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# B. F. Skinner's Legacy to Human Infant Behavior and Development

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*B. F. Skinner's legacy to human behavioral research for the study of environment-infant interactions, and indeed for the conception of development itself, is described and exemplified. The legacy is largely the practicality, the efficiency, and the comparative advantage—relative to diverse other behavioral and nonbehavioral approaches—of using the operant-learning paradigm to organize and explain many of the sequential changes in behavior patterns conventionally thought to constitute infant development.*

In diverse ways, B. F. Skinner contributed a great deal to advancing an understanding of basic psychological processes and to the applications of science-based interventions to problems of individual and social importance. He contributed to many realms of human and nonhuman behavior, including human behavioral development, and to various segments of the life span, including human infancy. Perhaps his most salient and lasting contribution was to delineate operationally the *three-term contingency* relation (antecedent stimulus, behavior, consequent stimulus), and the notion of reinforcement inherent in it. The consequence-of-behavior contingency, with its intrinsic conception of reinforcement, has provided the main engine for understanding behavior change in behavior analysis and in the areas of psychology, such as the study of infancy, to which the operant-learning paradigm has been extended.

More than any earlier behavioral-learning approach or conception of reinforcement (cf., e.g., Hull, 1943; Konorski & Miller, 1935; Thorndike, 1898, 1911), the application of Skinner's functional analysis of behavior-environment interchange has facilitated the analysis of infant learning and development. Using his operant-learning paradigm, researchers have investigated diverse infant phenomena, including attention, perception, memory, language, and emotional and socialization processes. Questions addressed include how the stimuli provided by the environment could affect neonate, infant, and child behaviors and how, in turn, those behaviors could affect the environment (e.g., the behaviors of parents and socializing agencies). It can be said that operant shaping and learning processes are central to an understanding of the acquisition of skills and socialization in human infancy and childhood.

The basic theme of this article is that infant behavioral development is amenable to an operant learning and

behavior analysis. Skinner's legacy is a powerful one in that an operant analysis makes it possible to move beyond the level of simple description to the level of identifying key processes that account for much of behavioral development. A corollary is that psychological phenomena that have been identified in descriptive accounts of infant development have benefitted, or could benefit, from systematic operant-learning analysis. With its methodology and research tactics, such an analysis can identify and specify how environmental variables impact on infant behavior change.

## The Concept of Reinforcement

The concept of reinforcement under the functional analysis used in operant learning is straightforward (Catania & Harnad, 1988; Skinner, 1931, 1935, 1938, 1945, 1953, 1969). Diverse definitions of environmental and behavioral events and their functional relations are possible in behavior analysis. A functional analysis examines the relations, if any, between environmental events and behavior, attending to systematic change in some attribute of the behavior (e.g., rate, amplitude, latency, duration, interresponse time) as a function of the environmental event contingent upon it (compared with when the environmental event is not so presented). The behavior change observed, constituting *learning*, confirms the functional utility of the categories and units developed for environment and behavior, and justifies terming the contingent event the *reinforcing stimulus* or *reinforcer* for the behavioral event (class) that is termed the *response* or *operant*. A corollary is that the contingent presentation of a stimulus is a necessary—though not a sufficient—feature of reinforcement.

An environmental event will come to function as a discriminative stimulus for (i.e., set the occasion for—some would say *cue*) that response if, in its presence, the response is followed by a reinforcing stimulus thereby constituting the three-term contingency. Thus, the implication of reinforcement is that stimuli exist that, when presented (or removed) as a consequence of a given response, will increase systematically the rate of that response. This outcome defines the codependent stimulus

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and response functions. There must be controls to ensure that the systematic behavior-unit increase results from the contingent stimulus functioning as a consequence rather than as an eliciting- or discriminative-stimulus antecedent of the behavior unit (Higgins & Morris, 1985). In this frame, the term *reinforcement* describes a basic principle of behavior.

Over the years, research has proceeded most fruitfully using the definition of reinforcement within the frame of the three-term contingency. Problems arise, however, when reinforcers are not identified as stimuli or related to particular responses in specific contexts. This has led to lists of reinforcing stimuli being enumerated in the literature, with the implication that these stimuli are likely to function as reinforcers for any behavior unit (response) in any context (e.g., Risley, 1977). But the operant-learning paradigm has been clear in its corollary that a stimulus that functions as a reinforcer for a particular response of an individual in a given context need not function as a reinforcer for a different response in the same context, for the same response in a different context, or for the same response of a different individual in the same context. Moreover, under that paradigm, only responses, not persons, can be reinforced by contingent stimulus presentations or withdrawals. An organism's responses are functionally related to stimuli, and no comprehensive empirical account of behavior and its development can be attained if the relations between stimuli and responses are not delineated. In this frame, the two functions of a stimulus of primary interest in operant learning are, first, to set the occasion for a response (i.e., as a discriminative stimulus) and, second, to be a consequence for a response (i.e., as a reinforcing or punishing stimulus).

But, for some, a question may remain about unconditioned primary reinforcers: Why is a stimulus event reinforcing? The proximal answer is provided by the functional relations of the contingent stimuli functioning as reinforcers for particular response classes to antecedent or concurrent environmental stimuli, such as contextual setting factors (that lower or enhance their efficacy). To the degree that an answer not couched in the terms of a reduced (under-the-skin) level of analysis is required, that answer lies in an explanation in evolutionary species-history terms: Unconditioned stimuli, including functional reinforcers for diverse species' responses, must result from survival contingencies in the evolutionary history of a species (Petrovich & Gewirtz, 1984, 1985; Skinner, 1953, 1966, 1981; see also Dawkins, 1976; Wilson, 1975).

