Theory in Behavior Analysis

An Application to Child Development

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Theory in behavior analysis is described, and its application to developmental psychology is illustrated using examples from the literature on the development of infant memory and perceptual size constancy. Traditional approaches to development are briefly described and juxtaposed with a behavioral approach. Behavior-analytic theory is evaluated according to several criteria of good scientific theories. It is concluded that modern behavior-analytic theory, which grew largely out of the work of B. F. Skinner, succeeds well at explaining many of the facts of infant memory and perceptual size constancy and may also succeed at explaining facts in other areas of developmental psychology. Behavior analysis may thus be able to provide some theoretical uniformity in the field of developmental psychology.

The General Problem

In the past several decades, the field of developmental psychology has grown and generated a vast amount of research. Despite this growth, the field remains theoretically fractionated, with very little of its research united by a common theoretical orientation. Not surprisingly, textbooks in the field reflect this state of affairs. Although many developmental textbooks are written from a generally cognitive perspective, none adopts a unitary theoretical approach. Based simply on the amount of information in the field, these textbooks give the impression that developmental psychologists know a lot about the behavioral changes that constitute development. On the other hand, the amount of contrasting evidence for many phenomena and the numerous explanations and theories seem to suggest that developmental psychologists are unable to make much sense of this information. They may be able to tell us what children are likely to do and at approximately what age but not how or why they are able to do it. At the very least, developmental psychology is a field with the appearance of confusion. Unlike the natural sciences, it seems to be accepted practice to assume that many different theories and explanations are needed to account for essentially the same subject matter, in this case, the behavioral changes that are observed over time in the life of an individual. This general practice results in the existence of a large body of factual information but one lacking theoretical consistency or unity. Students of developmental psychology may learn a lot of individual facts, and they may be better able to predict the average age at which certain behavioral changes emerge, but they are not given the theoretical tools with which to understand or explain these changes within a unified framework. In addition, those who work with children in applied settings gain little practical knowledge that can be used to reliably change behavior. Behavior analysts who are interested in development find this state of affairs troubling.

Although the theoretical systems within developmental psychology are largely unsatisfactory, at least for behavior analysts, some of the research may be valuable and therefore worthy of consideration. However, we need not throw the baby out with the bath water. Behavior analysts ought to ask whether it is possible to make sense of this accumulation of apparently unrelated data without necessarily accepting the accompanying explanations and theories. Over the years, there have been some attempts by behavior analysts to apply behavior-analytic theory to child development (e.g., Bijou, 1976; Bijou & Baer, 1978). However, behavior analysts by and large have not addressed the extensive research in the area conducted largely by psychologists who are not behavior analysts although there are some exceptions (e.g., Gewirtz, 1972a, 1972b; Gewirtz & Pelaez-Nogueras, 1990, 1991). Because much of the existing research in developmental psychology suggests a strong environmental component to behavioral development, behavior-analytic theory is in an ideal position to interpret the behavioral changes that define this development.

Although it is possible to show that behavior-analytic theory succeeds as a theory of behavioral development, its treatment in most developmental textbooks indicates that it is regarded as being relatively unimportant for the understanding of development. In some cases behavior-analytic theory is relegated to an almost historical place in developmental psychology (e.g., Scarr, Weinberg, & Levine, 1986). In other books, it is never credited with being able to explain anything more than trivial behaviors (e.g., Collins & Kuczaj, 1991). Still other textbooks offer rather lengthy sections on learning (not explicitly behavior-analytic theory) in which the principles of respondent and operant conditioning are detailed; however, subsequent discussions of behavioral changes attributed to

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learning rarely refer back to these principles (e.g., Dworetzky, 1991). In many textbooks the discussion of learning, not to mention behavior-analytic theory, is almost nonexistent (e.g., Collins & Kuczaj, 1991; Santrock, 1990). Finally, many standard textbooks in developmental psychology omit the significant empirical and theoretical contributions of behavior analysts to the scientific understanding of child behavior. This sizable literature includes, but is not limited to, notable work by Donald M. Baer, Sidney W. Bijou, Jacob L. Gewirtz, Lewis P. Lipsitt, and Carolyn Rovee-Collier and their respective colleagues. At the very least, this omission does a disservice to students of developmental psychology by depriving them of valuable empirical and theoretical analyses of behavioral development in children.

In the present article, I clarify a behavior-analytic position on scientific theory and then demonstrate how behavior-analytic theory can be used to interpret certain facts in developmental psychology. Throughout this article, a behavior-analytic theory of development is counterposed with traditional structural theoretical approaches. The purpose of the article is to show that interpreting developmental research according to behavior-analytic theory can provide theoretical cohesiveness to developmental psychology.

**Conception of Behavior in Developmental Psychology**

It has been standard practice in psychology in general, and developmental psychology in particular, to differentiate behavior largely according to its form. In developmental psychology, this practice has resulted in such presumably distinct categories as motor behavior, social behavior, emotional behavior (emotion), cognitive behavior (cognition), perceptual behavior (perception), language behavior, and so on. Even within these categories structural distinctions are made. For example, cognitive-developmental psychologists distinguish among imitation, conservation, and object constancy as if each of these behavioral classes was a different creature requiring its own distinct explanatory mechanism. The assumption is that each of these types of behavior are fundamentally and functionally different.

Once behavior has been distinguished largely on the basis of structural characteristics, it becomes easier to assume that different theories or explanations are required for the development of each type of behavior. For example, Piaget's theory intends to explain cognitive development, Freud's theory intends to explain social development, both Piaget and Kohlberg have theories of moral development, and there are different theories of emotional development, language development, and so on. Even within single theoretical systems, structurally differentiated behaviors are afforded different explanations. In Piaget's theory, for example, there are different mental structures to explain object permanence, conservation, egocentrism, and so on. In fact, the entire field of child development implies a domain that is functionally distinct from adult psychology, as if each were governed by different psychological principles. Students often wonder what to make of this theoretical eclecticism, which is often presented in developmental psychology textbooks as if it were a strength.

The implications of a structural approach in developmental psychology cannot be overstated. It assumes that classes of behavior, distinguished primarily on the basis of structural properties, are separate functional classes requiring different explanatory mechanisms. Unfortunately, all too often, the theories and explanations used to account for the development of these behaviors are arrived at by way of logical error that is often circular in nature. First, the behavioral class is given a name. The name is then reified and itself becomes the object of study. Finally, the name is used as the explanation of the observed behavior. Much of the Piagetian approach to development illustrates this. For example, by about 24 months, infants are able to behave effectively toward objects under a wide range of conditions of their absence. Piaget and other developmental psychologists have termed these observed behavior–environment interactions *object permanence*. When studying the development of the phenomenon, it is said that they are studying object permanence, or the emergence of the concept of object permanence, which implies that what is being studied is something other than the observed behavior–environment relations. Then, when infants are finally able to behave appropriately with respect to objects that are out of sight, it is said they can do so because they now possess the concept of object permanence or the mental capacity to represent objects. Object permanence, which began as the name for certain observed behavioral relations, has become a thing (a structure or process) located inside the child that is said to be responsible for the observed behavior. Although the logical errors in this type of theorizing have been noted by psychologists who are not behavior analysts (e.g., Dworetzky, 1991; Flannagan, 1991), it has done little to diminish such practices.

