The Behavior Analyst 1994, 17, 59-73 No. 1 (Spring)

Bridging the Schism Between Behavioral and Cognitive Analyses

Timothy A. Slocum
Utah State University

Earl C. Butterfield
University of Washington

A major schism in modern scientific psychology has occurred between behavior analysts and cognitive psychologists. The two groups speak in different languages, but the languages can be translated so that they are mutually understandable; when either language is translated into the other, similarities emerge from seeming differences. We draw an analogy between the basic units of behavior analysis (the operant and the establishing operation) and cognitive psychology (the production). We argue that both units describe behavior as a function of motivative and discriminative antecedents. In addition, the two perspectives account in analogous ways for ongoing changes in motivation and for control by verbal statements. Adherents of the two perspectives have experimentally analyzed some of the same problems and fashioned similar solutions for applied problems. We conclude that many of the commonly cited differences between the two perspectives are the result of misunderstanding, and that the real differences need not preclude communication and collaboration. The schism can be bridged.

Key words: behavior analysis, behaviorism, cognitive psychology

A major schism in modern scientific psychology has occurred between behavior analysis and cognitive psychology. Each of these two approaches began by rejecting the other's modes of explanation, and then developed in relative isolation from alternative views. Behavior analysis began by rejecting mentalistic and stimulus–response (S–R) explanations of behavior. Concepts of the operant, discriminative stimulus, establishing operations, and reinforcement were developed relatively independently of other approaches to psychology. Similarly, cognitive psychology began by explicitly rejecting S–R and behavior-analytic formulations. Concepts such as the production, context statements, goal setting, and mental representation were developed independently of behavior analysis.

Behavior analysts criticize cognitivists for mentalism—in other words, for being cognitive. Cognitive psychologists criticize behavior analysts for explaining behavior only at the level of observation—in other words, for being behavioral. These arguments over fundamental perspectives have obscured the large areas of similarities that are shared by the two approaches. In spite of the mutual isolation and antipathy of cognitive psychology and behavior analysis, the two have developed languages that describe the same relations. Meaningful translation, useful communication, and collaboration are possible.

Scholars from the two perspectives have invented similar concepts to describe behavior. We will argue that both approaches (a) use basic units that describe behavior in relation to its motivative and discriminative antecedents, (b) see complex behavior as the combination of these basic units, (c) use similar mechanisms to deal with ongoing changes in motivation, and (d) have developed concepts to account for the control of behavior by verbal statements and the distinction between verbal control and control that arises directly from interactions with the environment. In this paper, we attempt to build a bridge of translation across the schism that separates behavioral and cognitive psychologies. We draw

Address correspondence to Timothy A. Slocum, Department of Special Education, Utah State University, Logan, UT 84322-2865.

TABLE 1

Analogical mapping of productions and discriminated operants

Discriminated operant	Production	Shared function
Discriminative stimulus	IF context	Increase likelihood of action or response due to history with similar stimulus situations
Effective reinforcer	IF goal	Increase likelihood of action or response due to history with particular consequences
Establishing operation	THEN goal	Moment-to-moment changes in motivation
Response	THEN action	Solve problem or change subsequent conditions

an analogy between the basic units of behavior developed by behavior-analytic and cognitive psychologists, describe areas of contact between the two, and discuss their real and supposed differences.

Cognitive psychology, like behavioral psychology, has many different variants. In this paper, we compare behavior analysis, a specific variant of behavioral psychology associated with the work of B. F. Skinner, to information processing production system analysis (Anderson, 1983; Card, Moran, & Newell, 1983; Klahr & Carver, 1988; Newell & Simon, 1972; Singley & Anderson, 1989), a school of cognitive psychology. Similar comparisons could be made with other schools of cognitive psychology, such as situated cognition (Resnick, Levine, & Teasley, 1991), social learning theory (Bandura, 1971, 1986), cognitive development (Belmont & Butterfield, 1977; Bjorklund, 1991; Butterfield & Nelson, 1989; Butterfield, Siladi, & Belmont, 1980; Pressley, Borkowski, & O'Sullivan, 1985), and metacognition (Butterfield, Albertson, & Johnston, in press; Nelson & Narens, 1990, in press), and we believe the results would be the same.

BASIC UNITS OF BEHAVIOR: DISCRIMINATED OPERANTS AND PRODUCTIONS

General Description of the Analogy

Both approaches to psychology are analytic in the sense that they attempt to understand complex patterns of human behavior in terms of the interacting operation of simpler units of analysis. Each has developed a single conceptual unit to account for both overt and covert behavior. Each describes behavior as a function of changing motivational conditions and stimuli that have gained new behavioral functions as a result of a history of interaction.