### ***Reinforcement of Infant Behavior***

Skinner's functional analysis of behavior has generated a good deal of basic and applied research in the developmental-learning literature, especially on identifying stimuli that function as reinforcers for particular infant response classes (e.g., Caron, 1967; Gewirtz & Peláez-Nogueras, 1992a; Haugan & McIntyre, 1972; Siqueland & DeLucia, 1969). Much of this operant learning research necessarily has been accomplished in contrived contexts

in which, typically, every instance of the infant's response is followed immediately by the contingent stimulus, the putative reinforcer. In those standard laboratory procedures, the environmental contingencies (often provided by a parent) that are defined to be constant across trials typically provide the independent variable, and the infant's target response is free to vary and provides the dependent variable. The duration of each occurrence of the reinforcing stimulus usually is shorter than the duration of the infant response on which it is made immediately contingent. Ideally, there should be checks, such as yoked controls for elicitation effects, to demonstrate that the contingent stimulus increases the infant response attribute (usually rate, but sometimes duration or amplitude, or a systematic decrease in response latency) by its function as a reinforcer and not by its function as an eliciting stimulus (e.g., Bloom & Esposito, 1975; Higgins & Morris, 1985; Poulson, 1983).

These control procedures are used routinely in the laboratory to provide the experimental basis for concluding that certain stimuli, when contingent, can function as reinforcers for particular infant response classes. Such experimental situations also depend on the fact that total removal (by extinction) of that stimulus and the contingency it provides, or its functional removal by stimulus presentations independent of response occurrence, correlates with a systematic decrease in the same response attribute. In myriad studies with infants conducted under this paradigm, the relation among a response, its antecedents, and its consequences has been experimentally manipulated; in this way, the principles of the operant-learning paradigm have become established empirically for human infants. A good deal of the research involved has focused on processes delineating how behaviors are shaped and maintained by the delivery of patterns of particular contingent stimuli in differing contexts.

In operant-conditioning studies, a variety of reinforcing stimulus units for diverse infant responses have been identified. Such varied stimuli as infant feed formula or sucrose water, auditory, olfactory, visual, tactile and kinesthetic stimuli, including stimuli with social characteristics such as a mother picking up her child, vocalizing, smiling, or touching her child, have been found to function as reinforcers for particular infant responses, including head turning, high-amplitude sucking, tracking, orienting, kicking, smiling, reaching, touching, vocalizing, protesting, and crying. (Reviews of operant-learning research with infants can be found in Fagen & Ohr, 1990; Hulsebus, 1973; Millar, 1976; Pomerleau & Malcuit, 1983; Poulson & Nunes, 1988; Reese & Lipsitt, 1970; Reese & Porges, 1976; and Rovee-Collier, 1987.)

### ***Contingencies in Interaction***

Behavioral research has had a different emphasis and tactic in its approach to the study of contingencies in parent-infant interaction than has nonbehavioral research. For behavior-analytic researchers studying dyads, it is axiomatic that a response of the first of the two actors that routinely follows a recurring response of the second actor

can constitute a reinforcement contingency for the second actor's response if it increases systematically in rate. Thus, one feature of the dyadic interaction is the potential bidirectionality of reinforcement effects.

A problem in the study of spontaneous dyadic interactions, for instance in the parent–infant case, is that the identity and topography of response elements of the set of turn-taking responses (e.g., smiles, touches, vocalizations, turning away) of each member of the dyad can change at every turn in the series. For this reason, behavior-analytic researchers studying the effects of reinforcement contingencies on behavior ordinarily prefer to study the flow of influence in such interaction sequences in experimentally contrived settings. In such settings, the turn-taking response of one dyad member (typically the mother) is controlled or manipulated, and the infant's response that provides the dependent variable is left free to vary (e.g., Gewirtz & Peláez-Nogueras, 1991b, 1992b; Peláez-Nogueras, 1992; Poulson, 1983). The procedure also can be reversed, with the infant's recurring response held constant or manipulated and the parent's response (facial expressions, vocalizations) left free to vary (e.g., Gewirtz & Boyd, 1977).

Infant behavior also may be studied in natural interaction settings without contriving to use a limiting experimental procedure as detailed above. The researcher may record the behavior-unit elements of each of the two interactors and then search for conditional relations between, for instance, adult behavior elements at different turn positions (sequential lags) for each infant behavior of interest (e.g., Haupt & Gewirtz, 1968; Patterson & Moore, 1979). By using sequential-lag analysis, the researcher can examine the effect of presumptive reinforcement contingencies for each infant target response under ecologically valid circumstances. Even so, tools for identifying functional relations among large numbers of responses in interaction pose difficult problems (Sackett, 1979).

A method of sequential analysis of dyadic responses is not optimally conducive to translating the contingencies involved in the interaction into reinforcement effects because, at every turn in the interaction sequence, there could be different behavior combinations emitted by a dyad member, and a particular dyad member's behavior might occur only intermittently or infrequently. Thus, the researcher may have difficulty isolating the functional relations involved. These complications have led many researchers to study the flow of influence in two-way parent–infant interaction in experimentally contrived settings, in which the responses of one member of the dyad are controlled.