In addition to the number of different theories, developmental psychology is also noteworthy for the large number of facts researchers have collected. Unfortunately, many of the facts have been generated by nonexperimental, mostly correlational, research, and therefore they do not represent the types of basic facts that characterize a natural science approach, namely, functional relations between controlled variables. Also, because much of the correlational research involves the child's age as one of the variables, it is often implied that functional relations have been uncovered when they have not. In such accounts, the independent variable is said to be the child's age or some invented cognitive structure that develops and is conveniently said to be age specific. For example, Piagetian psychologists describe the development of object permanence during several substages of the sensorimotor period. Each change in children's behavior with respect to hidden or displaced objects is correlated with changes in their ages. Thus, during Stages 1 and 2 (1 to 4 months), objects that are out of sight are literally out of mind; in other words, infants will not continue to behave toward
such objects. However, by Stage 6 (18 to 24 months) infants will continue to respond to hidden objects.

Even though age is the variable correlated with the behavioral changes, the real independent variable is said to be a developing mental structure that enables the child to respond to hidden objects. Because the mental structure presumably develops maturationally, age is naturally a logical reflection of changes in it. Such structural normative approaches form the basis for many of the major “theories” in the area of human development and have encouraged the invention of stage theories of behavior change in developmental psychology. Correlational research does allow for a modicum of prediction, but the actual control of the relevant variables that is the hallmark of a natural science approach is absent and so too is scientific prediction and understanding derived from this control. Even when true experimental research is conducted in developmental psychology, the resulting data are rarely interpreted according to any particular theory. Instead, the data are left without interpretation or they are simply described using inferential circular explanations. For example, moral behavior is said to result from moral understanding, attachment behaviors are said to result from emotional bonds between child and parent, and other behaviors, called cognitive, are said to result from mental processes such as concepts, memories, or perceptions. Finally, the purpose of much correlational normative research seems to be nothing more than demonstrating the presence or absence of some behavior in children and the approximate corresponding ages but not how the behavior came to be.

The concept of stages and structures in developmental psychology is not totally without merit; it has aided in the organization of data and in communication between researchers (Lipsitt, 1981). However, the problems generated by structural normative approaches far outweigh these benefits. Lipsitt listed several of these problems. First, structural approaches to behavior posit structures that are not directly observable. Classic examples are Freud’s ego, super-ego, and id; Piaget’s cognitive structures, schemata, concepts, and rules; and the input, storage, and retrieval systems of the information-processing model. A second problem noted by Lipsitt is that the emphasis on hypothetical structures and processes has tended to obfuscate other, perhaps more central, underlying behavioral processes. Third, as I have already noted, structural normative approaches tend to confuse description with explanation. For example, according to Lipsitt, the transitional nature of behavior change, which is an important behavioral process in its own right, is overlooked when normative descriptions lead us to believe that we have explained a transition by saying, for example, that the child is now in “the preoperational stage.” A fourth problem with structural normative orientations is that inferred “constitutional-maturational determinants” of behavior change are emphasized at the expense of more direct environmental or physiological variables. A fifth problem is that structural concepts that emphasize stages reduce optimism about the potential of humans to benefit from environmental manipulations, especially those in education. If behavioral development is indeed constrained by the stagewise development of underlying structures and processes, then, in principle, it should be impossible to accelerate that development. However, there is sufficient evidence to force serious reconsideration of this interpretation of development so much so that the concept of maturational stages as important determinants of behavior is seriously threatened (see Dworetzky, 1991, pp. 262–266; Lipsitt, 1981). Finally, structural normative interpretations easily fall into the logical verbal trap of reification. According to Lipsitt, the empirical hazard is that we come to regard those stages as real conditions of the organism rather than as artifacts of our observational procedures and methodologies. Conceptualizations of development in terms of stages are usually followed closely by the adoption of a structural view of the mind. The postulation of structures is usually based upon behavioral observations, to be sure, but the language quickly becomes metaphorical. The special words, initially devised merely to abbreviate complex behavior patterns, now become taskmasters and slaves. (pp. 31–32)

The problem of reification leads to another troublesome verbal practice in developmental psychology. Locating the causes of behavior inside the child makes it easier to describe the child as the originator of his or her actions. Thus, after contact with environmental stimulation, the child is said to “sense,” “perceive,” “remember,” “think,” “judge,” “decide,” and so on as if these verbs referred to real actions. However, once described in this way, behavior can be more easily attributed to these presumably internal activities. The most conspicuous examples of this are found in cases of clear-cut operant or respondent conditioning. For example, according to Kalins and Bruner (1973), conditioning studies with infants provide evidence that infants are not only able “to anticipate an outcome,” but they are able to “choose” and “deploy” “means for achieving it.” Moreover, infants are said to have the “ability to correct and coordinate behaviour in a fashion that would lead it more directly to the goal” (p. 307). However, what are the actions to which the verbs anticipate, choose, deploy, correct, and coordinate refer? Although these are the words of common usage and are easily understood by everyone, they divert attention away from the controlling variables of the behaviors in question. In their study, Kalins and Bruner showed with infants that when sucking a nonnutritive nipple at a certain rate produced a focused picture, sucking rates increased, and, conversely, when a blurred picture was produced, sucking rates decreased. The facts are clear enough and the interpretation is simple enough: Seeing a focused picture strengthened the sucking rates that produced the focused picture; the process is called reinforcement. Conversely, the process of weakening sucking rates by presenting a blurred picture is called punishment. Saying that the child is “able to carry out skilled, voluntary-controlled, adaptive behavior that leads him to goals” adds nothing to the facts and diverts control of sucking away from the environment (i.e., the clarity
of the picture) to some hypothetical agent inside the child. Again, although such language seems benign enough, it is not completely objective, it states more than the facts allow, and it adds little to the prediction and nothing to the control of the behavior. In a word, it is unnecessary. Moreover, it reduces the likelihood that the true range of environmental determinants of the behavior will be identified. The conclusion from this brief presentation is that the general theoretical approach found in developmental psychology does not succeed well at understanding behavioral development. In this article, I am suggesting that behavior-analytic theory can do better.

Theory in Behavior Analysis

**Skinner on Theory**

The role of theory in behavior analysis has been a subject of debate in psychology especially since B. F. Skinner's well-known 1950 article, "Are Theories of Learning Necessary?" Misunderstandings of Skinner's position have been widespread; Skinner has been portrayed as being antitheory and behaviorism as being atheoretical. In his often cited article, "Are Theories of Learning Necessary?" Skinner argued against only certain types of theories: namely, those that appealed to inferred internal constructs as explanations of behavior. For Skinner, such theories and the hypothetico-deductive methods used to formulate them were actually detrimental to a science of behavior because they represented a diversion from the analysis of real behavior in the real world. Scientists using this approach would be more concerned with testing theorems than actually searching for orderly relations as is the practice in the natural sciences. As for the title of the article, Skinner simply meant that he and others had already begun to discover orderly behavioral relations using a research program "with a minimum of theoretical constructs and in the absence of hypothetico-deductive methods" (Zuriff, 1985, p. 88), and thus explanations at other levels of analysis did not seem necessary. Therefore, Skinner was not opposed to all theories in psychology, only those with explanations that appealed to inferred events when more objective events were available.

Although critics apparently reacted against Skinner's antitheory stance, it is more likely that what they really objected to were his interpretations. In other words, critics did not like Skinner's behavioristic theory (e.g., Baars, 1986). However, there may have also been misunderstandings about Skinner's views on theory in science and psychology. Let us, therefore, look at how Skinner used the term theory to define his own approach. Before doing so, it might be instructive to examine some of the definitions of theory found in the dictionary. According to Webster's Seventh New Collegiate Dictionary (1965), theory is (a) "the analysis of a set of facts in their relation to one another;" (b) "the general or abstract principles of a body of fact" or a "science;" or (c) "a plausible or scientifically acceptable general principle or body of principles offered to explain phenomena." To paraphrase, a theory includes some already established body of fact, abstract principles inductively derived therefrom, and the use of such principles to explain new facts.