The discriminated operant and the establishing operation are the basic units of behavior analysis (Michael, 1982, 1993; Skinner, 1938); the production is the basic unit of one school of cognitive psychology (Anderson, 1983). Discriminated operants describe behavior as a function of discriminative stimuli and motivative variables (Michael, 1982, 1993; Skinner, 1938). For instance, my reaching for a pencil on my desk would be described as a function of the discriminative stimulus of seeing the pencil and the motivational variables that account for the current reinforcing function of a pencil. Establishing operations account for moment-to-moment changes in motivation (Michael, 1982, 1993). At one moment, a pencil had no reinforcing function, but when I detected an error in the manuscript that I was reading, a pencil became reinforcing. This change in function is described as an establishing operation. Like discriminated operants, productions describe behavior and its antecedents. Productions are written in IF–THEN form: IF certain conditions exist,

TABLE 2

Operant and production analyses of making instant coffee

Event	Operants (O) and establishing operations (EO)	Productions (P)
Request for coffee	EO: request for coffee	IF goal is to be polite and someone asks for coffee
	New R+: cup of coffee	THEN set goal to make coffee
Open jar of instant coffee	Current R+: cup of coffee SD: jar of instant coffee	IF goal is to make coffee and you have a jar of instant coffee
	RESP: open the jar	THEN open the jar
Jar open, no spoon	EO: open jar and cup of coffee as R+	IF goal is to make coffee and you have open jar
	New R+: spoon	THEN set goal to get a spoon
Request spoon	Current R+: spoon SD: person near spoon	IF goal is to get a spoon and a person is near a spoon
	RESP: ask for spoon	THEN ask for spoon
Scoop coffee with spoon	Current R+: cup of coffee SD: open jar and spoon	IF goal is to make coffee and you have an open jar and spoon
	RESP: scoops coffee into cup	THEN scoop coffee into cup

THEN certain actions will occur. Antecedent conditions include contexts and goals. Actions include overt and covert behavior as well as the action of modifying a goal (Anderson, 1983). For instance, IF I detect an error in a manuscript, THEN I set a goal to obtain a pencil; IF I have a goal of obtaining a pencil and I see a pencil, THEN I reach for it. The parts of a production correspond to the parts of the analogous unit of behavior analysis.

Table 1 shows the parts of discriminated operants and productions, and the function that is common to the two. We propose that a discriminative stimulus is analogous to an IF-context statement: Each describes stimuli that increase the likelihood of a particular type of response because of a history with similar situations. Stimuli that are currently effective as reinforcers are analogous to IF-goal statements: Each describes motivational variables that increase the likelihood of a particular response. Establishing operations and THEN-goal statements are analogous, in that both describe moment-to-moment changes in motivation. Finally, responses are analogous to THEN-action statements: Each describes what the organism does overtly or covertly.

Example: Preparing Instant Coffee

In order to clarify the similarity of discriminated operants and productions, let us examine a sequence of behavior and analyze it into basic units of each type. Suppose a guest asks me for a cup of coffee. (In order to simplify the example, I'll make instant.) I happen to have a pot of hot water, a jar of instant coffee, and a cup. I open the jar, look for a spoon, and see that it is on the other side of the kitchen. I ask the guest to give me the spoon that is next to her. I use the spoon to put the instant coffee into the cup, and proceed with the sequence.

Table 2 shows this sequence broken down into a series of establishing operations and operants; it also shows the same sequence analyzed into productions. First, there is a request for a cup of coffee. In the operant analysis, the request is an establishing operation that makes a cup of coffee currently effective as a reinforcer. In the production analysis, the request fulfills the condition side of a production. The action of this production is to set a goal to make a cup of coffee. Second, I open the jar of instant coffee. This can be described as an operant controlled by the presence of a jar of instant coffee and the current effectiveness of a cup of coffee as a reinforcer. Opening the jar can also be described as a production that is contingent on the conditions of the presence of a jar of instant coffee and a goal to make a cup of coffee. Third, I need a spoon. The open jar, together with the reinforcing effectiveness of coffee, serves as an establishing operation that makes possession of a spoon reinforcing. Alternatively, the goal of making a cup of coffee and the open jar are described as the conditions of a production that sets a goal of acquiring a spoon. Fourth, I ask my guest to hand me a spoon. This is an operant motivated by the current effectiveness of a spoon as a reinforcer and is discriminative upon the presence of a person near the spoon. It is also a production: If you have a goal to acquire a spoon and there is a person near a spoon, then ask that person for the spoon. Finally, spoon in hand, I scoop instant coffee into the cup. As an operant, this depends on the reinforcing effectiveness of a cup of coffee and the presence of an open jar and the spoon. As a production, it is the result of fulfilling the conditions of having a goal to make a cup of coffee and the situation of having an open jar and a spoon.

The preceding example clarifies analogous elements of behavior-analytic and cognitive production systems by bringing the two to bear on a single sequence of behavior. This highlights the fact that the match between behavior analysis and cognitive psychology is most apparent when they are analyzing the same behavior—and they do sometimes analyze the same thing. If we had exemplified behavior analysis with a task from basic research on pigeons and exemplified cognitive analysis with the task of computer programming, the similarities would have been less obvious. Moreover, a behavior analysis of pigeons' behavior would appear trivial to cognitive psychologists, whereas the cognitive analyses of computer programming would appear absurdly complex and premature to behavior analysts.

