, Sullivan, Alessandri, and colleagues (Alessandri et al., 1990; Lewis et al., 1992; Sullivan, Lewis, et al., 1992) and others who have examined the role of contingencies in infancy (DeCasper & Carstens, 1981; Fagen et al., 1984; Millar & Weir, 1992; Watson, 1972, 1979) have proposed that the significant connection observed between behavior (operant response), cognition (expectations), and affect in the context of short laboratory procedures may be suggestive of the potential influence of environment-based and behavior-based contingencies on the behavioral, emotional, and cognitive development of infants. The picture that emerges is an infant who transacts with the environment in a manner that is organized according to, and compatible with, the coherence that he or she is exposed to on a behavioral, cognitive, and emotional level. However, for purposes of interpretation, we have been concerned with highly controlled experiments where environmental events correspond to little lights, images, sounds, brief segments of music, and noisy toys. Although such elements are present in the child's ecological milieu, they are not representative of the complexity of stimulations that a child must integrate from birth, including those in social interactions. Convinced of the importance of this mechanism in development, a number of researchers have attempted to integrate it in their accounts of parent-infant interactions and socioemotional development.

Conceptual and Methodological Considerations in the Study of Contingency in Interactions

We must address a number of points in a discussion of social and nonsocial contingencies. First, the focus of this article is on infant behavioral organization in the context of parent-infant (usually mother-infant) interactions. It is not denied that par-
ments are simultaneously involved in organizing their behaviors around those of their children. In fact, this aspect of contingency, often referred to in the context of studies of maternal responsiveness, is by far the most studied facet of contingency in interactions involving infants (Symons & Moran, 1994). This suggests that infants are able to reinforce the behaviors of adults in their social environment, as has been proposed by proponents of temperament theory (Rothbart, 1986). Maternal responsiveness researchers also testify to the dynamic properties of interactions and to the degree of cognitive sophistication necessary for participants to adequately account for the information constantly exchanged. However, in studies where parents are the focus, they speak more of adult rather than child competence, although the two may be related (Brazelton, 1984; Cohn & Tronick, 1988; LaFreniere & Dumas, 1992). Although adult responsiveness is clearly important in understanding the processes involved in interactions, we are solely interested in examinations of infant ability to coherently and contingently organize behavior around that of parents.

A second issue concerns the similarity of the two processes involved in detecting social and nonsocial contingencies. A number of researchers have suggested that infants are able to categorize stimuli into social and nonsocial domains (e.g., Ellsworth, Muir, & Hains, 1993). Many of these have attempted to show differences in infant visual fixations, smiling, and vocalizations to mothers, strangers, and objects. In an elegant study examining such variables in 3-month-olds, Ellsworth et al. demonstrated that infant smiles and vocalizations were more frequent when infants were confronted with either their mother or a stranger, in comparison with objects that resembled a person in varying degree. They claim that by 3 months infants are able to categorize social and nonsocial stimuli and organize their behaviors differently depending on the category of stimulus they are facing.

Conversely, Watson (1979) reported that infants act toward nonsocial objects in ways that resemble social behavior (smiling, cooing, etc.) if the nonsocial object "reacts" in a way that is contingent on infant behavior. Essentially, Watson stated that, in contingency detection tasks, affective behavior is akin to social behavior and that when an infant detects a contingency and uses it to organize behavior, the combination of behavior and affect takes on social-like properties. The extension of this argument is that contingency detection is neither social nor nonsocial but rather a generic mechanism that processes whatever information that happens to impinge on the infant's attention. Because it has been suggested that human interaction provides infants with the most frequent encounters of either environment- or behavior-based contingencies (Rovee-Collier, 1987; Stern, 1985; Watson, 1979), differences in behavior toward social and nonsocial objects may simply be related to the amount of experience that infants have had with both.

Recall also that Wentworth and Haith (1992) documented that familiarity with the stimulus positively influenced infant behavioral responses to contingencies. In both cases, the stimulus did not possess the dynamic and highly reinforcing quality of a person, but they increased the degree of attention the infant devoted to them, after only a few seconds of exposure. Usually, as in the Ellsworth et al. (1993) study, the previous social experience of infants is rarely incurred to explain differences in positive affect and vocalizations manifested toward people and objects. It is possible that within a given study, infants recognize people from objects because (a) people react in a manner which is contingent on the infant's behavior, (b) infants are more familiar with people, and (c) people provide the most salient and positive stimulation for the infant. Had infants been given previous contingent, frequent, and positively valenced experience with a nonsocial stimulus (e.g., a puppet that feeds the infant something sweet after lunch everyday and regularly interacts with them in a pleasant manner) and had this stimulus been included in the Ellsworth et al. study, the results may have been somewhat different with respect to the stranger (it is hard to believe that such a stimulus can compete with the mother for significance to the infant). Therefore, although it is a compelling explanation, it is difficult to conclude that infants are able to categorize between people and objects, rather than between stimuli that are contingently, frequently, and positively related to behaviors and events. Within the present review, it is suggested that the same mechanism is involved in both social and nonsocial behavior. In the least, if two mechanisms are involved in processing social and nonsocial contingency information, the data suggest that each mechanism functions in similar ways.

A third point that requires attention concerns methodology. Most studies that address the issue of contingency in interactions involve mothers and their infants. As previously mentioned, infants have had a history of interaction with their mother, which may influence the "universality" of the findings obtained. Infants in interaction with their mothers are not confronted with novel stimulation, as in nonsocial contingency detection tasks. Qualitative, individual differences in interactions exist, which may influence infant behavior during a task. Therefore, past history is always a consideration when determining the scope of the results reported (Gewirtz & Paláez-Navajas, 1992).