### **Overlooking and Misunderstanding Reinforcement in Developmental Psychology**

Reinforcement, based on the consequence-of-behavior contingency, has been the main determinant of response change in infant operant learning. Regrettably, the concept of reinforcement has been diminished in the popular and the scientific literature by errors of omission and er-

rors of commission. Errors of omission involve overlooking reinforcement contingencies and operant-learning principles, in particular when such principles are plausibly involved in the phenomena under study and their use could increase the power of an analysis. Errors of commission involve misunderstanding the role of reinforcement in operant learning, leading to its misuse in particular applications and often to the appearance rather than the substance of explanation.

### ***Overlooking Potential Reinforcement in Mother–Infant Interaction Contingencies***

In the nonbehavioral infancy literature, typically no account has been taken of whether the behavior of caregivers, interacting with the infant in the assessment setting, provides discriminative or reinforcing stimuli for the infant behavior being assessed. Assessments of infant behaviors routinely ignore the maternal behavior and contexts in which those infant behaviors occur. This characteristic omission in infancy research often goes with the conception that the infant responses are symptoms, indices, or outcomes of a putative underlying cause. For instance, the infant protest cued by maternal departures and separations has been treated as a symptom of the underlying cause: “attachment” (Bowlby, 1960; Schaffer & Emerson, 1964; Stayton & Ainsworth, 1973), “security of attachment” (Ainsworth, Blehar, Waters, & Wall, 1978), or “separation anxiety” (Kagan, Kearsley, & Zelazo, 1978). But the proximal explanation involving determinants of these cued responses is far simpler: Those infant protest-response patterns can be manifested in the assessment setting as a result of their histories of operant learning, such that they might have been cued and reinforced by maternal responses (Gewirtz & Peláez-Nogueras, 1987, 1991b, 1992a).

The objective of such researchers is the assessment of typical infant responses (e.g., those that denote attachment patterns) in circumstances involving departures of, separations from, and reunion with mothers. But routine lack of attention to the possibility that, if uncontrolled, maternal behavior in the assessment setting itself may provide reinforcing (or punishing) contingencies for the infant behaviors necessarily impeaches the validity of these assessments. The lack of control for potential discriminative stimulus and reinforcement variables operating under what are assumed to be nonintrusive conditions obscures and complicates an understanding of the processes underlying the phenomena under study. It also precludes an understanding of the proximate factors determining the infant's behavior, and indeed the mother's behavior, in the dyadic interaction under investigation. This problem can be exemplified by research in two arenas.

The first example focuses on the widely used “strange situation” assessment procedure that involves the infant's mother and a stranger with the infant in a series of separation and reunion episodes. That procedure was developed by Ainsworth and her associates (Ainsworth et

al., 1978; Ainsworth & Wittig, 1969) to assess for typologies in infant attachments to their mothers (e.g., the insecurely attached infant). The procedure fails to take into account responses of the interactive mother (and others, like the stranger), both in the test setting and in earlier settings, that could provide discriminative stimuli for, or be contingent on, the infant behavior under scrutiny and thus impact on the assessment and contribute to the attachment-classification scores.

The second example, introduced earlier, of how unrecognized reinforcement contingencies may be involved in an assessment procedure focuses on infant protests cued by maternal departures as the index of attachment, without account being taken of maternal responding contingent on the protests in the departure settings (Schaffer & Emerson, 1964). A series of experiments has illustrated how infant protests can come under the close control of discriminative stimuli and reinforcement contingencies generated by a mother's behaviors during her departures and brief separations from her child. We (Gewirtz & Peláez-Nogueras, 1992a) have demonstrated that such infant protests can be shaped, maintained, and increased by patterns of contingent maternal responding, and that these protests can be decreased or eliminated by a mother responding independently (noncontingently) of her infant's protests and contingently upon other, more constructive, infant behaviors (e.g., vocalizations, play, smiles). These experiments provide evidence for the conditioned basis of the separation protests that have served as unlearned indices of attachment for Schaffer and Emerson (1964) and denoted separation anxiety for Kagan et al. (1978).

Thus, in the parent-infant interaction arena, researchers rarely take systematic account of the possibility that maternal responses, uncontrolled in the test setting, might provide cues and reinforcement contingencies for the infant behavior being assessed, some the effects of antecedent contingencies. This is remarkable for at least two reasons. First, for almost a century now, the key approach to the process of response learning (first instrumental Thorndikian conditioning and its derivatives, and currently Skinnerian operant learning) has emphasized the consequence-of-behavior contingency that constitutes reinforcement as the main determinant of behavior change. Myriad experimental demonstrations have confirmed this operation. Second, in recent years, the parent-infant interaction literature has reflected an interest in the effects of contingencies provided by the behavior of the mother or infant for the behavior of the other in interaction (e.g., Cohen & Tronick, 1988; Sackett, 1979). Even so, many researchers have failed to recognize that contingencies may have reinforcement implications for the behavior unit they routinely follow (e.g., Levitt, 1980; Sullivan, Lewis, & Alessandri, 1992). This limited emphasis on contingencies without reinforcement may stem from a constraining underlying assumption of some theorists that contingencies (or the lack thereof) can result only in meaningful global-typology or trait-like behavior outcomes (e.g., Bandura's, 1977a, 1989, "self efficacy"; Seligman's, 1975, "learned helplessness") that are con-

ceived not to be under differential stimulus or contextual control.