Discriminative Stimuli and Context Statements

Discriminative stimuli and IF-context statements describe stimuli that increase the likelihood of a particular response as a result of a history with respect to similar stimuli. In both systems, these stimuli may be publicly observable or observable only by the subject. Discriminative stimuli gain their function as a result of a history of reinforcement. The stimuli described by a context statement in a production gain their function through a history of practice and feedback. Organisms learn to make a given response in some situations and not in others. This learning is often imperfect, and each system explains both correct and incorrect responses. Neither discriminative stimuli nor context statements are assumed to describe the stimuli that are most closely correlated with reinforcement; rather, they are stimuli that control responding.

Learners frequently respond in the absence of critical stimuli and fail to respond in their presence. A behavior analyst would describe this as imperfect stimulus control. Catania (1984) elaborates:

> We must recognize two classes of stimuli: one is the class correlated with a reinforcement contingency; the other is the class in the presence of which responding occurs. Our interest is not in either class alone, but rather in the correspondence between them. (p. 130)

A cognitive psychologist would refer to three sets of stimuli (Gick & Holyoak, 1987). *Represented* (or salient) *stimuli* are those that actually control responding. These correspond to discriminative stimuli—the class in the presence of which responding occurs. *Structural stimuli* are those that are most closely correlated with reinforcement. These describe objective features of the environment that have an objective relation to consequences—the class of stimuli correlated with a reinforcement contingency. *Surface features* are stimuli that may control responding but are not differentially correlated with reinforcement. Control by surface features is systematically weakened or eliminated in the process of discrimination training. When learners' represented stimuli correspond exactly with structural stimuli, they reach their goal most frequently; that is, when they are under perfect stimulus control, they achieve the highest possible level of reinforcement. When learners represent some but not all of the structural stimuli or represent surface stimuli, they fail to respond when a response would have been correct, or respond when a response is incorrect.

Consider the following production:

IF a goal is to have all nail heads flush with the wall
and you have a hammer
and a nail is protruding,
THEN hammer the nail.

This could also be described in the following behavior-analytic terms:

Having all nail heads flush with the wall is currently effective as a reinforcer.
The hammering response is under multiple stimulus control of (at least) a hammer and a protruding nail.

Both of these accounts are incomplete because it is unclear what objects function as a "hammer" for the subject. Would the subject respond with hammering if a claw hammer (or an electric drill or a rock) were present? For behavior analysts, this is a question of stimulus control. The discriminative stimulus includes all the stimuli that occasion hammering because of a particular reinforcement history. For cognitive psychologists, this is a question of representation. The context statement is fulfilled by all objects represented as hammers. Objects are represented as hammers because of the subject's history with those objects. In both analyses, the importance of objects is not based directly on their physical characteristics, but on how they affect the subject—as behavior analysts would say, their functional characteristics. The subject's history with similar objects determines the effect of (i.e., his or her representation of) a particular object. For behavior analysts, the discriminative stimulus is an objective feature of the (internal or external) environment. However, the environmental features that function as discriminative stimuli are not defined in physical terms. They are defined functionally as a class of stimuli that affect a subject in a particular way (Skinner, 1935). The discriminative stimulus for grabbing and hammering (in the above example) is not defined according to the length of a handle or curvature of a claw, but rather by the subject's tendency to bang things with it. As a subject learns, different objective stimulus features come to control a particular response. The boundaries of the discriminative stimuli change. Hammering with a drill may be extinguished, and thus the boundaries of the discriminative stimuli for hammering are redefined. In behavior analysis, the effect of this history is summarized in terms of the stimulus features that functionally control responding by that individual. In production systems, the effect of history is summarized in terms of what stimulus features are represented by (become functional for) the individual.

Both systems recognize and account for the effects of history on the individual. In the behavior-analytic system, this history is located in the discriminative stimulus. In the cognitive system, it is located in the subject's representation. Thus, by reading "discriminative stimulus" for "learner's mental representation," behavior analysts can make sense out of a statement by Gick and Holyoak (1987) that "a fundamental determinant of transfer is the similarity of the learner's mental representations of the training and transfer tasks" (p. 30). Read this way, Gick and Holyoak's cognitive statement poses no difficulties for many behavior analysts.

Cognitive psychologist Earl Hunt recognized the similarity between discriminative stimuli and representations when he read Skinner's (1966) "An Operant Analysis of Problem Solving":

Problem solvers are always responding to something. What they are responding to, though, are not physical characteristics of an external problem. They are responding to their internal representations of that problem. The words "internal representation" are . . . jargon of cognitive science rather than operant conditioning. The idea, however, is clearly stated in Skinner's (1966) paper, when he speaks of "discriminative stimuli." (E. Hunt, 1988, p. 250)

Goals, Goal Setting, Current Reinforcers, and Establishing Operations

Behavior is contingent not only on stimulus conditions but also on motivation. A sated pigeon will not peck, and an unmotivated computer programmer will not debug. In behavior analysis, motivation is described in terms of the various stimuli that are currently effective as reinforcers (Michael, 1982, 1993). If grain is not currently reinforcing, then responses that have functioned only to produce grain are not particularly likely. In production analysis, motivation is described in terms of goals. If obtaining grain is not a current goal, then actions for which grain is a goal are not particularly likely. Skinner (1966) commented, "to speak of the purpose of an act is simply to refer to its characteristic consequence" (p. 245). How can an observer know what goals a subject has? The same way one can know what stimuli are currently reinforcing. Test it functionally: Present stimuli in the presence of which a particular response has in the past led to the goal in question and observe the response. If I want to know whether a computer programmer is currently reinforcable by elimination of bugs, I would present a program with a bug in it and see whether the programmer debugs. If I want to know whether a pigeon has set a goal to obtain grain, I would present a green key and see whether it pecks.