Within this particular context, a variety of paradigms exist that allow for the examination of contingency in interactions. The procedures that are closest to nonsocial contingency detection paradigms involve infant control of some facet of maternal behavior. Consider a recent study, where Millar (1988) used the contingency detection paradigm described earlier (Millar & Weir, 1992) exactly as in studies involving nonsocial events. The difference was that, under behavior-based contingency conditions, infants controlled (by touching a knob in front of them) the appearance of their mothers from behind a small curtain, rather than the appearance of a slide or the onset of music. As in nonsocial studies, Millar demonstrated that 7- and 10-month-olds responded more frequently when mother appeared contingently to their having touched the knob, then when mother did not appear or when mother appeared noncontingently. Unlike the nonsocial studies, however, there appeared to be age-related differences in the manifestation of affective behaviors in the contingent and noncontingent conditions, during learning and extinction. First, the learning effects were more pronounced for 10-month-olds than for 7-month-olds. Second, although 10-month-olds showed the expected increase in positive affective behavior during learning, 7-month-olds also showed increases when the appearance of the mother was not
contingent on the child's behavior. Furthermore, 7-month-olds increased their visual fixations of the spatial location of their mother's appearance during noncontingent conditions. Millar suggests that interactive history plays a different role for infants within the two age groups, with 10-month-olds being perhaps more "competent" at detecting social contingencies than 7-month-olds, who appear to respond to the mother during the procedure in the same way as younger infants respond to novel stimulation in a habituation paradigm (increased fixation and smiling during noncontingent conditions).

In this type of procedure, researchers must consider the similarity between maternal behavior in this context and in the home. As shown later, many of the interaction tasks that examine the question of contingency ask that the mother act in a way that is different from how she normally behaves at home. It is possible that a 10-month-old can already account for the possibility that her mother has in her repertoire behaviors for which the infant has no experience. Thus, in a laboratory procedure, it is not a major difficulty for older infants to be faced with strange behavior (popping out from behind a curtain). However, does the 7-month-old and younger infants differentiate between mother and the behaviors she emits in a laboratory setting? If part of the young infant's definition of mother is that she acts in ways that are expected, then this infant may be confused at her behavior in a laboratory. In Millar's (1988) study, 7-month-olds may not have "learned" the contingency as did 10-month-olds because throughout most of the task their mother was violating infant expectations of how she normally acts. Millar cautioned against the simple transposing of nonsocial laboratory procedures to social conditions, as well as against the grouping of infants of varying age groups.

Two studies that examined the affective responses of infants to strangers can perhaps shed some light on the issues raised by Millar's (1988) results. Parrott and Gleitman (1989) focused on the responses of 2- to 8-month-olds to strangers when they violated an environment-based contingency. They found that when a peek-a-boo game was modified in two different ways—(a) switching the person who appeared for a certain number of trials and (b) having the person appear in a different location without warning—there was a significant decrease in smiling, laughter, and eyebrow raises.

In a related report, Levitt (1980) obtained results that underline the role of behavior-based contingency experience when infants interact with strangers. After an initial baseline period, 9½- and 10½-month-olds were exposed to one of three different conditions: a contingent condition, where the infant touches a knob and makes a stranger appear from behind a puppet stage; a noncontingent, high-frequency condition; and a noncontingent, low-frequency condition. Unfortunately, Levitt did not include a condition that involved an environment-based contingency. Infant reactions to the stranger during a subsequent play session were then coded, where stranger behavior was scripted such that it was progressively more intrusive. Results indicated that when strangers were nonintrusive during the play session, positive affective reactions (smiling, positive vocalizations, and reaching for a stranger) characterized infants who were in the contingent or high-frequency condition. However, as strangers became more intrusive in their play (picking up the baby and saying "hi"), infants in the contingent condition manifested consistently more positive affect than those in the two random conditions. In fact, Levitt reported that as strangers became more intrusive, infants in both random conditions, but especially those in the low-frequency group, tended to manifest negative affect (crying, fussing, visual–postural avoidance, and facial distress). One interpretation of these results is that as strangers became more intrusive, and perhaps less comfortable for infants, prior contingency experience is a more salient variable than the frequency of exposure in determining infant affective reactions during play. Together with the Parrott and Gleitman (1989) report, these results emphasize the potential role that the inclusion of the mother may have played in the results obtained by Millar (1988) and suggest that when transposing methods of investigating contingency in the nonsocial domain to the study of mother–infant interaction, interactive history should somehow be taken into account.

The still-face paradigm (SFP), developed by Tronick, Als, Adamson, Wise, and Brazelton (1978), is a commonly used laboratory procedure to examine the question of contingency between maternal and infant behaviors. This procedure, intended for infants aged 1 to 6 months, is composed of three brief phases of different durations in various studies. During the first phase, the mother is instructed to playfully stimulate her infant as she normally would at home in the context of face-to-face interactions. Second, the mother passes from an interactive state to the still face, where she maintains a neutral facial expression and does not respond to infant signals. Finally, in the third phase, the mother returns to playful stimulation. The procedure relies on the assumption that normal interactions are contingently organized, and it capitalizes on infant reactions during violation of contingency (the second phase) to obtain information concerning infant behavioral organization (Tronick et al., 1978). They reported that during the second phase, the infants first attempted to continue interacting with their mothers but then quickly stopped smiling, averted their gaze, and may have protested. This typical behavior has been termed the still-face effect (SFE) and is believed to be related to negative affect, resulting from the violation of normal interactive contingencies. The SFE highlights the role that contingencies between infant and maternal behaviors can play in interactions, as under normal circumstances, mothers easily engage their child in positive, playful, and reciprocal interactions. In the still-face phase of the procedure, mothers are not attempting to elicit negative affect but are merely not acting as they normally would. That infants would react negatively to neutral maternal behaviors testifies to the importance of the contingencies by which mothers and infants interact. This observation is analogous to that made of infant behaviors in the violation of contingency involved in nonsocial tasks described earlier. Contingency between events and behav-
ior is characterized by positive affect and behavior, whereas violation of contingency is linked to negative affect and behavior.

Ellsworth et al. (1993) have noted that the SFE is easily influenced by a number of manipulations of maternal behavior (e.g., parent–infant separation before still-face procedure, Field, Yega-Lahr, Scafidi, & Goldstein, 1986; absence–presence of interactive behavior–sounds, Gusella, Muir, & Tronick, 1988) and that strangers are able to elicit SFEs. Again, such findings imply, as previously underlined, that the history of interactions may influence the quality of contingency-related observations conducted in paradigms where experimental manipulation of maternal behavior is involved.