Skinner frequently discussed his position on scientific method and theory (e.g., 1938, 1947, 1950, 1956). However, Zuriff (1985, p. 89) summarized Skinner's (and the behavior-analytic) position. According to Zuriff, Skinnerian theory consists of concepts that express "empirical functional relationships between behavioral and environmental variables." More specifically, Theory, in the acceptable sense, evolves in the attempt to present the collection of empirical fact in a formal and economical way. A formulation using a minimal number of terms to represent a large number of experimental facts is a theory. As the theory develops, it integrates more facts in increasingly more economical formulations. Theoretical concepts thus merely collate observations and do not refer to nonbehavioral processes. A Skinnerian theory is, therefore, a simple, comprehensive, and abstract description of a corpus of data. (p. 89)

As can be seen from Zuriff's description, scientific theory for Skinner essentially mirrors the statements found in the dictionary: namely, a collection of empirical facts (specifically functional relations) and the formulation of principles derived inductively from those facts with a minimal number of terms and concepts. Some might suggest that Skinner's approach is nothing more than random fact gathering; however, this would be incorrect. In elucidating his position on the relation between fact and theory, Skinner (1947) wrote,

A theory . . . has nothing to do with the presence or absence of experimental confirmation. Facts and theories do not stand in opposition to each other. The relation, rather, is this: theories are based upon facts; they are statements about organizations of facts. The atomic theory, the kinetic theory of gasses, the theory of evolution and the theory of the gene are examples of reputable and useful scientific theories. They are all statements about facts, and with proper operational care they need be nothing more than that. But they have a generality which transcends particular facts and gives them a wider usefulness. Every science eventually reaches the stage of theory in this sense. (p. 28)

What is implied here, and in fact is stated directly by Skinner elsewhere, is that these theoretical principles should then be used to interpret (i.e., understand) novel empirical observations (e.g., Skinner, 1957). The interpretation of novel behavioral relations using established principles has been a consistent practice in behavior analysis for many years (e.g., Bijou, 1976; Bijou & Baer, 1978; Catania, 1984; Palmer, 1991; Skinner, 1957; Whaley & Malott, 1973). It is part of a long tradition in the natural sciences of using theoretical principles induced from scientific facts to understand novel phenomena that are usually more complex than what can be studied in the laboratory. According to Palmer,

Interpretation has served, and continues to serve, an honorable role in science, so honorable that we often fail to distinguish between an interpretation and an experimental analysis. Newton's explanation of ocean tides is an interpretation based on his experimental analysis of phenomena such as the motion of pendulums and colliding balls of wool, glass and cork. No one, least of all, Newton, has attempted to establish experimental
control over the tides. Yet Newton's principles (to a reasonable approximation) are so firmly established and the extrapolation to this phenomenon so plausible, that we accept his interpretation as if it were the direct outcome of an experimental analysis. (p. 261)

The key to a plausible interpretation is that it proceeds from a foundation of well-established principles derived from a rigorous program of basic research. This is the advantage that behavior analysis brings to the task of understanding that part of human behavior that has not yet been directly subjected to an experimental analysis.

In general then, behavior-analytic theory is concerned with lawful relations between observable events, namely, behavior and its environmental determinants. Consequently, the theory is maximally descriptive and minimally inferential. This is one reason why behavior analysts are so strict (some would say picky) about their use of language in describing behavioral events. Specifically, behavior-analytic theory is composed of the laws and principles, derived from the experimental analysis of basic units of behavior, that describe known functional relations between behavior and environment. Behavior-analytic theory includes, but is not limited to, the laws of respondent (Pavlovian) conditioning as well as the operant laws of reinforcement (and punishment) and stimulus control, and all of their related principles and respective parameters.

Basic Units in Behavior Analysis

The key to the emergence of laws of behavior has been the discovery of functional analytic units of behavior. The success of any science depends on whether that science has discovered "proper units" of analysis. As Zeiler (1986) noted,

A well-defined unit clarifies the way phenomena are conceptualized and thereby guides research and theory. Isolation of a unit brings order to otherwise discrepant phenomena; invalid units easily lead to confusion as to the meaning and significance of the data. (p. 1)

The generic units of modern behavior analysis were first described by Skinner (1935). Skinner defined stimuli and responses not as independent structural units but as functional classes. Thus, stimuli were not defined by their physical energy and responses were not defined by their topography. Rather, both were defined functionally, that is, by their respective effects on one another, and, as a result, fundamental units of the analysis of behavior were discovered. Several behavior analysts have described the importance of this discovery for a science of behavior (e.g., Branch, 1977; Catania, 1973; Zeiler, 1986). According to Zeiler,

The fundamental units (operants, respondents, discriminative operants) are the smallest entities that display the full characteristics of adaptive behavior. The previous structural entities (stimuli and responses in isolation) now become components of the basic units, analogous to nuclei and cytoplasm as components of cells. Research can involve the variables determining how generic classes are constructed and the factors responsible for particular forms of coordinated behavior, but never is it necessary to move to a nonbehavioral level of analysis. (pp. 4–5)

This last statement is, of course, Skinner's (and the behavior-analytic) position on the role of explanation (or theory) in the study of behavior. In the present article, I argue that it is because of these fundamental units that behavior analysis can bring order and clarity to developmental psychology, which, borrowing from the earlier quote by Zeiler (1986), can be characterized as possessing "discrepant phenomena" with "invalid units," all of which produce "confusion as to the meaning and significance of the data." Just as the discovery of the cell, as a basic unit of biology, integrated the disciplines of anatomy, embryology, botany, and zoology into the unified field that we now call the biological sciences (see Zeiler, 1986), so too can the basic units of behavior analysis help to unify the various topical subareas of developmental psychology.

The concept of basic units of analysis has implications for the distinction between structural and functional approaches to behavior. Behavior analysts do not deny that behavioral units can have structure. Rather, they assert that the units must be functionally defined. As Branch (1977) put it,

The crux of the issue is not whether units can have structure; they do. The important question is, to what is the structure due? A structural account points to structural aspects of the behavior whereas a functional account will emphasize the role of manipulable variables in the formation of the units. (p. 172)

For behavior analysis, the "manipulable variables" responsible for the formation of units of behavior are to be found largely in the individual's environment.

Behavior-Analytic View of the Environment

The concept of environment is a common one in psychology; however, the conception of environment in behavior analysis differs from that found in other psychological approaches; therefore, it warrants clarification. Most standard views of the environment are not only structural in nature but molar as well. In child developmental psychology, the environment is typically defined by people (e.g., parents, teachers, friends) and institutions (e.g., schools, communities; Collins & Kuczaj, 1991) or as the experiences a child has (Scarr et al., 1986). For example, in the debate about the effects of early adverse experiences, the environment is described as either being enriched or deprived or restricted (e.g., Collins & Kuczaj, 1991). With regard to social development, the context is said to be important. The context of social development usually is said to include the family, its socioeconomic status, the number of siblings, parents' employment status, and so on. Although allusions to specific interactions are sometimes made, the environment usually is viewed as a structural entity with properties that can be quantified and thus included in correlational calculations with the child's age or developmental progress. These conceptions of environment may aid in conducting correlational studies, but they fall prey to some of the same problems
described earlier concerning structural conceptions of behavior. Namely, they tend to obscure more fundamental and molecular environmental variables, and they become easily involved in circular explanations. Finally, standard psychological conceptions follow from the lay vernacular that the environment is something that surrounds us.