Some infancy researchers who use operant-learning procedures prefer to use mentalistic or cognitive explanatory constructs (e.g., "contingency expectancy") rather than the well-established principles of reinforcement in discussions of their operations and results. Their research reports are usually insufficient in their descriptions of the learning operations. For example, a recent remarkable instance of an emphasis on contingencies without reinforcement is found in a report of infant operant learning in which the term *reinforcement* does not appear even once (Sullivan et al., 1992). In that study, audiovisual stimulation was provided contingent on arm pulls (apparently on a continuous reinforcement schedule) and, on average, infants doubled their response rates in the first learning phase, compared with the rate in the preceding baseline phase. The authors, however, were primarily concerned with emotional expressions during the apparently successful conditioning and extinction phases, and did not chart arm-pull learning curves. They simply attributed infant learning to "contingent stimulation" and to the "contingent procedure" (p. 62). In an earlier report, these researchers (Alessandri, Sullivan, & Lewis, 1990) assumed that learning is a time when infants build up expectations about control and extinction is a time when infant expectations regarding the contingency are violated. It appears that contingent stimulation and the built up expectations are informal proxies for the reinforcement concept. The point is that the extensive infant operant-learning reinforcement literature likely provided a basis for this operant-learning study. Nonetheless, the authors did not cite this literature and instead used the terms *contingencies* and *expectations* to carry the reinforcement implications without alluding to the reinforcement conception underlying operant learning per se. By overlooking reinforcing contingencies, these authors seemed to be suggesting, we believe unjustifiably, that the operant-learning literature is not relevant to their work or that it involves an entirely separate research domain.

### **Some Reinforcement Misconceptions**

Errors of commission have often involved the reinforcement concept, but an unrecognizable reinforcement concept that has been bowdlerized if not diluted beyond recognition by "hyphenization" (Gewirtz, 1971a, 1971b). Thus, terms such as *vicarious-reinforcement* and *intrinsic-reinforcement* have been applied to explain matching-behavior occurrences in contexts in which the behavior's reinforcement history is unknown and little or no attempt has been made to identify extrinsic reinforcers that might have been maintaining the behavior unit (e.g., Bandura, 1971).

The operational emphasis in Skinner's conceptual approach to the three-term contingency, including the terminal reinforcing stimulus together with an emphasis on contextual setting factors that lower or heighten the efficacy of stimuli involved, precludes the need for such loose usages as postulating motives or drives or hyphen-

ated reinforcers (e.g., intrinsic-, self-, or vicarious-reinforcers) to organize or explain behavior occurrence. Thus, an unexhibited operant of an observer child said to have been produced or strengthened by the nonoperant-paradigm term vicarious-reinforcement (Bandura, 1971), under Skinner's operant-learning operational logic must be one that is instead being maintained by a valid operant-paradigm operation.

The case of "vicarious-reinforcement" from Bandura's (1969, 1971, 1977b, 1986) work in the developmental-learning literature is pertinent. After a child has observed that a model's behavior is followed on that single occasion by a contingent event (from some environmental source) that could conceivably function as a reinforcer for the model's response, a matching response of the observer child is more likely to occur. This phenomenon has been reported to occur in contexts in which an absent extrinsic reinforcer cannot be provided contingent on an also-absent overt response of the observing child, thereby diverging from the requirement of the operant paradigm that extrinsic stimuli affect an overt target response. Without examining an observing child's reinforcement history with reference to the matched behavior, gratuitous conceptions such as "intrinsic-" or "vicarious-reinforcement" (or "observational learning" as a primary process) have been applied to explain such behavior of the observer. These conceptions diverge from explanatory usage under the operant-learning paradigm that has given the extrinsic reinforcement conception (in relation to target responses) its functional meaning in behavioral psychology. As indicated earlier, the operant-learning paradigm implies—and widespread research under this paradigm has confirmed—that an observer's behavior matched to the behavior of a model can result from intermittent schedules of extrinsic reinforcement for that matching behavior class. Matching responses occurring after observation of the model's nominally reinforced response denoting "vicarious-reinforcement" can result from the nominally reinforced model's response functioning to provide a discriminative stimulus for the observer's matching-response class that is imbedded in a matrix of extrinsic reinforcement for that matching-response class (Gewirtz, 1971a, 1971b; Mazur, 1990).

In summary, the use of such reinforcement labels as vicarious-, self-, or intrinsic-reinforcement in behavior-development research can suggest that a process explanation has been provided in terms of generic operant-learning concepts and paradigms when, in reality, it has not. When only the appearance of explanation in operant terms is provided, critical evaluations of the underlying mechanisms may be precluded or postponed.

#### **Other Problem Usages of the Reinforcer Term**

A problematic usage, particularly by cognitive-developmental psychologists, is the conception of *contingent feedback*, as if such feedback is indistinguishable from the conception of reinforcement. Contingent feedback in the form, for example, of information provided following a particular performance class that results in child per-

formance improvement, and even feedback derived from self-recordings, have been shown to function as reinforcers (Sulzer-Azaroff & Mayer, 1991). But contingent feedback is by no means reinforcement. Performance feedback provides functional, differential reinforcement to the extent that it results in systematic increases in the response class on which it has been contingent (Balcazar, Hopkins, & Suarez, 1985–1986).