Various events, stimuli, and processes change the motivating quality of stimuli. Michael (1982, 1993) has described such events and stimuli as establishing operations. Establishing operations describe changes in the function of stimuli as contingent on other stimuli and events. One function of an establishing operation is to evoke responses that have led to the stimulus that was established. This matches closely with the goal-setting function of productions. Productions may result in actions, or they may set new goals. Productions describe the setting of goals as contingent upon other stimuli and events. An establishing operation changes the set of stimuli that currently function as reinforcement, and goal setting changes the set of stimuli that currently function as goals. For example, in the coffee-making example above, the request for a cup of coffee could be described as an establishing operation that increased the likelihood of responses that have historically produced coffee. In production terms, the request caused me to set a goal to make coffee. This new goal increased the likelihood of actions that follow from a goal of making coffee.

Both behavior analysts and cognitive psychologists have noted that responses tend to be specific to the motivational control under which they were established and that when this is not taken into account, students may not produce desired responses in "real-world" situations. Gick and Holyoak (1987) note that "failures to apply knowledge learned in school to practical problems encountered in everyday life may largely reflect the fact that material taught in school is often disconnected from *any* clear goal" (p. 31). Stokes and Baer (1977) described the strategy of introducing the student to natural maintaining contingencies in order to promote generalization. In this strategy, one transfers "behavioral control from the teacher-experimenter to stable, natural contingencies that can be trusted to operate in the environment to which the subject will return, or already occupies" (p. 353). Responses are often taught with artificial discriminative stimuli and with consequences such as teacher requests to perform an activity and teacher praise for performing it correctly. But if the response is to be generalized to natural settings, it must be evoked by establishing operations and discriminative stimuli that will be available in that setting.

Actions and Responses

Discriminated operants and productions both describe subjects' actions that are likely to occur under particular antecedent conditions. Actions and responses can be either overt or covert. Neither analysis makes a distinction based on the public accessibility of the response. Both approaches assume that overt and covert responses operate in the same way, and that neither is to be ignored or to be given special status.

DIFFERENCES BETWEEN BEHAVIORAL AND COGNITIVE ANALYSES

Behavior analysis is differentiated from cognitive psychology along many dimensions. We believe the core difference is that behavior analysts' explanations are cast in behavioral language and cognitivists' explanations are cast in mentalistic language. Several other differences revolve around this core. The explanatory languages that distinguish the two are combined with many preferences and traditions that are not necessary to the integrity of either approach, but do foster the impression that the two approaches are more different than they are. These correlated differences include preferences for different types of experimental tasks and tendency toward functional versus structural questions.

Complexity of Tasks and Questions of Function and Structure

Cognitive psychologists have *tended* to devote their attention to investigation of relatively complex repertoires such as programming computers and playing chess. In contrast, behavior analysts have *tended* to investigate relatively simple repertoires. Of course, there is no reason in principle that either approach is limited to particular experimental tasks. Nonetheless, the differences in favored experimental tasks do inhibit communications. Later in this paper we describe tasks that have been analyzed by both cognitive and behavior analysts to show that inhibited communication is not essential.

Cognitivists have tended to ask structural questions, and behavior analysts have tended to ask functional questions (Catania, 1973, 1984). Structural questions consider the relations between elements of a repertoire, and functional questions consider the relations between elements of a repertoire and the environment. But, as Catania (1973, 1984) has argued, the two are intimately connected; "they complement each other, and our analysis of behavior will be deficient if we ignore either" (p. 125). Structural and functional questions in psychology are analogous to anatomy and physiology. The first asks about the nature of and relations among parts; the latter asks about the relations between parts and their environment. The shape of a bone is an aspect of structure. The effect of a bone's shape (e.g., allowing the beast to run fast) is a function. The structure of a bone is a result of evolutionary selection based on its functions. And the reason that an organism has certain functions (e.g., it can run fast) is because of its structures. An operant is defined by the common function of a class of responses. It is defined functionally, but as a class, it has a structure. One could ask structural questions about the dimensions of an operant. For instance, by probing for generalization, one may attempt to define the boundaries of an operant. In addition, one might be interested in properties of behavior that can come to form an operant. For instance, the demonstration that novelty (Pryor, Haag, & O'Reilly, 1969) and randomness (Neuringer, 1986; Page & Neuringer, 1985) can be operants adds to our understanding of the structure of behavior (Catania, 1984). Thus, although behavior analysts do not usually describe their work in explicitly structural terms, understanding the structure of behavior is important to behavior analysis.