The behavior-analytic view of the environment is, by contrast, a functional one. Behavior analysts view the environment as consisting of energy changes (i.e., stimuli) of various sorts that affect not only the sensory receptors of organisms but also their behavior. Thus, stimuli, as well as other events (e.g., motivational operations), and behavior can enter into orderly functional relations with each other. These functional relations form the basic units of behavior from which the laws and principles of behavior analysis have been induced. A functional conception of the environment implies, among other things, that the depiction of the environment as something that surrounds us is incomplete at best. If, in fact, the environment is defined functionally as all of the events that enter into functional relations with an organism's behavior at any one time, then we must expand our view of the environment to include events both inside as well as outside the body. Hence, the skin is no longer an arbitrary structural boundary, and the environment may now be viewed from a thoroughly functional perspective.

**Behavior-Analytic View of Locus of Control**

Any discussion of environment raises the problem of where the determinants of behavior lie. The issue of locus of control is central in behavior analysis and is one of the features that most distinguishes it from other psychological approaches to behavior. Previously, I described how some developmental researchers interpreted a relatively simple demonstration of operant conditioning in infants by placing the determiners of the behavior inside the child. In this typical account of behavior, the child is exposed to an environment but it is the child who "attends," "decides," "chooses," and, thus, "behaves." It is not surprising that such interactions are described as voluntary behavior in which the child is seen as the agent (i.e., originator or initiator) of his or her own actions.

Behavior analysts register several objections to such agent-action accounts of behavior (e.g., Hineline, 1990). The most obvious objection is that, in many cases, the control of behavior is clearly not inside the child but in the environment. The Kalnins and Bruner (1973) study is a perfect example. The rates of sucking changed whenever the experimenters changed the outcome of sucking, that is, the clarity of the picture. Thus, changes in the environment and not the child were responsible for the changes in sucking behavior. It would be as though an experimenter repeatedly operantly conditioned and then extinguished a rat's lever press but then attributed the changes in behavior to the rat's own decision making and voluntary control. At the very least, such descriptions are redundant and add nothing new to the understanding of behavior. At worst, they lead researchers away from the real controlling variables and in search of elusive qualities that can only be inferred after first manipulating the subject's environment.

In short, behavior analysis attributes human behavior to a constellation of variables including the individual's genes and physiological makeup but primarily to the environment, both past and present. Consequently, differences in behavior between individuals are more likely to be attributed to differences in the functional aspects of their environments. When behavior can be unequivocally traced to environmental interactions, as it can often be in a controlled laboratory, such an account is strengthened.

What follows is an illustration of how behavior-analytic theory might be applied to two research areas in child development that are not typically presented as being related. A behavior-analytic interpretation relates them by examining them as examples of adaptive behavior, that is, behavior as a function of environmental variables and subject to the same natural laws.

**Illustrative Examples of Developmental Phenomena**

**Infant Memory**

The importance of the concept of memory for cognitive approaches to psychology cannot be overstated. To the extent that the study of memory cannot be separated from the general study of what is called information processing (Cohen & Gelber, 1975), it is possible to view it as the essence of modern cognitive psychology. As a result, a vast and complicated theoretical network has emerged around the concept of memory, and this raises difficulties for a behavior-analytic interpretation of infant memory. The main difficulty is that behavior analysis and at least some versions of cognitive psychology hold diametrically opposed views of reality. According to McDowell (1991), "behavior analysis presupposes a materialistic ontology, according to which the world consists of material objects and events," whereas (cognitive) "psychology presupposes a nonmaterialistic ontology, according to which the world consists of non-material objects and events as well as material objects and events" (p. 29). Hence, trying to make sense out of concepts such as memory traces, storage locations, and retrieval systems using behavior-analytic theory is like comparing apples and oranges. Theoretical questions in the memory literature also reveal the difficulties behavior analysis has working within a different framework. So, for example, questions such as "Is there only one storage system in which traces are set down?" or is there "a limited capacity short-term memory in which items are held for only brief periods of time, and a high-capacity long-term memory in which items are complexly coded thereby greatly reducing information loss due to forgetting or retrieval failure?" (Cohen & Gelber, 1975, pp. 348-349) are unanswerable because the proposed theoretical entities are not accessible to empirical methods. As I stated earlier, rather than disregarding behavior because a theory is unstable, the behavior-
analytic approach attempts to understand the behavior according to the established laws and principles of behavior analysis and to regard the particular inferred theoretical constructs as unnecessary. I have already described behavior analysts' opposition to inferred internal events as explanations of observed behavior. Behavior analysts' opposition to inferences, however, is not an absolute one to all inferences but rather only to those that are unverifiable. The task of behavior analysis when confronting a psychology based in large part on inferred internal events is to examine the behavior from which the internal events are inferred.

This may seem inadequate for cognitively oriented psychologists, and it may be partially responsible for the criticism that, by concentrating primarily on observable behavior, behavior analysis ignores what is most interesting about human psychology (McDowell, 1991). The inadequacy, however, may arise from the selection of the particular behavior not by the behavior analyst but by the cognitive psychologist. It is this point that raises a second difficulty for a behavior-analytic interpretation of (infant) memory. Attempting to interpret units defined by cognitive psychologists means buying into the general cognitive strategy of identifying units of analysis in advance of their measurement "merely on the basis of their putative structure or topography" (Branch, 1977, p. 171).

The concept of memory and all of its components (e.g., short-term and long-term memory and so on) qualifies as such a unit. Recall that for cognitive psychology behavior seems to be important largely insofar as it reflects inferred internal events. So cognitively oriented psychologists are less likely to define behavior on the basis of its functional relation to environmental variables than by what it suggests to them about underlying structures and processes. The behavior analyst who attempts to interpret data derived from this fundamental assumption, then, does so at some risk. Notwithstanding these difficulties, let us look briefly at how behavior-analytic theory might approach some of the facts that comprise the topic of infant memory.

Standard description of (infant) memory. One developmental textbook defines memory as "a person's mental record of an event" (Scarr et al., 1986, p. 232). This definition brings with it all of the attendant problems of structural approaches to behavior described previously. Briefly, behaviors are observed in certain situations and they are given a name, in this case, memory. The behaviors are reified as a "mental record of an event." The mental record is never directly observed. Finally the concept of memory or of the "mental record of an event" is used to explain the very behaviors they are said to represent—a circular explanation. For example, the relatively poor memory of preschoolers has been attributed to a lack of meaningful organization of their memories, their limited information-processing capacity, and an inadequate knowledge base (Scarr et al., 1986). Of course, lack of meaningful organization, limited information-processing capacity, and inadequate knowledge bases are all inferred from the behaviors to be explained in the first place. Descriptions such as these create surrogates for the child's behavior, which are then moved inside the child without any independent empirical confirmation. Scarr et al. (1986) provided two examples in their respective discussions of the poor memory organization and limited information-processing capacity of preschoolers:

One might compare the storage area of the human mind to a vast library, filled with endless shelves of information. To recall a particular experience or retrieve certain information, the child must search the shelves to find what she needs. If her memory collection is organized in a meaningful way, if it is cataloged, the search is much easier. (pp. 233–234)

and,

When faced with a memory task, an older child automatically begins grouping items in his mind, rehearsing the lists of words, and applying other strategies to the task. He has a program or scheme for memorization. The younger child does not have such a scheme. She has to think about how she is going to learn the pictures or words. This uses up mental "space," leaving less room for actually storing information. (p. 234)

The first quote is clearly analogical, but the second quote implies the existence of mental structures (schemes) and processes. Such descriptions do make communication easier; everyone knows what a library is and what a (computer) program is, and we are all familiar with searching the shelves of a library for a book and with storage "space" in computers. In these descriptions, however, things do not happen in the real world of behavior and environment but in another world of inferred events called mind or cognition. Although all of this appears relatively benign, it contributes little to the understanding of the behavior from which all of it is inferred. Moreover, concentrating on memories and other inferred mental structures directs researchers away from investigating more fundamental underlying processes such as the reinforcement contingencies responsible for the observed behaviors ("memory"). A behavioral analysis takes a different approach.