Another example from the child-development literature in which the concept of reinforcement is used routinely in an inadequate manner is the use of the term *reward* as a substitute for the term *reinforcement*. In various introductory texts and the popular literature, reward is used as a synonym or explanation of reinforcer, although reward does, and reinforcement does not, carry mentalistic, hedonistic, or drive-reduction baggage. Furthermore, the tendency of many investigators to use the reinforcer term indiscriminately is remarkable, their assumption appearing to be that the efficacy of such reinforcers (or "rewards") is homogeneous for every child response class. In this connection also, environmental events that should sometimes have value for particular children are routinely termed reinforcers, without the appreciation that the reinforcer efficacy of those stimuli first must be confirmed and account must be taken that reinforcer efficacy could vary with the child's current and historical context (Gewirtz, 1972; Morris, 1988).

### **The Conceptualization of Human Development**

Pioneering developmental psychology within the behavioral approach, Bijou and Baer (1961, 1965, 1978), Gewirtz (1956, 1961, 1991), and others have used the principles and methods set forth by Skinner to investigate infant learning and development. These researchers conceived of infant psychological development as entailing progressive interactions between the behavior of the infant and the discriminative and contingent events produced by its environment. As noted earlier, a substantial research literature has accrued on the operant conditioning of diverse behaviors of human neonates, infants, and children, involving numerous environmental contingency types. This literature has demonstrated that learning can occur efficiently and rapidly (in rather brief time segments), can be facilitated or inhibited by contextual setting operations, can reflect efficiently moment-to-moment changes in environmental stimulus conditions, and can provide an effective basis for organizing discriminative operants and their controlling conditions under a number of headings (some metaphorical, like "attachment").

For the most part, advocates of traditional approaches to development use age as a metric to organize the progressive changes in behavior systems that they take to constitute development. They neither consider it important to search for changes in the environment that might be associated with the behavior changes that denote development to them nor consider it relevant to survey ways of changing (by facilitating or inhibiting) the course or rate of behavior development (e.g., Bjorkland, 1989).

Many researchers identify those behavioral changes of the child that vary with gross changes in its chronological age, and term their area of interest "developmental." As a descriptive, classificatory, or summary variable, with large enough time-segment units, the age of a child can index average levels or sets of responses found in groups of children who share age, and in that way can provide some summary information. For instance, researchers may find age units useful as rough markers for children having in their repertoires certain behaviors or skills that are preconditions for serving as subjects in a study. Baer (1970) has noted that chronological age can order developmental change in many environments because certain behavior-change contingencies are typically provided at particular age points by the culture. Thus, although the age variable can be useful for some purposes, it does not provide the conceptual leverage required for understanding the processes that account for behavioral development and individual differences. The following is Skinner's (1953) position on age:

When changes in behavior extend over long periods, we speak of the independent variable as the age of the organism. A response may appear at a given age and later disappear. The increase in probability as a function of age is often spoken of as maturation. We achieve some degree of prediction by discovering these developmental schedules. . . . [But] individual differences may be great; we cannot predict accurately when an individual will engage in a certain kind of sexual behavior by establishing the average age of onset in a population. Usually, therefore, practical problems of this kind are not solved by appeal to schedules of maturation...chronological age may be of little value in determining readiness. The presence or absence of the relevant behavior may have to be determined by direct observation of each child. (p. 156)

The process theories in psychology (e.g., Freud, 1905/1938; Piaget, 1936/1952, 1983; Werner, 1957), in addition to Skinner's (1938, 1953) as noted above, have had no place for age as such. The paucity of process-theory use of age may indicate that principles based on the passage of time alone are thought inefficient in accounting for development. In this context, age qua time can be seen as an empty variable insofar as it constitutes merely the space in which the individual's behavior and environment can interact and process variables can operate to produce their effects in behavior. Therefore, age as such has very limited explanatory value for the behavior of an individual (Baer, 1970; Gewirtz, 1969, 1978; Schaie & Hertzog, 1985).

Even so, age norms are available in the developmental literature. In those studies in which operant-conditioning procedures have been used with target responses for which age norms were available, typically the behavior criterion levels on such target responses were reached many months earlier than the normative age levels for those behavioral skills reported in the developmental literature. For example, in our research (Gewirtz & Peláez-Nogueras, 1991b, 1992a), the operant training of infant protests during maternal departures was done by mothers orienting and verbalizing contingently on those protests,

leading to 6-month-old infants exhibiting cued protest rates as high as those that Schaffer and Emerson (1964) identified in infants at 11 and 12 months. Such an example makes the point that it is not age or time as such but the processes that can occur within time, wherein environmental variables are related to orderly, progressive, and increasingly complex behavior changes, that imply development. This view can be contrasted with the traditional developmental psychologist's view that the behavior changes associated with conventional age units are the content of child development. For instance, Bjorkland (1989) has argued in his work on the development of children's thinking that "all children go through development in approximately the same way at approximately the same time" (p. 4). Such a traditional developmental notion downplays intrasubject and intersubject variation.

Any age-defined concept is limited in utility insofar as it ignores the underlying process variables that require a detailed analysis of the sequential features of environment-behavior (organism) interaction. Once the processes through which cumulative experience affects behavior systems are analyzed, such age-linked concepts as *critical period* and *sensitive period* lose even the modest precision their time limits might suggest.