Cognitive psychologists typically focus on the structure of behavior. Anderson and his colleagues (e.g., Singley & Anderson, 1989), for instance, have built large systems of productions that model the behavior of computer programmers. However, productions, the structural units, imply functional relations. Writing a production is an assertion that there is a functional relation between specific antecedent conditions and specific actions. In addition, many cognitive psychologists have investigated skill acquisition as a result of environmental manipulations (e.g., review by Gick & Holyoak, 1987). For both behavior analysts and cognitive psychologists, basic units must have functional and structural characteristics, and a complete account of behavior must account for both function and structure.

Level of Explanation and Mentalism

There is one fundamental difference in principle between cognitive and behavioral analyses. In behavioral analyses, explanations *must* be cast at the level of observation; but in cognitive analyses, explanations *must* be cast at the level of mental representation (Gardner, 1985; Schnaitter, 1986; Skinner, 1977). Behavior analysts describe functional relations between the organism and the environment. The operant and the establishing operation are units of functional relations. Learning is described as changes in the function of stimuli and in classes of responses. Cognitive psychologists describe the organism's mental representations of relations between itself and the environment. The production is a unit of mental representation. Learning is described as changes in the representation of stimuli and actions. In each case, the relation being described may be the same, but the location of the relation is different and so are the languages used to describe the relations. One language is behavioral; it locates changes at the level of observation. The other language is mental; it locates changes inside the organism at the level of representation. The level of representation is the level of mental entities and events. The concept of *mental* is the crux of the behavioral/cognitive schism. The concept is fundamental to cognitive psychology and anathema to behavior analysis. One source of difficulty in clarifying the relation between behavior analysis and cognitive psychology is the multiple meanings of the term *mental.*

In one meaning, *mental* is synonymous with private or covert. For example, a child probably engages in mental math when she multiplies 25 by 13 without overt accompaniment. Given this meaning of mental, there is no conflict between the two approaches. Both embrace private behavior as critical subject matter. Both understand that some public human behavior is the result of previous private behavior. Both account for private behavior in much the same way as they account for public behavior.

A second meaning concerns the sense in which representations and productions are mental. As we argued above, an organism's mental representation of a stimulus is analogous to a discriminative stimulus for that organism. The concepts of mental representation and discriminative stimulus both account for the unique effect of a particular stimulus on a particular organism that is the result of that organism's history. Productions, like operants, result from an organism's history. Behavior analysts place the effects of history in structures such as operants and establishing operations. Cognitivists place the effects of history in mental structures such as productions. In this sense, the term *mental* refers to the effects of history on the organism. For the cognitivist, the changes that occur as a result of interaction with the environment are mental changes. Skinner (1988) wrote, "Traditional expressions referring to mental events I regard as surrogates of histories of reinforcement" (p. 212). Skinner did not approve of these surrogates, but for our purposes it clarifies the point of contact between behavior analysis and cognitive psychology. When cognitivists say that productions are mental, they mean that they are features of the organism that are the result of a history and account for future behavior. This is very similar to what behavior analysts mean when they say that repertoires are the product of history. Roitblat (1982) writes, "A representation is a remnant of previous experience that allows that experience to affect later behavior" (p. 353). Butterfield and Nelson (1989) state, "speaking cognitively, past learning is stored in mental models" (p. 11).

A third meaning is the sense of mental process. In some cases, mental processes can be understood to be covert behavior, but in other cases mental processes do not imply any behavior. For instance, in certain contexts, seeing an open jar of instant coffee initiates a mental process of setting a goal to acquire a spoon. The mental process of goal setting does not imply covert behavior; rather, it describes the effect of a function-altering event. Thus, one meaning of mental process is the process whereby an existing repertoire is changed by a function-altering event. (See Schlinger & Blakely, this issue, for a complete discussion of function-altering events.) This meaning is similar to the second in that *mental* refers to a repertoire. Mental representations and mental models correspond to repertoires of behavior, and mental processes often correspond to the action of function-altering events.

Basic Units and Rules

Misunderstandings about rules have created a major stumbling block to effective communication between behavior analysts and cognitive psychologists. The problem arises from a confusion between two meanings of the word *rule* in psychology (Reese, 1989, 1992). One meaning is a verbal description of a regularity or a contingency (Reese, 1989). For instance, "smoking causes lung cancer" is a rule constructed by biologists to describe a regularity in nature. "One spoonful per 6 ounce cup" is a rule articulated by an instant coffee manufacturer to describe the proper mixing of instant coffee. "If there is an 'e' at the end, the vowel says its name" is a rule describing a relation between written and spoken English. Descriptive rules do not control the things they describe. Smoking would cause cancer whether or not the rule had been articulated. Operants and productions can be considered descriptive rules constructed by psychologists to summarize patterns of behavior. An observer may say that I have a discriminated operant of reaching for objects given the discriminative stimulus of the object in sight and the current reinforcing effectiveness of the object. This same regularity in my behavior could be stated in the form of a production. In either case, it is a rule that describes my behavior.