Experimental facts of infant memory. It has been said that imitation, object permanence, attachment, conditioning, and preference for novel stimuli in infants all imply and require memory (Cohen & Gelber, 1975). Studies of memory in infants are often concerned with what is called recognition memory. Visual recognition memory is inferred "when infants respond differentially to familiar and novel stimuli" (Werner & Siqueland, 1978, p. 79). Investigators have used both habituation and novelty preference procedures to test for such recognition memory. Consider a typical habituation procedure. A single pattern (e.g., consisting of geometrical shapes or pictures of faces) is presented repeatedly until visual fixation time decreases, and then in test trials both novel and familiar stimuli are presented. The dependent measure is the difference in fixation time between the two types of stimuli. The novelty preference procedure, which is a variation on the habitation procedure, involves simultaneously presenting two identical patterns to infants, one on the left side and the other on the right side. After this has been done repeatedly, a test trial is presented in
which a novel stimulus is presented with the familiar stimulus. Again, the dependent measure is the proportion of visual fixation time to the novel versus the familiar stimulus (Cohen & Gelber, 1975). Results of both types of procedures show generally that visual fixation behavior is proportionally longer to the novel stimuli (Miranda & Fantz, 1974). There are at least two questions concerning both procedures: What is being measured? How should the results be interpreted? The answers provided by traditional developmental psychology and behavior analysis reveal the differences in their respective approaches. For developmental psychologists, what is purportedly being measured is recognition memory, which is itself inferred from the differential fixation times. That is, if there are differences in fixation times, recognition memory exists, and if there are no differences, then there is no recognition memory. The standard explanation of the behavior of the infants under these tests of “short-term memory” seems to be the same as the memory itself and, thus, circular. For example, Miranda and Fantz (1974) concluded that “the infant is able to take in and retain information from a visual stimulus and thereby to differentiate between that stimulus and an unfamiliar one” (p. 651). However, is this saying anything more than there are different fixation times to different stimuli? In fact, the only evidence for the taking in and retention of information and the differentiation between stimuli is the very behavior to be explained: differential fixation times.

A behavior analysis of infant memory. Recall that behavior analysts might not conduct this specific type of research, and therefore they are at some disadvantage when attempting to interpret the results. Nevertheless, for behavior-analytic theory, the dependent measure in the habituation and novelty preference studies would probably be the amount of time the infant’s eyes fixate on a particular pattern (or, more molecularly, the actual eye movements to the stimuli). The behavior-analytic interpretation of the results would very likely be in terms of stimulus control as predicted by the extant experimental literature on habituation rather than appealing to inferred internal events (i.e., recognition memory). Such theoretical parameters as rate of habituation, the inter-stimulus interval, generalization, spontaneous recovery, and dishabituation may be brought to bear. For behavior-analytic theory, it is sufficient to account for infants’ behavior on the basis of what is already known about habituation, the facts of which occupy part of behavior-analytic theory. Of course, habituation may be understood at another level—that of underlying cellular processes (e.g., Kandel, 1975)—although this does not negate the principles of habituation at the level of behavior and environment. None of this, however, requires appealing to inferred internal entities or processes. Incidentally, habituation has been studied in many other species, including those with relatively simple nervous systems, such as the marine invertebrate Aplysia (see Kandel, 1975), without inferring hypothetical cognitive events to account for the facts. It is also possible that these so-called studies of habituation are not really studies of habituation at all but rather studies of operant stimulus control. That is, the actual movements of the eyes described by the phrase “visual fixation” may be functionally related to the consequence of seeing the stimulus display. This might be especially true in infants because it is known that many types of visual stimuli seem to function either as (unconditioned) positive reinforcers for the behavior that produces them (e.g., Kalninsh & Bruner, 1973; Siqueland & DeLucia, 1969) or as unconditional eliciting stimuli (Fantz, 1961). In any case, a behavior analysis would be able to tease apart the real controlling variables by systematically examining the functional relations between them.

Interestingly, especially for the present article, several experiments have investigated visual memory or retention in infants using operant conditioning procedures (e.g., Rovee & Fagen, 1976; Sullivan, Rovee-Collier, & Tynes, 1979; Watson, 1967). In one experiment, Rovee and Fagen (1976) studied memory or “retention” of operant foot kicks in 3-month-old infants. Each infant’s right foot was attached with a ribbon to a mobile hanging above the infant’s crib so that when the infant’s foot moved, the mobile would immediately move. The more vigorously the infant’s foot moved, the more the mobile would move. The subjects were presented with daily sessions lasting 15 minutes, the last 12 minutes of which right-foot kicks were followed by the moving mobile for 9 minutes followed by a 3-minute extinction period. There was significant and specific response carryover from one day to the next, prompting the investigators to conclude that “clearly, 3-month-old infants are capable both of integrating simple perceptual-motor responses and of directing them selectively at later intervals” (p. 10). However, it wasn’t the infants who integrated “simple perceptual-motor responses.” It was the environment created by the experimenters.

Unlike most studies of infant memory, the experiments by Rovee-Collier and her colleagues (e.g., Rovee & Fagen, 1976; Rovee-Collier & Sullivan, 1980; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Sullivan et al., 1979) demonstrated how a research program into a stronghold of cognitive psychology—memory—can be derived from behavior-analytic theory. Moreover, the results of these experiments not only challenge the conclusions about infant memory generated by more “traditional paradigms” (Rovee-Collier, 1983), but the results are easily interpreted in terms of the principles of operant stimulus control. However, cognitively oriented psychologists can take even straightforward demonstrations of operant conditioning in infants and interpret them as evidence for inferred events. So, for example, Cohen and Gelber (1975) interpreted operant conditioning in infants by saying that “whatever is stored... must include some information about the appropriate response and therefore may be an instance of enactive memory” (p. 351). However, is it really necessary to infer storage, information, and enactive memory to understand, predict, and control the behavior? Watson (1967) likened the memory required for operant conditioning in infants to a “computer-like
process” in which “the memory records of stimulus input and response output are scanned under the guidance of a ‘learning instruction’ reading: ‘Find and repeat the response which preceded the reception of the reward stimulus’ ” (p. 55). Needless to say, the view of the present article is that these invented processes are unnecessary obstacles to understanding the behavior from which they are inferred. From a behavior-analytic perspective, the results from the operant conditioning studies in infants can be predicted and understood according to the extensive literature on operant conditioning. For example, the finding by Rovee and Fagen (1976) that response strength was so high on Day 2 “after just 9 minutes of reinforced responding” on Day 1 could have been predicted. Behavior analysts already know that considerable response strength can be generated after just one or a few reinforced responses (Neuringer, 1970; Skinner, 1938). The fact that foot kicks occurred on days after training (even after brief extinction periods at the conclusion of the preceding session) may be predicted by the principles of reinforcement and operant stimulus control. That is, the functions of the stimuli associated with the experiment (e.g., the sight of the mobile and the ribbon attached to the infants’ legs and so on), especially at the beginning of the session, evoked leg kicks because they had in the past been correlated with reinforcement for the behavior. In fact, operant stimulus control has been clearly demonstrated in very young infants when, for example, changes in the visual characteristics of the prevailing stimuli were reflected in changes in the response rates of infant leg kicks (Rovee-Collier & Capatides, 1979).