### **A Behavior-Analytic Approach to Infant Learning and Development**

Some traditional child-development theorists have contrasted development with learning, arguing that although both are reflected in changes in behavior over time, development is broad and spontaneous, occurring over relatively long time segments, whereas learning is narrow in focus, precipitated by specific stimulus conditions, and typically occurring over relatively brief time segments. The age-validating approach to identifying the behavior changes that make up development must necessarily be slow, for gross behavior changes are required to correspond to the age units used (e.g., Bjorkland, 1989). A corollary of this usage is to disclaim the potential relevance of the results of process-oriented conditioning paradigms that organize behavior change efficiently in relatively short time segments, even though the behavior changes involved are often analogous to behavior changes validated against the age-unit metric that conventionally denotes development.

In analyses of human learning and development, conventional theorists have used complex, often unparimonious, constructs to order the overlapping areas of cognitive, social, and personality development. They have used global concepts, such as *traits* (e.g., easy/difficult, inhibited/uninhibited), that summarize infant behavior patterns through lengthy time spans while minimizing environmental context variables (e.g., Bates, 1980; Kagan, Reznick, & Snidman, 1986). Conversely, a behavior-analytic approach to development, founded on Skinner's work, calls for a finer-grained analysis of stimulus structure and functions, response structure and functions, their interchange at a particular moment, and the sequences of such interactions across successive moments. A be-

havior analysis of infant development is interested not only in the principles responsible for the changes observed in behavior, but also in the different directions, speeds, and contingency arrangements that result from the infant behavior-environment interchanges. In addition, Skinner's operant learning paradigm provides a valuable model for the study of infant (indeed all human) development, if only to determine which behavior change denoting development could, and could not, be susceptible to learning operations. These learning operations can focus those contextual and environmental factors that can raise or lower the efficacy of stimuli for behavior and, in that way, inflect the course of human behavioral development.

The laws governing infant development should in no way differ either in general flavor or detail from the laws governing other psychological sectors in which behavior provides the dependent variable. In behavior analysis, the term *development* is an abstraction for those progressive, orderly changes in the organization of stimulus-behavior relations. A functional analysis of infant behavioral development must focus on the many variables likely to be directly responsible for behavior change patterns. Thus, to understand behavioral development, analyses are required for: (a) changes in the complexity of the controlling environment, including the origins and changes in reinforcing stimuli for infant behavior; (b) early experiences as potential determinants of later behavior systems; and (c) the contextual variables that affect the functional relations between stimuli and infant responses.

To flesh out this last point, it is difficult to have a reasonable operational concept of development because the specification of those behavior systems whose sequential changes are taken to reflect development is arbitrary. Much of what looks like development might depend on teaching practices arranged in an order by society or culture (Baer & Rosales-Ruiz, in press). Even so, by focusing on environmental events that have a functional relation to behavior, namely discriminative and reinforcing stimuli, a functional approach to development can indicate ways in which the environment can shape the changing capacities of the infant and thus maximize or optimize development of behavior classes in important traditional areas (e.g., cognitive, emotional, social). Likewise, behavior analysis can describe the way in which the infant organism affects its environment (e.g., its mother's behavior), taking into account the ever-changing interaction between the two.

### *Analyzing Changes in the Complexity of the Controlling Environment*

Behavior changes often can be accounted for by increasing complexity of the stimulus patterns that acquire control over behavior. For example, upon presentation of an auditory stimulus, an infant initially may orient its head in the general direction of the sound (in which its mother is usually found), but eventually the infant will respond this way only to particular sounds appearing at certain times or in conjunction with a variety of other distal cues.

Thus, the discriminative stimuli for the infant head-turning response have changed, although the single head-turning response it controls remains unchanged. Systematic increases in the behavioral complexity of a more experienced child (often an older child, certainly one more advanced developmentally or operating at a higher stage) may be due primarily to systematic increases in the complexity of stimulus control of the environment. In this way, the developmental level of a child's response systems is determined, in part, by the range or complexity of the functional stimuli experienced (cf., e.g., Vince, 1961; for an illustration of this type of analysis, see the work of Etzel, in press, on the development of conceptual behavior and the hierarchies of elements in learning complex visual-auditory stimuli).

In addition, an analysis of the origins and changes in reinforcing stimuli as a function of the roles they play in behavior is necessary. It remains an empirical question at successive points in development which of the myriad potential stimuli function as unconditioned or conditioned reinforcers for infant behavior. In addition to positive reinforcing stimuli, a variety of contingent removals of aversive conditions (e.g., those that produce pain, cold, and wetness) can function as negative reinforcers for diverse infant responses. Such negative reinforcing stimuli also play a direct role in the process of infant behavioral development.

As the infant behavior repertoire increases and becomes more complex, some of these potential reinforcing stimuli may drop out functionally to be superseded by others, or their relative ability to function as reinforcers may change. The nature of the event patterns constituting the reinforcing property of certain stimuli changes as the infant moves from one capacity level to a higher one. For example, the social (and very likely conditioned) reinforcing stimulus of attention produced by the parent may be superseded in salience by that of verbal approval provided by parents for successively more complex or mature performances. This occurs in restricted settings in which the parent's approval (e.g., as denoted by smiles) mediates the delivery of most of the important reinforcing stimuli for the infant. As proposed here, a developmental analysis would examine changes in the efficacy of reinforcing stimuli for diverse infant behaviors, considering changes in the infant's receptor and effector capacities that are due to early neonatal experiences.

### *Analyzing Early Experiences as Determinants of Later Behavior Systems*

Development results from the changing organization of existing behaviors. The assumption that later experience builds upon the results of early experience does not apply uniquely to young children, but may hold for any time segment in the life of an individual. Early experience may influence the development of behavior systems later in life for several reasons.