A second meaning of *rule* is (roughly) verbal behavior that controls other behavior (Catania, Shimoff, & Matthews, 1989; Reese, 1989; Skinner, 1989). Behavior that is controlled by rules is referred to as rule governed. For instance, by following the manufacturer's recommendation for mixing coffee, my behavior is rule governed. If the rule about an "e" on the end of a word is controling my reading of particular words, then that part of my reading would be rule governed.

Cognitive psychologists frequently speak of rules that a subject has learned. By this they mean patterns of behavior that are consistent with rules. They are asserting that a pattern of behavior is describable by a rule, and that they have formulated a rule to describe it. This terminology, however, has led to the misconception that cognitive psychologists assume that all behavior is rule governed. In fact, rule governance is not generally implied when they say that a subject has learned a rule. This can be seen in cognitive psychologists' distinction between procedural and declarative knowledge. Procedural knowledge is described by productions. It is demonstrated by performance of a task. Declarative knowledge is demonstrated by a subject when he states facts or relations. Thus, declarative knowledge is a verbal repertoire. In making the distinction between procedural and declarative knowledge, Singley and Anderson (1989) note that "declarative knowledge tends to be knowledge that can be accessed and stated verbally, whereas procedural knowledge cannot" (p. 198). This corresponds to the behavior-analytic argument that we do not have direct conscious access to our nonverbal repertoires. Cognitivists Ericsson and Simon (1980) have explored some of the complexity of the relation between verbal reports and patterns of behavior.

Hayes (1986) argues that Ericsson and Simon's analysis of verbal reports is compatible with a behavioral analysis: Verbal reports are behavior that can be analyzed and related to other behavior.

A verbal statement can, of course, control other behavior. A behavior analyst would call this rule-governed behavior, and a cognitive psychologist would describe it as transfer from declarative to procedural knowledge (Singley & Anderson, 1989). Declarative to procedural transfer is demonstrated when knowledge in a verbal form (i.e., the ability to state a rule) is at least partially responsible for a different instance of behavior (i.e., behavior that conforms to that rule). Cognitivists such as Bransford (Bransford, Franks, Vye, & Sherwood, 1989) have described some of the limitations of behavior that is the result of following rules alone. He quotes Balzac: "So he had grown rich at last, and thought to transmit to his only son all the cut-and-dried experience which he himself had purchased at the price of his lost illusions; a last noble illusion of age" (p. 470). Bransford explains:

> The argument is not that people are unable to learn from being shown or told. Clearly, we can remind people of important sets of information and tell them new information, and they can often tell it back to us. However, this provides no guarantee that people will develop the kinds of sensitivities necessary to use relevant information in new situations. (p. 470)

In behavioral language, rule-governed behavior may lack the subtleties of control by discriminative stimuli and establishing operations that are found in contingency-shaped behavior. Bransford et al. epitomized the argument: "wisdom cannot be told" (p. 470). Skinner (1966) was more specific: "different controlling variables are necessarily involved, and the behavior will have different properties" (p. 274).

Singley and Anderson (1989) note that a new production is formed as a by-product of declarative to procedural transfer. Stated behaviorally, rule governance can be pure only in the first instance of some behavior; after that, the behavior is likely to be under the control of the rule as well as the effects of the consequences of previous instances.

POINTS OF CONTACT BETWEEN COGNITIVE AND BEHAVIORAL EXPERIMENTATION

Experimental literature in the two traditions overlaps at many points. This overlap occurs with varying degrees of explicit acknowledgment of the relations between the two literatures and with varying degrees of combativeness. Here we describe only a few examples to show that combativeness is unnecessary.

Control by an establishing operation (goal setting) has been reported in both behavioral and cognitive research reports. In the behavioral literature, Hall and Sundberg (1987) reported the conditions necessary to transfer control of a response from a teacher's request to an establishing operation that results from the subject's own previous responses. First, they taught students to say the names of (tact) objects when an experimenter asked, "What is this?" Second, they trained chains of behavior that required the use of an object that the subjects had learned to tact. Finally, they told the subjects to begin the chain when an object was missing. The question was whether the subjects would request (mand) an object they had previously learned to name. In the cognitive literature, Crisafi and Brown (1986) analyzed tasks that are analogous to those in the study by Hall and Sundberg. They began by establishing a response under the control of an experimenter's directions. They presented young subjects with two closed containers, each containing a particular kind of token (e.g., pennies were in a bag and nickels were in a box). Subjects were taught to acquire each type of token when it was requested. Crisafi and Brown then trained a second task that required the token in order to complete a sequence (e.g., operating a gumball machine with a nickel). Finally, they presented the second task, but rather than supplying the token, they made the closed containers available. In several experiments, Crisafi and Brown explored variables that promote this kind of transfer of function. Crisafi and Brown, of course, conceptualized their work very differently from Hall and Sundberg, but they were investigating very similar issues of transfer of control of a response.