In short, in the particular experimental environments found in the experiments of Rovee-Collier and her colleagues, foot kicks were adaptive. Of course, neither the experiments nor the present interpretation explain why the sight of the moving mobile functions as a reinforcer—if we are interested in the parameters of reinforcers for human infants, that is another experimental question—but that it does is sufficient to understand the occurrence of the behavior. Any analysis of operant foot kicks in terms of infant memory is unnecessary because we can account for the observed changes in behavior without it. For behavior analysis, the operant behavior is important in its own right and not as an indicator of inferred underlying structures or processes. A behavior-analytic interpretation takes nothing away from the infant; on the contrary, as the studies by Rovee-Collier and her associates showed, a behavior-analytic approach demonstrates a way of more thoroughly investigating the behavioral capabilities of young children.

**Perceptual Size Constancy**

*Standard treatment of size constancy. Another area of study that demonstrates the amenability of phenomena to behavioral interpretation is perceptual behavior. Perception is often contrasted with sensation. The term sensation is usually used to refer to the basic effects of stimuli on the sense organs. Perception, however, has been cognitizedized as*

The process by which animals gain knowledge [italics added] about their environment and about themselves in relation to the environment. It is the beginning of knowing, and so is an essential part of cognition. More specifically, to perceive is to obtain information [italics added] about the world through stimulation. (Gibson & Spelke, 1983, p. 2)

Dworetzky (1991) used the term perception to refer to how the organism interprets the sensory experience. Size constancy is an example of one type of experience that organisms are said to interpret.

The rule about the constancies of objects goes something like this: Even though the size, shape, and position of objects change with respect to the image projected on the retina, the actual size, shape, and position of the objects in the environment remain constant. Size constancy is said to refer to “the stability of apparent size, despite changes in projected retinal image size” (Banks & Salapatek, 1983, p. 523). However, what is it that is stable? Dworetzky (1991) described an example of size constancy as follows:

When you look at your parked car as you are walking away from it, your visual sensory system sends a message to your brain. First the image of the car is projected through the lens onto an area at the back of each of your eyes called the retina. As you walk away (still looking at your car), the image projected onto the retina gets smaller and smaller as you get farther from your car. . . . Although the sensory image of your car is shrinking rapidly, you don’t perceive that your car is changing size. Instead, you perceive that your car is simply becoming more distant. (p. 134)

However, what is this perception?

Dworetzky (1991) defined size constancy as “the learned perception that an object remains the same size, despite the fact that the size of the image it casts on the retina varies with its distance from the viewer” (p. 134). What is the “perception” and how is it “learned”? It is sometimes said that we know that an object is the same size even though it appears smaller. It is even said that although the object casts a smaller image on the retina, we still see it as being the same size. Developmental researchers characteristically have been interested in the age at which children “acquire size constancy” (e.g., Day & McKenzie, 1981; Yonas, Granrud, & Petterson, 1985). However, what exactly is acquired?

These confusing ways of talking about the phenomenon pose all of the problems of any structural interpretation of behavior. Just as with memory, behaviors are observed in certain situations and they are given a name, in this case, perception, or more specifically, size constancy. The name is reified as a type of knowledge or cognition about the world, although the knowledge or cognition is never directly observed. In this case, the child is said to “possess size constancy.” This implies that, as a result of certain experiences, a structure is created inside the child that enables the child to correctly interpret the sizes of objects. Concentrating on this and other inferred structures prevents researchers from investigating more fundamental behavioral processes, like the nature of the experiences themselves (e.g., the reinforcement continu-
gencies that contribute to the observed behaviors ["per-
ceptions"]). The emphasis is not on the child’s behavior
but on inferred surrogates of the behavior, called inter-
pretations or recognitions, the only evidence of which is the
very behaviors they are said to explain. In other words,
the behavior of the child in the particular environmental
context that defines the perception in the first place is
overlooked in lieu of inventing internal surrogates, which
are said to interpret the sensory information.

Experimental facts on depth perception/size con-
stancy. Researchers have determined the approximate
ages when sensitivity to the cues for depth, and thus size,
perception first appears. There is general agreement that
control by the binocular cue of retinal disparity is first
evident in infants between 2 and 3 months of age and is
fully present by 5 months of age (Banks & Salapatek,
1983). Several studies indicated that depth-appropriate
responding occurs at about 5 months (Bechtoldt & Hutz,
1979; Gordon & Yonas, 1976; Yonas, Oberg, & Norcia,
1978). For example, using a stereoscopic display that
simulated the approach of an object on a collision course
with the infant’s face, Yonas et al. (1978) showed that 5-
month-olds but not 3½-month-olds exhibited more
reaching, head withdrawal, and blinking.

Interestingly, control by monocular cues appears
later. Yonas, Cleaves, and Petterson (1978) used a trap-
ezoidal window presented parallel to the frontoparallel
plane to investigate control by the monocular cue of linear
perspective. When one eye was covered, both adults
and 7-month-old infants (incorrectly) reached more to the
larger ("nearer") side of the trapezoid, whereas 5-month-
olds reached about equally often to both sides. In another
study, Yonas, Petterson, and Granrud (1982) compared
the control by familiar and unfamiliar size cues in 5- and
7-month-olds. The familiar objects were two different-
size pictures of the infants’ mothers; the unfamiliar objects
were two checkerboards of different sizes. All stimuli
were presented at the same distance and were viewed mon-
ocularly. Results showed that the 7-month-olds reached
more often to the larger face but equally often to the two
checkerboards, whereas the 5-month-olds reached equally
to all stimuli, suggesting that the 7-month-olds but not
the 5-month-olds exhibited size-appropriate responding
to familiar objects.

Although researchers have a good idea about what
infants do and when they do it with respect to size con-
stancy, there has been no attempt to relate these facts to
the wealth of other facts of child development. The reason
is developmental psychologists generally believe that no
single theory can accomplish such a task (Hetherington
& Parke, 1986). Moreover, the normative facts of the
emergence of size constancy encourage the assumption
of maturational processes, even though there is little direct
evidence for them. Another, more parsimonious, expla-
nation of the relevant behavior is in terms of its adaptive
value. In short, for behavior analysts the question might
be “What typically happens to infants between about 5
and 7 months of age that produces a transition between
non-size-appropriate and size-appropriate behavior?

A behavior analysis of size-appropriate behavior. A
behavioral theory of perceptual size constancy first de-
scribes behavior in its context and then interprets it ac-
cording to established principles. Specifically, perceptual
behavior seems to be behavior under complex stimulus
control (e.g., Knapp, 1987; Malott & Whaley, 1981;
stimulus control is usually of a visual or an auditory na-
ture, but there is no reason why it cannot be demonstrated
with other sensory systems. A behavioral approach does
not dismiss questions about the chronology of certain
behavioral changes; however, it looks for answers in the
interactions between the behavior and the environment.
Hence, we might ask why control by monocular cues
appears to develop later than control by binocular cues.
To answer this, behavior analysts would want to under-
stand the nature of the infant’s early visual experiences.
They might discover, for example, that from the earliest
days after birth and for the first several months, the in-
fant’s visual environment consists largely of objects that
move toward the infant (e.g., people’s faces, bottles, pac-
fiers, and so on), which produce the binocular cues of
convergence and retinal disparity. In the presence of these
events, certain consequences (e.g., being touched, having
something placed into the mouth, or simply seeing the
object) immediately follow the infant’s behaviors (e.g.,
looking or reaching). Some of the infant’s reactions (e.g.,
head withdrawal and blinking) are probably initially parts
of unconditional reflexes and are elicited by objects that
move quickly toward the infant’s face; however, other be-
havior (e.g., looking or reaching) becomes operant and
thus comes under the stimulus control of the binocular
cues. Reaching in the absence of approaching objects is
not followed by the same consequences, whereas reaching
when these things approach is reinforced either by touch-
and grasping the object or some form of attention
from the parent. Many of the monocular cues (e.g., linear
perspective, interposition, and texture gradients) probably
become more important once the infant is in a sitting
position, which typically occurs between 5 and 8 months
of age. The quantity and quality of potentially functional
stimuli increases dramatically when the infant’s body po-
tion changes from the prone or supine to the sitting
position and then again from the sitting to the standing
position. Just as with behavior that we speak of as mem-
ory, behavior-analytic theory asks about the variables that
determine changes in the behavior of infants under these
functional perceptual cues. Thus, in part by asking dif-
f erent questions, behavior-analytic theory offers an ob-
jective and parsimonious way of describing the phenom-
ena as well as a parsimonious explanation of the changes
in behavior. However, what about size constancy?