First, some structural biological systems underlying behavior systems appear to require stimulus input to become or remain functional. Physiological development

also depends on the interaction between the individual's physiological systems and its environment. For example, a physically developed eye may not be functional until it has been exposed to the light (Hinde, 1966). There is a valid place for diverse research strategies and tactics directed to the biological substrate of molar receptor and effector functions and to coordinating such variables with molar behavior. Because changes in physiological systems and in behavior systems occur in both early and later segments of the life span, the principles governing early behavioral development should not differ from those governing later behavioral development. Furthermore, although certain kinds of stimulation may be required early in life to make some physiological systems functional, stimulation also may be required throughout development to maintain the functioning of these and other systems.

Second, many behavior systems of a child depend directly on the previous acquisition of component response systems during infancy. There is a dependence of late-developing skills on those acquired earlier. For example, all forms of ambulatory behavior require the earlier acquisition of the ability to stand and maintain balance. To be able to divide, a child must learn first how to add, subtract, and multiply. It is important to note that an infant in the first phase of life has had relatively little cumulative commerce with the environment, and thus the context for the effects of experience on its development will be different from that of a later phase of development in which it has had more cumulative experience and the necessary skills for the learning of a new response.

Third, certain more advanced, later appearing, behavior systems during childhood would be established more effectively when supported by behavior systems that were learned and maintained early in life, such as those involving eye contact, visual following and orienting, smiling, and vocalizing, and that can subsequently become the elements of the basis of diverse response complexes and sequences. Although the individual's behavior is changing continuously due to experience and organismic factors, and therefore learning processes may vary throughout the life span, later development, with all its complexity, is necessarily related to these early experiences and existing behavior. This process underpins the notion of continuity or consistency of environmental input over time.

#### ***Analyzing the Contextual Determinants of Behavior Development***

Contextual determinants not only inflect behavior and the various antecedent and concurrent variables affecting it (e.g., inhibitory and facilitory mechanisms), but also affect the interplay between reciprocal interactions among stimuli and response functions in context. Indeed, the probability of learning at any given moment, even within a narrow segment of the life span, may vary as a function of contextual conditions. Numerous researchers have dealt with these variables under different headings: "third variables" (Skinner, 1931), "setting factors" (Kantor,

1946), "setting events" (Bijou, in press; Bijou & Baer, 1978), "state" and "potentiating" variables (Goldiamond & Dyrud, 1967), "contextual determinants" (Gewirtz, 1972; Morris, 1988), and "establishing operations" (Michael, 1982).

Rather than take context as a source of variation and hold it constant—which has been the typical operation within behavior analysis—Morris (1988) proposed that historical and contemporaneous context should be a subject matter for experimental analysis. Knowledge of phylogenetic history (i.e., species-typic boundaries and preparedness in biological structure–vulnerability and behavioral function) and ontogenic historical causation (individual-typic boundaries and preparedness in biological and behavioral form and function, and variability in both) is fundamental for a complete behavior-analytic research. The structure of the current context involves the biological organism (i.e., the child's anatomy and physiology), the environment (physical ecology), and the changes and variability in both. The function of the current context potentiates or actualizes the functions of stimuli and responses for behavior. The function of contextual stimuli for responses involves the analysis of such variables as deprivation, illness, fatigue, and drug effects, among others.

#### **Skinner's Methodological Legacy: Operant Paradigms Used to Investigate Infant Cognitive, Social, and Emotional Phenomena**

B. F. Skinner's operant paradigm has provided the basis of a significant portion of the methodology used in infant research from the late 1950s to the present. The use of operant-contingency procedures (with their inherent learning principles) has increased in many areas of fundamental infant research, and diverse theoretical approaches to infant development have benefited from them. In general, early investigations revealed great infant behavioral plasticity in adjusting to diverse environmental contingencies. More recently, operant methodology has been used to investigate learning processes in the human infant, even in the prenatal and newborn periods.

The early experiments typically demonstrated the generality and applicability of behavioral principles, such as reinforcement, extinction, and discrimination, and confirmed the practicality and efficiency of carrying out research under the operant-conditioning paradigm (e.g., Brackbill, 1958; Caron, 1967; Koch, 1968; Papousek, 1961; Rheingold, Gewirtz, & Ross, 1959; Simmons, 1964; Siqueland, 1968; Siqueland & DeLucia, 1969; Siqueland & Lipsitt, 1966). In recent years, operant research with infants has emphasized the investigation of more fundamental and complex behavior, including a range of infant cognitive, social, and emotional phenomena (e.g., Boller, Rovee-Collier, Borovsky, O'Connor, & Shyi, 1990; DeCasper & Spence, 1986; Gewirtz & Peláez-Nogueras, 1992b; Poulson, Kymissis, Reeve, Andreatos & Reeve, 1991).

A complete review of infant research that has used operant methodologies in the past 30 plus years is beyond



the scope of this article. This literature has been organized under various arbitrary and overlapping domain headings, including the conditioning of, or applications to: infant discrimination of various stimulus modalities (e.g., DeCasper & Fifer, 1980; Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Lipsitt, Kaye, & Bosack, 1966; Olsho, 1985; for a review see Jusczyk, 1985); infant memory (e.g., Enright, Rovee-Collier, Fagen, & Caniglia, 1983; for a review see Rovee-Collier, 1987); vocal conditioning (e.g., Poulson, 1983; for a review see Poulson & Nunes, 1988); language learning (e.g., Moerk, 1990, 1992; for a review see Poulson & Kymissis, in press); categorization (e.g., Greco, Hayne, & Rovee-Collier, 1990); infant performance under reinforcement schedules (e.g., Lowe, Beasty, & Bentall, 1983); and intervention with handicapped infants (e.g., Brinker & Lewis, 1982).