Two points need to be made regarding the use of the SFP in studying interactive contingencies. First, a basic assumption is that the SFE is based on the difference in maternal behavior between the normal and still-face phases. Interactive history is rarely spoken of in this context, although studies involving mothers with depression in the SFP have shown that such an effect may be present (Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986). Second, in Millar (1988), one wonders what is the source of infant negative behavior during the still-face phase. Is it that a contingency established in a laboratory context has been violated, or is it that the mother is acting in a way that defies the infant’s understanding of mother. Recall Watson’s (1979) argument that nonsocial objects that act contingently to an infant’s behavior can elicit “social,” affective infant responses. Within the SFP, could the reverse situation take place? When the infant ceases to emit social (i.e., positive behavior), this may be an indication of the infant’s understanding of who mother is. Because the person in front of the infant does not act like mother, this is not mother. This possibility requires some consideration, given that most SFP studies are conducted when infants are quite young (2 to 6 months) and may still be developing their concept of mother. This issue is also related to the question of the relative contributions of contingency and stimulus characteristics in eliciting child behavior.

The examples from Millar (1988) and the SFP studies illustrate how contingencies are studied through manipulation of maternal behavior. However, most studies that have sought to examine contingencies in interactions have favored an approach where manipulation of maternal behavior is maintained at a minimum and where mothers and infants are observed in different contexts, ranging from free play or face-to-face, naturalistic settings (Symons & Moran, 1994) to laboratory situations involving complex, problem-solving types of tasks at later points in development (LaFrenière & Dumas, 1992). Typically, such studies attempt to show a greater than chance relation between maternal and infant behaviors occurring within a given time frame. A time frame is defined according to the needs and logistic possibilities of different researchers. Essentially, if the occurrence of a child’s behavior is said to have a greater probability of occurrence when it follows a specific maternal behavior, than when it takes place on its own, then a contingency is said to exist between the two actions. Different types of analyses are used to operationalize this principle (Cohn & Tronick, 1988; Fogel, 1988; LaFrenière & Dumas, 1992; for reviews, see Bakeman & Gottman, 1986; Moran et al., 1992; and Sackett, 1987).

Researchers who have examined contingency in interactions have shown results that parallel those of studies of contingency detection in nonsocial contexts. Thus, relations between a variety of maternal and infant behaviors have been established involving facial expressions (Malatesta, Culver, Tesman, & Shephard, 1989; Malatesta & Haviland, 1982) and other dimensions of affective behavior, such as smiles, fixations, gazes, and interactional phases (Cohn & Tronick, 1983, 1988; Moran, Krupka, Tutton, & Symons, 1987). Two of the limitations of such studies are that little work has been conducted with infants older than 6 months and, perhaps as a consequence, that few studies have focused on behavior that is not predominantly affective (smiles, coos, and eyebrow movement). There is, however, support for the conception that maternal and infant behaviors in nonaffective domains are also contingently related, as manifested in the works of P. Dunham and F. Dunham (lexical development; Dunham & Dunham, 1995; Dunham, Dunham, Tran, & Akhtar, 1991) and of Poulsone (generalized imitation; Poulsone & Kymissis, 1988).

Another theoretical concern in the study of contingency in interactions was first raised by Watson (1979) and reiterated by Moran, Symons, and Dumas (Moran et al., 1992; Symons & Moran, 1994). They contend that two different kinds of behavior-based interactive contingencies exist. The first is labelled responsiveness and refers to the kind of contingency that has thus far been discussed. If we take from Symons and Moran the example of infant smiles, then the analysis involved in examining this type of contingency asks the question, “Do infant smiles follow mother smiles?” The second type of contingency is dependency. Testing for the presence of this contingency would mean asking the question, “Do mother smiles have to take place before an infant smile can be observed?” The issue is one of sufficiency versus necessity. Few studies account for the second type of contingency, either in establishing its presence or suggesting how it may be involved in interactions. Together with other, aforementioned limitations, the lack of consideration for this type of contingency suggests that the study of interactions may still undergo considerable methodological and conceptual development.

In summary, studies which have examined the contingent, behavioral organization of infants either in social or nonsocial contexts confirm with regularity at least four major points: (a) Infants are able from a very young age to detect temporal links between environmental events and between their behaviors and environmental consequences. The data support the belief that infants are equipped with a mechanism whose functioning is based on the detection of relations between events and behaviors, and gears perception and attention in different sensory spheres, toward those stimuli that manifest coherence in their occurrence. This mechanism permits infants to predict and influence the occurrence of events in their immediate environments, thereby having potential motivational and adaptational implications. (b) A highly related, if not the same, mechanism is involved in the manner in which infants organize their social behaviors with their primary caregiver, and possibly with other adults. (c) In both social and nonsocial domains, contingent behavioral organization is highly correlated with specific affective manifestations—positive affect in the presence of contingency, or as the infant is learning the contingency, and negative
affect when this contingency is violated. The connection of behavior, cognition, and affect enforces the notion that the contingency detection mechanism possesses potential as a motivational and adaptational construct, providing a process by which the infant and environment transact and leading to representations of the external world based on the predictability of social and nonsocial events and on the perception of control that the infant is able to exert over some of these. (d) Infants are sensitive to both the temporal aspects of the contingency and to the attributes of the stimuli involved, although the manner in which the two elements interact is relatively understudied.

Several researchers have discussed the potential motivational and adaptational possibilities that may be related to the phenomena of contingency detection. Seligman (1975) emphasized that repeated exposure to environment-based contingencies involving aversive stimuli are related to the onset of depression-like symptoms in animals and people. Recall also the research of Gunnar and her colleagues (Gunnar, 1980; Gunnar et al., 1984), who found evidence that momentary exposure to such contingencies are linked to manifestations of fear in young infants. This formulation is suggestive of the potential role of stimulus characteristics in these types of contingencies. Watson (1979) underlined that when infants learned that they had behavioral control over the movement of an overhead mobile, the manifestations of positive affect during the experimental procedure increased in frequency. Gunnar (1980) observed that even when the stimulus was potentially aversive, it was linked to positive affect if it was part of a behavior-based, rather than an environment-based, contingency. In addition to these results, individual differences in contingency detection between normative and clinical samples at high biological and sociodemographic risk, in social and nonsocial contexts, have led to the suggestion that this mechanism may be involved in translating risk into less favorable outcome (Alessandri, Sullivan, Imaizumi, & Lewis, 1993; Brinker & Lewis, 1982; Jacobson et al., 1992; Millar et al., 1992; Stevenson, Roach, Ver Hoeve, & Leavitt, 1990). However, in spite of increasing recognition that one of the primary developmental tasks of infants is to see how events and behaviors are related, relatively few researchers have examined how this mechanism is related to individual differences in developmental outcome in samples of low-risk infants when environmental or biological variables are not sufficient to account for differences in development.