The instructional technique of reciprocal teaching (Palincsar & Brown, 1984) is frequently cited as an example of the success of cognitive psychology applied to education. The technique involves students and teachers in an oral dialogue. Students read a section of text, then developed a main idea question, summarized the section, asked about unclear ideas, and predicted what would be covered next. These activities were intended to place the students in a situation in which they needed to understand the material. The activities were intended to establish motivational control of reading comprehension. If a student failed to give an adequate summary, this fact was treated as information that comprehension was not proceeding as it should, and that remedial action, such as rereading or clarifying, was needed. In behavior-analytic terms, the dialogue was an attempt to bring behaviors that enhance comprehension under the control of the appropriate establishing operations (i.e., the stimuli associated with low comprehension). The goal was to make comprehension strategies more likely when understanding a text is an effective reinforcer.

The instructional processes of reciprocal teaching are very familiar to behavior analysts; however, their language is not. Palincsar and Brown explain their instruction:

> The teacher models and explains, relinquishing part of the task to the novices only at the level each one is capable of negotiating at any point in time. Increasingly, as a novice becomes more competent, the teacher increases her demands, requiring participation at a slightly more challenging level. (p. 169)

The authors describe these procedures in terms of Vygotsky's concepts of expert scaffolding and teaching within the child's zone of proximal development. Behavior analysts would describe them as modeling and shaping, which are practices used explicitly by some cognitive investigators. For example, Zhu and Simon (1987) attributed the success of their teaching of complex mathematical problems to shaping:

> A production system capable of performing the task was constructed to represent the skills that students would acquire in mastering the task. . . . Examples and problems were sequenced so that the initial problems could be handled with a small subset of the productions, and subsequent problems required additional productions for their solution. Thus, in accordance with the usual principles for shaping behavior, learners could attend to one or a few aspects of the problem situation at a time. (p. 141)

Engelmann and Carnine (1982) have developed a system for instructional design that is firmly within the behavior-analytic framework. Three key points for efficient instruction are:

> 1. The setup principle: To minimize the number of examples needed to demonstrate a concept, juxtapose examples that share the greatest possible number of features. . . .
> 2. The difference principle: To show the difference between examples, juxtapose examples that are minimally different and indicate that they have different labels. . . .
> 3. The sameness principle: To show sameness across examples, juxtapose examples that are greatly different and treat the examples in the same way. (p. 39)

In reviewing the cognitive literature on instruction, Gick and Holyoak (1987) made the following generalizations:

> Exposure to relatively similar items may help establish generalized rules. (p. 28) [Engelmann & Carnine's setup principle]

> Exposure to instances that vary in surface features will allow people to form generalized rules that are not restricted to overly specialized contexts, thus facilitating transfer. (p. 27) [Engelmann & Carnine's difference principle]

> Exposure to relatively variable training instances facilitates classification of novel instances, [and] . . . more variable instances can be used to elaborate the rule set. (p. 25) [Engelmann & Carnine's sameness principle]

In a cognitive analysis of instruction, Bransford et al. (1989) observed that "Through exposure to relevant sets of contrasts, students can be helped to notice important features of events that they might otherwise miss" (p. 492) (Engelmann & Carnine's sameness principle and difference principle).

The most general principle of instruction—that students can be taught generalizations through teaching multiple examples—can be expanded to include higher level generalizations. Students can learn abstract relations that are consistent across several similar lower level generalizations. Haring (1985) demonstrated this kind of higher level generalization from within the behavior-analytic perspective, and Butterfield and Nelson (1991) demonstrated it from within the cognitive tradition. Haring (1985) defined a specific play topography for each of several types of toys. Airplanes were manipulated in a specific way, cars in a different way, and so on. He taught young children the play topography for one example of each class of toys. His subjects did not generalize the appropriate play response to novel examples of each class. Then Haring systematically introduced multiple examples of a single class of toys (e.g., he taught the proper car play response for multiple cars) until he produced generalization to novel cars. He then taught multiple examples of a second class until he got generalization to other members of that class. After teaching several classes in this fashion, students spontaneously generalized from a single example to novel examples of the same class. Thus, he had taught the higher level generalization that the proper response for one member of a class is the proper response for other members of that class.

Butterfield and Nelson (1991) taught a different higher level generalization using very similar methods. Their tasks required dimensional integration; that is, correct responding required integration of two dimensions of a task by multiplying values of the dimensions. They used three dimensional-integration tasks: balance scale (requires integration of number of weights and their distances from a scale's fulcrum), volume estimation (requires integration of width and height of containers whose depths are equal), and inclined plane (requires integration of angle of track and starting position of ball). Training in each type of problem was based on multiple examples to induce generalization to novel instances of that type of problem. Each subject was trained in two types of problems, and Butterfield and Nelson found generalization to the third type. Students learned a higher level generalization about integrating two dimensions of a problem.