Operant conditioning studies on infant social and emotional phenomena have been grouped in the literature under such headings as attachment and separation distress (e.g., Gewirtz & Peláez-Nogueras, 1991a, 1991b; Wahler, 1969); crying (e.g., Etzel & Gewirtz, 1967); imitation (e.g., Baer & Sherman, 1964; Kymissis & Poulson, 1990); and social referencing (Gewirtz & Peláez-Nogueras, 1992b; Peláez-Nogueras, 1992).

The work of Rovee-Collier and associates (Greco et al., 1990; Boller et al., 1990; Rovee-Collier & Fagen, 1981) illustrates the role of operant methodology in the study of infant memory. Infants placed face-up in a crib viewing an overhead mobile kicked their legs to produce a proportional movement of the mobile. During the conjugate reinforcement phase, the mobile's movement was activated by a ribbon connected from the infant's ankle to the mobile. This conditioning procedure facilitated the delineation of short- and long-term memory processes, indicated by retention of cued responding after delays of hours, days, and weeks. Variations of this mobile conjugate reinforcement procedure have been used to assess the contextual determinants of retrieval in early infancy (e.g., Rovee-Collier, Griesler, & Earley, 1985). Much of what is known about infant memory derives from use of the operant-conditioning paradigm.

The use of operant learning to study infant perception and learning is illustrated by the work of DeCasper and associates, who demonstrated the effect of systematic prenatal auditory exposure on postnatal learning (DeCasper & Prescott, 1984; DeCasper & Sigafos, 1983; DeCasper & Spence, 1986). In operant learning, human newborns exhibited increased nonnutritive sucking to produce the acoustic properties of a speech passage their mothers had recited repeatedly during the last trimester of gestation, in preference to a passage that their mothers had not recited (DeCasper & Spence, 1986). Also, the maternal voice, to which the fetus was exposed during gestation, functioned as a more effective reinforcer for the newborn (as evidenced by high sucking response rates) than did a stranger's voice (Spence & DeCasper, 1987). These studies suggest that in-utero auditory experience can affect postnatal behavior and learning in human infants.

In the area of infant social and emotional development, we (Gewirtz & Peláez-Nogueras, 1992b) have demonstrated that infant social referencing (i.e., being cued by the mother's facial expressions) and subsequent behavior can result from operant learning generated by positive and aversive contingencies for differentially cued infant behavior in ambiguous contexts. We showed that, in uncertain contexts, maternal facial response cues need not be limited to those providing affective or emotional information to their infants, such as those of joy and fear, as proposed by Campos (1983). Our research suggests that the extent to which an infant turns to search its mother's face for discriminative expressive cues in contexts of uncertainty depends on success in obtaining such information and on its validity and utility. That is, for the referencing response to be maintained in the infant's repertoire, maternal facial expressive cues must be consistently contingent on infant referencing behavior and must predict reliably the environmental consequences of the infant's ensuing action in ambiguous contexts.

In summary, the operant-learning paradigm has been remarkably fruitful in generating research questions and answers concerning cognitive and social phenomena. Behavior analysis has been an effective and powerful approach for advancing knowledge of infant behavior capacities, learning, and development. As demonstrated in the work listed earlier, behavior-analytic research has progressed beyond mere demonstrations of the acquisition of simple human behavior and has attained a level of conceptualization adequate to organize diverse complex processes during infancy.

## Conclusion

The basic theme of this article has been that infant behavior and development are amenable to an operant-learning analysis. In this frame, B.F. Skinner's legacy to infant behavior analysis is a very powerful and practical one. Operant analysis has made it possible to move beyond the level of simple description of infant behavior to the level of identifying key processes that account for much of behavioral development. Furthermore, operant analysis has been used to determine which behaviors denoting development could, and which behaviors could not, be susceptible to learning operations. A corollary is that the phenomena that have been identified in descriptive accounts of infant behavioral development have benefited, or could benefit, from systematic operant-learning analyses.

In behavior analysis, the term *development* is an abstraction for progressive, orderly changes in the organization of environment-behavior relations. A functional analysis of infant behavior must focus on the many variables likely to be directly responsible for behavior change patterns denoting development. Thus, to understand behavioral development, analyses are required for changes in the complexity of the controlling environment (including the origins and changes in reinforcing stimuli for infant behavior), for early experiences as potential determinants of later behavior system, and for the contextual

variables (including setting factors) involved and their interplay in interactions among stimulus and response functions.

Because many studies have shown that operant procedures could produce rapid behavior changes in infants, those procedures have become—for behavioral and non-behavioral researchers alike—the preferred methods for studying processes that otherwise have been inaccessible by the traditional methodologies of nonbehavioral psychology. In this manner, the use of operant procedures and derivative methodologies has progressed enormously in the past four decades, leading to an impressive advance in knowledge of the infant's behavior. Advances have been made under such basic psychological rubrics as discrimination, perception, memory, language and information processing, and such basic emotional and social themes as parent–infant reciprocal conditioning effects, attachment, imitation, and social referencing.

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