Contingency Detection, Contingencies in Interaction, and Outcome

Outcome as Response in Contingency Tasks

Consider the following study: DeCasper and Carstens (1981) subjected a group of neonates (less than 3 days old) to a variation of the traditional contingency detection paradigm. Here, infant non-nutritive sucking was associated to the onset of music. The neonates in this condition manifested all of the behaviors involved in contingency detection—acquisition of the behavior during the contingency sequence and increase in activity, interpreted as negative affect, in the noncontingent episode. A second group was first exposed to the noncontingent onset of music, then to contingent stimulation. The second group was unable to acquire the behavior during the contingent occurrence of music. DeCasper and Carstens claim that infants in the second group learned that music occurred haphazardly and that behavior was not linked to the onset of the observed event. Therefore, prior exposure to noncontingency, even in the context of a potentially positive stimuli (music), influenced the infant's ability to detect the presence of a behavioral contingency. The adaptational implications are similar to Seligman's (1975) learned helplessness hypothesis and suggest that during the course of development, continued exposure to noncontingency and, therefore, to the lack of predictability of events and perception of behavioral control may be related to the absence of adaptive behaviors in contexts when predictability would be possible. That the stimuli involved was positive emphasizes the role played by the absence of contingency.

Building on such data, Lewis et al. (1992) used a modified contingency detection task, where they subjected 2- to 8-month-olds to the first three phases (baseline, acquisition, and extinction) and to a fourth phase, made up of a second exposure to contingency. Here, they sought to examine whether infant behavioral and affective reactions during extinction—when an expectation of contingency is violated—are related to behavioral and affective manifestations during a subsequent learning sequence. They found that, among infants who were able to learn the contingency during the first phase, those who reacted with anger during extinction manifested greater levels of interest and enjoyment during the second learning phase than those who reacted with sadness or with both anger and sadness. Lewis et al. observed parallel results with respect to the role of anger and sadness during extinction for the operant response (arm pull) during the second learning phase, but the results did not reach statistical significance. As did DeCasper and Carstens (1981), Lewis et al. interpreted these findings as being connected to learned helplessness. The negative correlation observed between sadness during extinction and joy during the relearning phase may reflect a predisposition to process the perceived lack of behavioral control in a way that may lead to a form of passivity in cases when contingencies are present, thus limiting the quality of infant learning. Children who were angry during extinction may have processed the loss of control differently, enabling them to regain interest and to focus again on the task in an efficient manner during the second learning phase. Lewis et al. propose that such differences in behavioral and affective organization during the extinction and relearning phases of the task may reflect early differences in development, possibly related to more general manifestations of functioning during other periods of development.

The Lewis et al.'s (1992) findings are particularly noteworthy in that they support certain elements of recently stated cognitive theories of emotion (Scherer, 1993; Smith & Lazarus, 1990). Such theories emphasize the role played by appraisals of events as a function of goals, needs, and available coping resources. In this context, the emotions of sadness and anger are conceptually close, as in both cases the person is prevented from attaining a goal. They differ only in the degree to which the individual expects to have control over them, where the expectation of control is linked to anger. When no control is antici-
panied, sadness occurs. Thus, in the Lewis et al. study, infants who manifest sadness may be experiencing little control over the task, as evidenced by their loss of interest and pleasure during the fourth phase of the procedure. Infants who show anger during extinction are assumed to expect control over the task, and it is those infants who maintain interest in the contingency during the second acquisition phase.

One of the theoretical issues with the data provided by DeCasper and Carstens (1981) and Lewis et al. (1992) concerns the origins of the different developmental outcomes reported in their studies. Given that DeCasper and Carstens examined neonates, one might suspect that the effects reported are a consequence of the experimental paradigm rather than endogenous or social variables. However, this is not the case with the Lewis et al. study. Here, infants who were not different in experimental condition, age, sociodemographic status, or level of biological risk performed differently in the extinction and reacquisition of an operant behavior. Differences appeared to be related to expressions of affect during the extinction phase of the contingency detection paradigm. Infant manifestations of sadness or anger in an extinction phase may be a function of past experience.

To illustrate the possible transfer of contingency effects from social to nonsocial domains (or the reverse), it is necessary to consider two studies conducted with 3-month-olds by P. Dunham, F. Dunham, and their colleagues (Dunham & Dunham, 1990; Dunham, Dunham, Hurshman, & Alexander, 1989). In both studies, the researchers examined the relation between contingency in mother-infant interactions and performance in a perceptual contingency detection task. Dunham et al. (1989) manipulated the level of contingency in interactions by showing mothers how they should act with their infants during a 5-min, face-to-face interaction. Four groups were thus determined, ranging from highly contingent to noncontingent interactions. Infant performance in the perceptual task was assessed next, with speed of learning as the dependent variable. The results demonstrate that experimental manipulation of contingency in interaction is related to infant ability to detect a nonsocial contingency in a subsequent task. Infants who were exposed to noncontingent maternal behaviors learned the perceptual task more slowly than those whose actions were linked to contingent maternal behaviors. In a follow-up study, Dunham and Dunham (1990) demonstrated a correlation between the level of interactive contingency and infant performance in the subsequent, nonsocial task. Together, these results extend the findings of DeCasper and Carstens (1981), in that there appears to be, in the short term, a generalization between the level of contingency in the first phase of a procedure (social interactions or the occurrence of musical stimuli) with the acquisition of a contingent behavior in the second phase (perceptual task or behavior contingent onset of music). These results also have implications for the interpretation of the findings from the Lewis et al. (1992) study. Dunham and Dunham showed that there may be a generalization between the contingencies learned in one context and those involved in other situations. Because Dunham and Dunham did not investigate infant affective reactions during extinction and Lewis et al. did not examine contingency in social interactions, it is difficult to draw firm conclusions concerning the relation between the results found by both teams of researchers. However, one suggestion is that at least part of the effects found concerning the manifestations of sadness and anger in an extinction phase, and the subsequent performance differences in the reacquisition phase, may be related to the contingencies involved in the interactions the child regularly experiences.