First, let us be clear about what is seen when the
distance of objects changes. The image cast on the retina
becomes smaller as objects become more distant and
larger as objects get closer. If we move away from our
automobile, the image on the retina gets smaller and,
however we describe it, we never see it as anything but
smaller. When it is said that we perceive it as being the
same size, what is meant is that we react to it as being the same size. What are these reactions? They are behavior like any other behavior. For example, as the retinal image of our automobile gets smaller, we do not shriek that our car is shrinking. We still behave toward our automobile in most of the ways we always have. We still call it our automobile. We may reach in our pocket for our keys, and we will walk toward it when we want to go somewhere and so on. So what is size constancy? An objective description of size constancy is to say that even though we actually see objects as smaller or larger (in terms of retinal image size), we continue to behave toward them in most of the ways we always have. Size constancy, like all object constancies, is a property of objects in the real world. That is, the sizes of objects are constant. It is not necessary to infer cognitive structures, behavioral surrogates, or perceptions to explain the size-constant behaviors. In addition, it is not necessary to say that the constant sizes of objects are taken in and acquired. For psychology, it should be sufficient to say that our behavior comes under the stimulus control of objects and either varies or does not vary as the sensory characteristics of their size, shape, and position change depending on the operative contingencies. How does this happen? Many accounts of depth perception and the related perception of size constancy allude to experiential factors but offer no interpretations (e.g., Banks & Salapatek, 1983). Behavior analysis is in an ideal position to offer an interpretation.

A stimulus control account of size constancy requires the identification of the stimulus characteristics involved when the distance of objects varies. The ability to react appropriately to distant objects (or depth) depends on several types of cues. There are two general classes of depth cues: binocular cues and monocular cues (Banks & Salapatek, 1983). The binocular cues include convergence and retinal disparity (or binocular parallax). The monocular cues can be classified according to those that are static (often called pictorial cues because they are used by artists to create the impression of depth) and those that are kinetic and require motion by either the object or the observer (Banks & Salapatek, 1983). The static monocular cues that are important for depth perception include linear perspective, interposition, texture gradients, relative and familiar size, aerial perspective, and, to a lesser degree, visual accommodation. The kinetic monocular depth cues include changes over time in the retinal image produced either by the movements of the observer's head and body (e.g., motion parallax) or by the movements of objects (e.g., optical expansion or perspective transformation; Banks & Salapatek, 1983). The critical question is “How do these cues come to control behavior?”

One problem in assessing perceptual stimulus control is the actual behavior to be measured. Perceptual behavior is whichever behavior is being investigated under the control of perceptual cues. However, it is possible to argue that, with some behaviors such as visually guided reaching, infants may not be physically capable of exhibiting the behavior, but some behavior may still be brought under the control of perceptual cues. In some cases, this problem has been overcome by using other measures such as changes in heart rate or sucking rate (e.g., Campos, Langer, & Krowitz, 1970; Kalnin & Bruner, 1973). The implication is that if stimuli do not yet differentially control some behavior, then we cannot speak of perception. In other words, psychologists do not speak of perception in the absence of some measurable (perceptual) response just as they don't speak of recognition memory in the absence of differential fixation times.

I previously described research by Yonas et al. (1982) regarding the emergence of size constancy in infants. These results are interesting not only because they indicate that size-appropriate responding is typically present by 7 months of age but also that they are amenable to a behavior-analytic interpretation. Accordingly, objects become “familiar” because of a history of reinforcement that has produced perceptually appropriate responding to them. However, a behavior analysis must do more than offer post hoc explanations; it must offer plausible mechanisms. First, a behavior-analytic interpretation approaches the transition from non-size-appropriate to size-appropriate responding as adaptive behavior. Ideally, the next step would involve an experimental demonstration in which size-appropriate responding is generated in an organism without such behavior. Lacking such a demonstration, behavior analysts would offer a plausible interpretation according to the laws and principles of behavior analysis. Let me suggest how one might interpret such a behavioral transition in infants in their “natural” environment.

One response in infants that comes under the appropriate control of object size and depth cues fairly early is (visually guided) reaching. Obviously, operant reaching cannot occur until the underlying musculoskeletal structures have matured, although such development apparently can be accelerated by environmental manipulation (White, Castle, & Held, 1964; White & Held, 1966). Consider an infant lying in its crib. By the time reaching is physically possible, one of the first contingencies to which the infant is exposed must involve the sight of the parent as a stimulus in whose presence reaching out is successful; that is, reaching produces some type of contact or interaction with the parent. Such a stimulus is termed a discriminative stimulus (S^D), and its control over behavior is evidenced when, on subsequent occasions, it evokes the behavior that was previously successful. In the present example, however, successful reaching is possible only when the retinal image of the parent is relatively large (e.g., when the parent is leaning over the crib). When the retinal image is small (i.e., the parent is farther away), reaching out, which probably occurs during the initial stages of discrimination learning, goes unreinforced. In this situation, retinal image size is probably the most important S^D (or S delta, that is, a stimulus in whose presence behavior is unsuccessful) for the size-appropriate behavior.

Consider another scenario. An infant is sitting on the floor of an average-size room. There are two stuffed animals of different sizes. The smaller of the two is next
to the infant, and the larger one is on the other side of the room; however, both stuffed animals produce the same retinal image size. There are also other toys in the room, some of which produce the same retinal image size as the farthest stuffed animal even though they are closer to the infant and vice versa. What visual cues are provided by the two stuffed animals and the other toys that determine reaching behavior to the stuffed animals? Traditional approaches might ask how the infant "knows" which stuffed animal is really closer, how the infant "calculates" distances, or whether the infant has "acquired" size constancy? The behavior analyst asks what experiences (i.e., interactions with environment) produce size-constant behavior? Recall that both stuffed animals produce the same retinal image size, so retinal image size cannot be a functional stimulus for size-appropriate reaching. Initially, the infant reaches for both of the stuffed animals. Reaching for the closer one is successful, and reaching for the farthest one is unsuccessful. The binocular cues notwithstanding, most of the other static monocular cues come into play. For example, the closer stuffed animal or other close objects tend to obscure the more distant stuffed animal (interposition). Moreover, any receding lines in the room will appear to converge near the farthest stuffed animal (linear perspective). Also, the more distant stuffed animal and other equally distant objects produce a finer grained texture than closer objects. In the presence of this stimulus complex, then, reaching for the closer stuffed animal is successful (i.e., it is reinforced); and this particular complex becomes an $S^P$ and will under similar circumstances in the future evoke reaching for closer objects. Reaching for the farthest stuffed animal is not successful; the same stimulus complex becomes an $S$ delta (i.e., a stimulus that is correlated with failure or non-reinforcement of responses) and will not evoke reaching for farther objects. Of course, determining the particular properties of the environment that become functionally relevant requires an experimental analysis; the present interpretation can only suggest possible candidates.