Another piece to the puzzle may be provided by an oft-cited study by Cohn and Tronick (1983). Using the SFP, they instructed a third of the mothers in their study to interact with their infants as if they suffered from depression. The SFE for infants in this group was compared with that of infants participating under control conditions. Cohn and Tronick reported different patterns of behavior and affect, characterized by greater levels of protest, wary reactions, and brief positive elicits for infants in the experimental condition, than those in the control group, who showed less negative and more homogenous behavior and affective expressions. They showed that infants in the experimental condition were exposed to less contingent interactions than those in the control condition. Mothers did not respond to infants in coherent ways, and infants could not organize their behaviors around their mothers', thus supporting the claim that levels of contingency in interaction influence the nature of the behaviors during sequences of violation of contingency and perhaps during periods where contingencies are present as well—as suggested by the Lewis et al. (1992) and DeCasper and Carstens (1981) results.

If such processes are present throughout infancy, then they may exert a powerful impact on socioemotional development and outcome. Infants, who are exposed to home environments that are characterized by predictability in the behavior of individuals and in the events that occur, when exposed to violations of contingencies, react in ways which reflect attempts to reestablish some measure of coherence—as suggested by Cohn and Tronick (1983). Infants who are in homes lacking in such coherence do not actively seek to detect contingencies in their social and nonsocial environments, manifested as passivity or sadness and reflecting the lack of control to which they have been exposed. The added implication of the DeCasper and Carstens (1981) and the Lewis et al. (1992) studies is that even in cases where contingencies are linked to positive stimuli, infants do not learn them if they were first faced with noncontingent stimulation.

However, there is an important alternative explanation that accounts for the totality of the results described thus far concerning outcome implications. Both the Dunham and Dunham (1990; Dunham et al., 1989) studies and the Cohn and Tronick (1983) report showed that manipulation of maternal behavior in interaction immediately before observation of the dependent variable (performance on perceptual task or SFE) appeared to influence infant behavior. In both studies, there is no examination of the long-term influence of contingency, or absence thereof, on the behavioral and emotional manifestations of infants in subsequent tasks of phases of experimentation. Thus, it is entirely possible that the effects observed in the Lewis et al. (1992) study were the results of differences in maternal behavior immediately before the contingency detection task and had minimal relation to the home environment. Lollis (1990) has
demonstrated how such "procedural noise" may be related to child affective behavior in laboratory paradigms. To avoid such pitfalls, it is necessary to address the same issues through designs where various assessments are temporally independent (not all taken during the same laboratory visit), through longitudinal designs, or both. In all cases, it is more difficult to attribute infant indices of outcome to interactions that immediately precede assessment. The need for increased longitudinal research is further emphasized by the fact that infants possess limited long-term memory, thus restricting the generalizability of contingencies unless they are maintained for a certain length of time, especially past the age of 4 months. The infants seen by DeCaspers and Carstens (1981) who did not detect the contingency might have been able to had the researchers waited longer before exposing them to contingent stimulation (Rovee-Collier, 1987). Longitudinal investigations also permit measures of infant responses in contingency tasks and interactions to be compared with more global and predictive assessments of developmental outcome.

Relation of Contingency to Temperament and Attachment

Temperament. Although there is a debate concerning its definition, temperament is globally perceived as being the constellation of physiologically based, behavioral, and affective characteristics of infants that influence their responses to various stimuli, including those involved in interactions with adults, and various aspects of their nonsocial environment (Campos, Barrett, Goldsmith, & Stenberg, 1983; Emde et al., 1992; Rothbart, 1986). Traditionally, assessments of temperament have depended on maternal perceptions of child behavior, where infants are evaluated on several aspects of their relational styles as they are manifested in different environmental contexts (e.g., Bates, Freeland, & Lounsberry, 1979; Carey & McDevitt, 1978; Thomas, Chess, & Birch, 1968). Researchers have shown such measures to be fairly stable over time, especially when they take assessments after the 1st year of infancy (see Pedlow et al., 1993). Furthermore, they are correlated with certain clinical indices of adaptation during the preschool and school years, such as conduct disorders, the development of violent behavior, and attentional problems (Goldsmith & Harman, 1994). Other indices of temperament exist that possess similar validity and reliability credentials to parental report measures (e.g., laboratory assessments of behaviors, Kagan & Snidman, 1991; and physiological measures such as saliva cortisol levels, Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989), however these have to our knowledge not been reported concurrently with assessments of contingency in social or nonsocial contexts.

Several researchers have suggested that part of the variance involved in studies of contingency may be a function of stable child characteristics, related to the manner in which they interact with their environment (Lewis et al., 1992). This hypothesis has been directly addressed in two different studies. Fagen and Ohr (1985) found a moderate link between negative affect and temperament in a sequence where infants learned a contingency and then the stimuli were unexpectedly changed, causing a certain level of discomfort and distress to the infants. Specifically, maternal reports of infant activity level, duration of orienting responses, and distress reactions to novel stimulation accounted for 13% of infant crying during this sequence. Temperament was unrelated to the operant response during a violation of the expectancy phase of the experiment. In light of the previous discussion, however, there are two conceptual difficulties with this study. First, crying is assessed as if it had the same emotional significance for all children involved. Some researchers have recognized that infants may cry when they are angry or sad (Izard, 1983; Shiller, Izard, & Hembree, 1986), which makes this response an inadequate assessment of emotional reaction, other than to say that negative affect is observed. As in the Lewis et al. (1992) study, if infants were divided between angry and sad reactions to the violation of the contingency, then certain effects may have been lost in analyzing the sample as a whole. Second, infants in this study were between 3 and 4 months old, a time when parental assessments of temperament are notably unreliable (Pedlow et al., 1993). It is not clear that parental assessments of temperament at this time possess the same validity credentials as later on during infancy. Therefore, although Fagen and Ohr presented results that are deserving of further attention, they do not illustrate, or negate, a clear link between temperament and children's affective reaction in the context of the violation of an expectancy.

Alessandri et al. (1990) reported a similar study using the traditional contingency detection paradigm and examined the relation of temperament, behavior, and facial expressions during the extinction phase. They did not show any significant relation between these constructs. Temperament was unrelated to behavioral or affective response during extinction. These results are somewhat opposed to those reported by Fagen and Ohr (1985); however, as previously mentioned, there is a difference in the nature of the variables examined. By using Izard's (1983) MAX to assess affect, in addition to behavioral response, Alessandri et al. increased the level of precision in their identification of emotional responses involved in the task. They did report in a subsequent, longitudinal study (Sullivan, Ramsay, & Lewis, 1992), however, that certain temperamentally related behaviors (smiling and distress to novelty) are related to an infant's ability to remain focused on the contingency detection task, but not to learning itself. This result suggests, as did Fagen and Ohr, that temperament may be related to elements of affective reactions during learning, but it is too early at this point to understand the nature of that relationship.

As with Fagen and Ohr's (1985) study, Alessandri et al. (1990) reported the temperament of infants aged 2 to 8 months, again creating some uncertainty as to the precision of maternal perceptions of child behavior. Furthermore, Alessandri et al. excluded a number of children (n = 8) who did not complete the task because of continued fussiness or inactivity. It is unclear how this may have influenced the obtained data, given that fussiness and inactivity, if adequately operationalized (criteria for exclusion are not discussed), may be important dimensions of temperament. No such cases are reported by Fagen and Ohr, perhaps because fussing was part of the dependent variable.

To adequately assess the relation between temperament and
behavioral and affective responses to contingency detection, we need to consider two points. The first concerns the use of maternal reports of temperament. It may be helpful to use such reports with older children (between 8 and 12 months) or to use a laboratory assessment of temperament for younger age groups (Kagan & Snidman, 1991). This might help eliminate problems related to instrument reliability. Second, in light of the weakness of the findings reported, even in the Fagen and Ohr (1985) study, it is possible that temperament is unrelated to contingency learning in infancy. However, this does not preclude that temperament may play a role in other facets of the contingency phenomenon. For example, it is possible that stable child characteristics may be related to the generalizability of contingency experience from one context to another, or from one developmental period to another. Such possibilities require further investigation given the use of the temperament heuristic.

Attachment. Attachment theory maintains that the quality of mother-infant interaction during the 1st year lays down a basic predisposition for child behavioral organization in different contexts throughout early development. Most often, attachment is assessed through the Ainsworth strange situation (SS; Ainsworth et al., 1978; Ainsworth & Wittig, 1969). The SS is a progressively stressful laboratory procedure composed of a 30-s introduction and seven 3-min episodes where the child is either alone, with mother, with mother and a stranger, or alone with a stranger. At the heart of the procedure are two separation and two reunion episodes. The manner in which the infant organizes his or her exploratory and interactive behavior around the presence of the mother and the way in which the infant greets the mother during the reunion are the basic elements considered during coding procedures. Standard coding procedures yield a tripartite classification scheme: secure, insecure-avoidant, and insecure-ambivalent.

The value and validity of the SS has been demonstrated in two ways: First, it has been documented that infant behavior in the SS is related to the quality of mother-infant interactions and maternal behavior in the home throughout the 1st year of the infant’s life, suggesting that attachment classifications provide a descriptive index of the quality of the relational experiences of the infant (Egeland & Farber, 1984; Isabella, 1993; Pederson & Moran, in press). Second, attachment classifications have been shown to be related to various facets of social, cognitive, and emotional functioning and adaptation, at different points in development through to early adolescence (Fagot & Kavanagh, 1993; Hazen & Durrett, 1982; Lewis, Feiring, McGuffog, & Jaskir, 1984; Matas, Arend, & Sroufe, 1978; Sroufe, Egeland, & Kreutzer, 1990). The construct and predictive validity of the SS have permitted attachment theorists and researchers to contribute in significant ways to the state of knowledge concerning the impact of the early mother-child relationship on the quality of development during infancy and early childhood.

The attachment relationship is defined as a function of infant strategies of adaptation within the SS in response to distress caused by standardized maternal behavior (Lamb, Thompson, Gardner, Charnov, & Connell, 1985). During reunion episodes, secure infants manifest proximity seeking and contact maintenance toward their mother, are comforted by their mother, and return to exploratory behavior within the 3-min episode. Avoidant infants systematically refuse or ignore interaction with their mother on her return and are usually the infants who show the least crying during separation episodes. Ambivalent infants are quite distressed during separation and seek proximity and contact but are apparently unsatisfied by it, which sometimes intensifies their manifestations of distress.

Attachment researchers have theorized that infant behavior in the SS is based on an inner working model (IWM), a labile system of representation that maintains information collected throughout mother-infant interactive history concerning expectations of maternal behavior in various contexts, maternal emotionality during interaction, the temporal and contextual stability of maternal behavior, maternal descriptive attributions of the child, and expectations regarding maternal reactions to child initiatives. It is clear from this description that researchers in this area perceive the behavior patterns of infants in the SS as based on infant expectations of maternal behaviors, built throughout the 1st year of life. Not surprisingly, secure attachment relationships are linked to “sensitive” maternal behavior, where mothers accurately perceive infant needs and emotional states and act on them in warm, coherent, and predictable ways. On both the temporal and stimulus characteristics levels, the contingencies in such interactions can only be viewed as positively contributing to the course of social development. Mothers of avoidant infants are viewed as being constant in their interactive behaviors, however, they are generally perceived as lacking sensitivity with respect to needs and behaviors. Their behaviors are characterized as being predictably insensitive and sometimes stressful to their child by their degree of intrusiveness (Belsky, Rovine, & Taylor, 1984). It is also possible that mothers in such relationships reject manifestations of affective behavior, negatively reinforcing competence and independence (Main & Weston, 1982). In either case, maternal behavior is characterized by regularity, but without the warmth of secure relationships, resulting in infant behavior in the SS linked to the control of distress and the avoidance of the mother on her return. The behaviors of mothers of ambivalent infants have most often been seen as lacking in consistency and regularity, as well as being deficient in their appropriateness in respect to infant behavior (for reviews, see Ainsworth et al., 1978; Cassidy & Berlin, 1994; Isabella, 1993; Main & Weston, 1982; and Pederson & Moran, 1995, in press).