Visually guided reaching is not the only example of size-constant behavior. Once verbal behavior is present, that too becomes part of the class of responses controlled by depth cues. For most people, verbal responses controlled by the sight of objects are usually acquired under a variety of conditions in which the sensory characteristics of the objects vary. One of the verbal responses that continues to be appropriate despite these changes is called a tact (Skinner, 1957), which is roughly equivalent to the name of an object. Most verbal communities maintain the constancy of tacts regardless of sensory changes in other characteristics of objects. The acquisition of this verbal behavior might be expedited through stimulus generalization from the stimulus characteristics present when the tact was first conditioned, or it might require more direct training. For example, the tact "mama" might be acquired when the mother is very close, thus creating a large retinal image. If, however, the mother moves away, her physical features, which remain constant, may still evoke "mama," which would normally be quickly reinforced by the mother reacting to the infant's speaking. If it does not, prompting may be necessary. More likely, however, tacts, like most other behavior, are acquired under varied conditions; thus, stimulus generalization is built in.

I have presented a brief and general account of a behavior-analytic theory of infant memory and of perceptual size constancy. Some readers may claim that the thrust of my objections to standard developmental accounts is primarily semantic. It is true that some of my objections are largely semantic, but that does not render them trivial or unimportant. Behavior analysts, with Skinner in the forefront, have often pointed out the "pitfalls associated with the use of terms that lead easily to the postulation of inner, hypothetical structures" (Branch, 1977, p. 178). Other readers may object that the present account of infant memory and perceptual size constancy is not based on direct behavior-analytic research of the phenomena, and they may, therefore, question the value of such an enterprise. Its value, however, depends on the power of the theory and the laws it makes up. What follows is a brief evaluation of behavior-analytic theory.

**Behavior-Analytic Theory Evaluated**

Theory in behavior analysis is grounded in the law of effect or the principle of reinforcement. What leads us to call reinforcement a scientific law? McCain and Segal (1988) listed four criteria that must be obtained before any statement can qualify as a scientific law:

1. The statement must be about kinds of events and not directly about any singular event. (2) The statement must show a functional relation between two or more kinds of events ("kind of event" refers either to things or to properties of things). (3) There must be a large amount of data confirming the law and little or none disconfirming it. (4) The relation should be applicable to very different events (although there may be limiting conditions).

(p. 52)

Thus, a scientific law "is a collection of facts grouped into a consistent body of knowledge, from which it is possible to make predictions" (Bachrach, 1972, p. 49). This is indeed consistent with Skinner's (1947) conception of the relation between fact and theory in science. According to these criteria, then, reinforcement qualifies as a scientific law. As Bijou and Baer (1978) wrote,

It is a summary of many, many well-proved facts, and it is also an induction that goes beyond them to suggest that the uniformity with which they are found to be true suggests strongly that they are generally (but not universally) true. In that the induction goes further than proven facts, it is a statement of theory; in that it goes beyond fact only to suggest that an observed generality is probably more general than the cases observed so far, it is empirically based and characteristic of a natural science approach. (p. 8)

However, what about the larger issue of theory?

Psychological theories can be evaluated according to several criteria. There have been various attempts to evaluate developmental theories (e.g., Green, 1989; Thomas, 1985). Although these treatments suggest somewhat different standards, they agree on some. For ex-
ample, a good scientific theory should (a) be testable, (b) be internally consistent, (c) possess predictive validity, (d) possess external validity, and (e) be theoretically economical. With respect to these criteria, behavior analysis is rated comparatively high as a theory of development (Green, 1989; Thomas, 1985), even though it is not an explicit theory of development. It is possible to abstract a subset of important criteria for the evaluation of psychological theories in general (see Poling, Schlinger, Starin, & Blakely, 1990; also Bachrach, 1972). They include empirical support, logical support, generality, parsimony, and utility.

**Criteria for Evaluating Theories in Psychology**

**Empirical support.** Any theory must have observations that relate to it and support it, and the theory must not be so general as to be able to account for any possible set of observations. Behavior-analytic theory has a large number of supporting observations in the form of empirical functional relations between behavioral and environmental events with numerous species, including humans, and under myriad experimental conditions, which not only support the theory but, as we saw earlier, actually together comprise the theory. Thus, they do well in interpreting or explaining the possible environmental determinants of behavior.

**Logical support.** The mechanisms proposed by a theory must be plausible and must not involve reification, circularity, teleology, or nominal fallacy. The plausibility of explanatory mechanisms is enhanced by being grounded in empirical observations. Clearly, then, the mechanisms proposed by behavior-analytic theory are plausible. They are plausible because they are generalities of objective scientific facts. However, they do not by themselves escape from the logical errors of reification, circularity, teleology, or nominal fallacy; those are syntactic errors. However, the primary explanatory mechanisms in behavior-analytic theory—respondent and operand units—are directly testable without inferring events at other levels; hence, they are more resistant to logical error.

**Generality.** Generality refers to the range of behaviors a theory claims to explain and the range of conditions under which it does so. Behavior analysis is, by definition, the study of ontogenetically adaptive behavior. Any behavior that undergoes change as a result of interactions with environmental variables is considered adaptive and is thus potentially understandable with behavior-analytic theory. Behavior analysts have shown that other developmental phenomena can be understood according to behavior-analytic theory, for example, exploratory behavior (Bijou, 1976), cognitive abilities (Bijou, 1976; Malott & Whaley, 1981), social referencing (Gewirtz & Pelaez-Nogueras, 1991), attachment (Gewirtz, 1991), and moral behavior (Bijou, 1976; Gewirtz & Pelaez-Nogueras 1991). If behavior-analytic theory can provide plausible accounts of what is termed infant memory and perceptual behavior, then it will have enhanced its generality.

**Parsimony.** Good theories invoke simple explana-

tory mechanisms first. A simple explanation is one that is potentially observable and has both empirical and logical support. Not all adequate explanations possess these characteristics, but parsimony dictates that the ones that do should be invoked first. Behavior-analytic theory appeals to established laws and principles concerning relationships between observable behavior and objective environmental events. If these explanations are sufficient to account for behavior, then more complex ones—that is, those that appeal to unverifiable events and processes—may not be necessary.

**Utility.** One feature of the natural sciences that has “sold” them is not only their power to understand natural phenomena but their power to change them. As Schwartz (1989) put it, “science has delivered the goods” (p. 3). Behavior analysts have consistently maintained that the goals of a science of behavior are prediction and control. Perhaps it would be more accurate to say control and prediction, because the prediction in behavior analysis is predicated on being able to control the subject matter. This relation between prediction and control is the same within biology, physics, and chemistry. The applied branches of those sciences—for example, medicine and engineering—are to a certain degree accountable for their claims by being able to effect technological changes. So too can behavior analysis. In fact, some cognitive psychologists have noted the successes of the applied fields of behavior analysis while questioning the methods and theory (e.g., Baars, 1986). However, this misses the point that the scientific methodology and theory of behavior analysis derived from years of basic research have made the applied successes possible.

Thus, it appears that behavior-analytic theory not only meets these criteria of good scientific theories, but, I argue, that in so doing it may be able to offer more plausible interpretations of behavioral phenomena than other psychological theories.

**Conclusion**

I have presented only two brief examples of the application of behavior-analytic theory to problems of child development. However, they reflect the general strategy of analyzing behavior in terms of the basic units of behavior analysis and the laws and principles that summarize them. Similar applications of behavior-analytic theory to other problems of child development should encourage optimism that the science of behavior analysis can, if given a chance, potentially unite the disparate subdisciplines of developmental psychology, thus not only enabling a better understanding of the behavioral changes that define development but also enhancing the effectiveness of applications to parenting, educational, and therapeutic endeavors. The ultimate evaluation of the behavior-analytic approach, according to Bijou and Baer (1978), “will depend on the adequacy with which it accounts for the psychological development of humans” (p. 8). In this article, I have attempted to offer a glimpse of how that account might proceed.
REFERENCES