The rather long introduction to this section has served to illustrate the importance of the role attributed by attachment researchers to infant expectations of maternal behavior in the SS. The essential premise behind the attachment classifications is that infant behavioral organization is directly related to the manner in which (a) the primary caregiver has organized the different kinds of information that the infant has been exposed to in the 1st year and (b) infants have organized their behavior around caregiver behaviors in the home. In light of these observations, it is intriguing that very few studies actually test this basic idea. Do secure, avoidant, and ambivalent infants expect their mothers to act differently? Numerous researchers have documented the qualitatively different maternal behaviors in the home shown by mothers involved in the three types of at-
tachment relationships. However, not only have such researchers usually accounted for relatively low percentages of the total variance of attachment relationships (see Goldsmith & A Landry, 1987; Lamb et al., 1985; Moran, Pederson, & Tarabulsy, in press; and Schneider-Rosen & Rothbaum, 1993), but it is assumed that these behaviors lead to different infant expectations of maternal behaviors. Attachment researchers have rarely postulated how patterns of behavior in the SS are linked to infant expectations of maternal behavior in other contexts. One way of addressing this issue is to examine the contingencies involved in mother–infant interaction. Interactive contingencies reflect the predictability and mutual expectations of the actors’ behaviors. Finding a relation between patterns of contingency in interaction and attachment would provide convergent validity for the hypothesis that contingent interactions are linked to certain outcome characteristics and would equally confirm the role attributed to infant expectations by attachment researchers in their interpretations of infant behavior in the SS.

Isabella and Belsky (1991; Isabella, Belsky, & von Eye, 1989) have conducted two longitudinal studies where they examined the frequency of synchronous mother–infant interactions in the home at 1, 3, and 9 months and its relation to the security of attachment at 12 months. Synchronous interactions are operationalized as “reciprocal and mutually rewarding behavioral exchanges between mother and infant” (Isabella et al., 1989, p. 376). By their description, synchronous interactions involve contingently organized behavior on the part of both interactants. In both studies, Isabella and his coworkers found that the frequency of synchronous interactions at 1 and 3 months, but not at 9 months, was significantly related to attachment security at 12 months. They also reported that the asynchronous interactions that characterized infants who had avoidant attachment relationships involved mothers who “intruded” on infant activity by acting out of turn, whereas mothers in C dyads did not respond as often as mothers in secure relationships to infant vocalizations (Isabella et al., 1989, p. 376). By their description, synchronous interactions involve contingently organized behavior on the part of both interactants. In both studies, Isabella and his coworkers found that the frequency of synchronous interactions at 1 and 3 months, but not at 9 months, was significantly related to attachment security at 12 months. They also reported that the asynchronous interactions that characterized infants who had avoidant attachment relationships involved mothers who “intruded” on infant activity by acting out of turn, whereas mothers in C dyads did not respond as often as mothers in secure relationships to infant vocalizations (Isabella & Belsky, 1991). All of these findings suggest that when mothers are sensitive to infant behaviors, and respond in a way that is contingent on their occurrence, the development of a secure attachment relationship is favored.

Although these studies provide evidence of a link between contingency in interaction and attachment, the results raise at least two questions: First, the definition of synchronous interactions allows for asynchronous interactions to be contingent, thus making the role of contingency in the development of different types of attachment unclear, as it is hidden within the more global concept of synchrony. Second, the definition of synchronous interaction says little about infant behavioral organization, given that interactions may be labelled as asynchronous on the basis of maternal behavior only. The role of contingently responsive infant behavior, related to expectations of maternal behavior during interactions, is somewhat downplayed. Had Isabella and Belsky (1991) broken synchrony into its component parts (sequential, reciprocal, and mutually rewarding), a clearer picture of developmental changes in interactions, and the specific role of interactive contingencies, may have emerged.

Pushing this point a little further, it may be of interest to code the emotional expressions of infants who were not involved in secure relationships. The synchronous definition of interactions appears to be related to positive affect in the presence of contingency. However, in past research, the three attachment types have not been characterized by similar categories of negative affect. Within the SS itself, infants in ambivalent dyads manifest more sadness than those in secure relationships (Shiller et al., 1986). This was not the purpose of Isabella and Belsky’s (1991) studies, however, given the importance of emotional expressions in the contingency literature, especially as it relates to the violation of expectations (Alessandri et al., 1990); further investigation of infant manifestations of emotions in relation to contingent behavioral organization and attachment may provide accurate information concerning the status of infant expectations of maternal behavior in the SS.

Some of the issues raised by the Isabella and Belsky’s (1991) report are addressed in a study by Cohn, Campbell, and Ross (1991). This study is particularly noteworthy in that it uses the SFP, a laboratory procedure that creates a violation of interactive contingency for the infant by standardizing maternal behavior and for which we have validity and reliability information. This is the only study we found where an aspect of infant responsiveness to his or her mother was addressed in relation to attachment. The study involved 66 primiparous parents and their infants who participated in the SFP at 2, 4, and 6 months and in the SS at 12 months. Cohn et al. tested the hypothesis that affective reaction when an interactive contingency was violated (in the still-face phase of the procedure) was related to the quality of the attachment relationship. One strength of this study is that it rests on previous findings linking interactions with the SFE and SS—both procedures are believed to reflect the quality of interactive history.

Cohn et al. (1991) found that at 6 months (but not at 2 and 4 months), during the still-face phase of the procedure when infants manifest negative behavior and affect, the presence of positive elicits was related to secure attachment at 12 months. The absence of positive expressions during this phase was predictive of avoidant attachment (the low number of ambivalent dyads precluded their inclusion in the analyses). Overall, these results suggest that the processes that lead to individual differences in infant behavior in the SFP are related to those involved in the SS. The results suggest a relation between affective and behavioral correlates of interactive contingencies when infants are 6 months old and the development of attachment.

It is necessary to view these results in their procedural and methodological context. First, a high percentage of the mothers in the Cohn et al. (1991) study suffered from postpartum depression or had depressive symptomatology during the length of the investigation. Although they noted that such samples may serve to amplify underlying processes difficult to detect in normative groups, it is equally possible that certain processes are qualitatively different in dyads with clinical problems.

A second issue concerns the lack of significant relations between behavior at 2 and 4 months and the SS at 12 months. Cohn et al. (1991) argue that at 6 months, where the data show a significant relation, long-term memory is sufficiently developed to allow infants to use interactive contingencies to form expectations regarding maternal behavior, thus the beginning of attachment formation. Isabella and Belsky (1991; Isabella et al., 1989), however, found relations between synchronous in-
interactions and attachment at 1 and 3 months but not at 9 months. It is difficult to harmonize these results, although it is possible that differences in procedures or coding strategies are involved. Cohn et al. (1991) used a laboratory procedure that standardized maternal behavior and examined the mother–infant relationship in a situation where normal interactive contingencies are violated. Furthermore, as in the SS, their focus was on infant behavior. Isabella and Belsky observed mothers and infants in the home under naturalistic conditions and attended mostly to maternal responsiveness. It is possible that as infants develop, the role of their responsiveness during interactions may increase in importance, whereas that of mothers may decrease. In that researchers have usually not considered the contributions of contingently organized infant behavior during interactions, such an explanation may provide clues as to why researchers who have addressed the role of maternal responsiveness in the development of attachment have usually accounted for significant, but low to moderate, percentages of SS classification variance (see Goldsmith & Alansky, 1987; and Lamb et al., 1985). A final difficulty with this study is that although the SFP may be related to patterns of interactions outside the laboratory, no description of control interactive contingencies is revealed from the data.

Therefore, even though Cohn et al. (1991) and Isabella and Belsky (1991) spoke to the relation between interactive contingencies and attachment, the different methods used, and the varying results obtained, underline that future work is necessary which places greater emphasis on the behavioral organization of infants rather than that of mothers. Nevertheless, both groups of researchers have laid the vital groundwork toward understanding the input of contingency-related expectations and behavior in the development of attachment and outcome.

Future Directions

Overall, research in the area of contingencies has advanced in important ways. Throughout this report, we have made an attempt to underline some of the basic observations that have resulted from this work. Thus, infants are actively involved in detecting how events and their behaviors are related in social and nonsocial contexts. These relations seem to have important developmental consequences in cognitive, behavioral, and emotional spheres, and more recent empirical research confirms this notion. However, a number of key issues need to be addressed before the role of contingencies in developmental outcome can be more fully understood.

First, the question of the relation between the social and nonsocial aspects of this mechanism requires further theoretical consideration. Is contingency detection a generic, perceptually based mechanism that processes all stimuli in the same fashion, regardless of the source of the stimulation (social–nonsocial), with preference for those which are temporally related to behaviors or events in the environment (Flavell, 1985)? Or do two separate mechanisms exist for social and nonsocial spheres of stimuli (Ellsworth et al., 1993)? It is also possible that a single contingency detection mechanism exists, but it is hardwired to favor the specific characteristics of social stimulation. This position has not been systematically laid out, but it has been regularly referred to by researchers who have examined the role of early parent–infant relationships on development (Bowlby, 1969; Stern, 1985) and those who readily acknowledge the link between social and cognitive development (Hinde, 1987). Its basic premise is that infants possess a predisposition to efficiently process socially relevant events and stimulation and form, as a result, patterns for processing nonsocial information. This is one possible interpretation of the Dunham and Dunham (1990) study. As a consequence, there is no need to postulate a nonsocial mechanism because the social one, driven by social stimulation, carries out the task of detecting the coherence in the less frequent and less salient nonsocial contingencies, according to how it was first “tuned” by the social context. Addressing the issue of the function of the contingency detection mechanism, and its role in organizing social and nonsocial sources of stimulation, would allow us to more accurately understand the workings of this important cognitive process and also encourage researchers to debate the differences between social and nonsocial contexts for infants.

A second issue concerns the role of stimulus characteristics in contingency-related behavior. Thus far, the work of Gunnar and her colleagues suggests that the nature of the contingency is involved in the interpretation of stimulus valence (Gunnar, 1980). Furthermore, Wentworth and Haith’s (1992) findings suggest that infant contingency detection capacities are enhanced when the stimulus is familiar. One could conclude that it is perhaps more important to organize behavior around stimuli that are recurrent rather than transient. In addition, it seems that moderately positive stimulation (music and image) is not enough to elicit operant behaviors, suggesting that the contingency is critical for infants to attend to such events (Lewis et al., 1990). However, given that most studies have focused on exclusively positively valenced stimulation and have rarely involved sequences of non-contingency (see Lewis et al., 1990, for an exception), the critical experiment concerning the role of stimulus features in contingency learning has yet to be carried out. Such a study would involve four independent variables: (a) the level of contingency (e.g., contingent stimulation vs. noncontingent stimulation, (b) stimulus valence (e.g., positive vs. negative vs. control), (c) level of predictability (e.g., the same stimulus vs. changing stimulus), and (d) phases of experimental procedure (e.g., baseline, learning, extinction, and learning). The dependent variables in this type of study would need to include operant responses and a precise assessment of the infant's emotional state. The latter is especially important in light of evidence indicating that affective dimensions of infant response may reveal information concerning the contingency experience of the infant, information that is otherwise not directly available from other types of behaviors (DeCasper & Carstens, 1981; Lewis et al., 1992). Moreover, this protocol should be operationalized in social and nonsocial contexts.

Finally, the study of contingency in infant behavioral organization will benefit from the inclusion of longitudinal studies for three major reasons. First, the reviewed studies have indicated that in both the social and nonsocial spheres, not only do infants of varying ages differ in behavioral response but also that contingency experience in one area is related to that in another area. Longitudinal investigations may permit us to map out the
developmental characteristics of the behavioral and emotional correlates of contingency experience in social and nonsocial contexts. Moreover, such studies would help us to understand the factors that influence the continuity, coherence, and discontinuity in the contingent organization of behaviors in the social and nonsocial domains and how the contingency experience of the child interacts with, and relates to, other facets of development.

Third, these studies would permit researchers to examine the link between social and nonsocial contingency-related behavioral organization throughout infancy and global indicators of development and adaptation, for which longitudinal data is available past infancy, such as temperament and attachment.

The reviewed research confirms that infants possess a surprisingly efficient information-processing mechanism that traces connections between events in the environment and between behaviors and events. Although the essential premises on which this research is based were established decades ago, it is only recently that we have developed an appreciation for the role that infants may play in actively organizing information and behaviors in coherent and meaningful ways that affect future outcome. In the present review, we have attempted to organize some of the literature in this area and have sought to ask some enduring questions which will fuel further research.

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