Researchers from both perspectives have identified rate as an important dimension of performance. Precision teaching, an educational derivative of behavior analysis, is predicated on the importance of rate of performance. From this perspective, Haughton (1972) proposed that when component skills (such as reading words) can be performed at a high rate, composite performances that include that component (such as reading comprehension) will improve. From a cognitive point of view, LaBerge and Samuels (1974) identified the same relationship. As is typical of this kind of convergence, the behavior analysts have described the phenomena in terms of the correlations between the observable rate of reading words and observable indicators of comprehension; the cognitivists have described it with reference to intermediate constructs such as the attentional requirements of components of the task. But clearly, they are describing the same relations.

Perhaps it is not surprising that the educational practices that come out of both theoretical traditions sometimes converge on common procedures. Some researchers and practitioners from each tradition are controlled primarily by student performance, which leads them to effective procedures. Both traditions continue to evolve and, in doing so, change to accommodate new data. So perhaps on a certain level, the fact that cognitive researchers have used procedures that have a long history in behavior analysis is trivial. But on another level, that is precisely the point: Both traditions are empirical and flexible, and workers in these traditions do frequently analyze the same phenomena. Occasional convergence is not that surprising. The problem is that because converging findings are described in different languages, the underlying similarities are not readily apparent.

Our point is not that cognitive psychology and behavior analysis are the same, or that they could merge, or that behavior analysts should become cognitive psychologists, or that cognitive psychologists should become behavior analysts. Our point is that there are important areas of contact between the two fields, so workers in each tradition could learn from work of the other. It is possible to make behavior-analytic sense out of a good cognitive analysis. If a cognitivist has shown (according to rigorous standards of the cognitive verbal community) that a particular production describes a pattern of behavior, then a behavior analyst can understand this in terms of a corresponding operant. As behavior analysts take on more complex repertoires, they may find that cognitivists have already researched them. We need not ignore these efforts; instead, we can build upon the best cognitive analyses. We can reverse the process that Herbert Simon described:

> The cognitive revolution, if there was a revolution, did not destroy gestalt psychology or behaviorism. There were all those great experiments out there, observations, careful observations of human behavior. That's what we have to explain, whether those observations were made by Thorndike or Skinner. (in Kent, 1991, p. 20)

Todd and Morris (1992) argue that psychologists' misconceptions about behaviorism "preclude sharing and exchanging insights on points of commonalty that might advance everyone's understanding of behavior" (p. 1449). We believe this to be true, and that behaviorists' unfamiliarity with the language of cognitive psychology also precludes a productive exchange.

> Rather than arguing about the best language, all would profit from the more difficult but productive activity of translation.... Translation brings differing points of view and modes of research to bear upon a given phenomenon and helps to broaden the audience. (Neuringer, 1991, p. 5)

We believe that translation can also broaden productive understandings and reduce unproductive antagonisms. The schism between behavior analysts and cognitive psychology can be reduced. We offer the preceding analysis in hopes that it will contribute to a more productive exchange between behavior analysts and cognitive psychologists.

REFERENCES

Anderson, J. R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Bandura, A. (1971). *Social learning theory.* New York: General Learning Press.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Belmont, J. M., & Butterfield, E. C. (1977). The instructional approach to developmental cognitive research. In R. Kail & J. Hagen (Eds.), *Perspectives on the development of memory and cognition* (pp. 437–481). Hillsdale, NJ: Erlbaum.

Bjorklund, D. F. (Ed.). (1991). *Children's strategies: Contemporary views of cognitive development.* Hillsdale, NJ: Erlbaum.

Bransford, J. D., Franks, J. J., Vye, N. J., & Sherwood, R. D. (1989). New approaches to instruction: Because wisdom can't be told. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 470–497). New York: Cambridge University Press.

Brown, J. S., & Van Lehn, K. (1980). Repair theory: A generative theory of bugs in procedural skills. *Cognitive Science, 4,* 397–426.

Butterfield, E. C., Albertson, L. R., & Johnston, J. C. (in press). On making cognitive theory more general and developmentally pertinent. In F. Weinert & W. Schneider (Eds.), *Research on memory development: State-of-the-art and future directions.* Hillsdale, NJ: Erlbaum.

Butterfield, E. C., & Nelson, G. D. (1989). Theory and practice of teaching for transfer. *Educational Technology, Research and Development, 37,* 5–38.

Butterfield, E. C., & Nelson, G. D. (1991). Promoting positive transfer of different types. *Cognition and Instruction, 8,* 69–102.

Butterfield, E. C., Siladi, D., & Belmont, J. M. (1980). Validating theories of intelligence. In H. Reese & L. P. Lipsitt (Eds.), *Advances in child development and child behavior* (Vol. 15, pp. 96–162). New York: Academic.

Card, S. K., Moran, T. P., & Newell, A. (1983). *The psychology of human-computer interaction.* Hillsdale, NJ: Erlbaum.

Catania, A. C. (1973). The psychologies of structure, function, and development. *American Psychologist, 28,* 434–443.

Catania, A. C. (1984). *Learning* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Catania, A. C., Shimoff, E., & Matthews, B. A. (1989). An experimental analysis of rule-governed behavior. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and in-*

structional control (pp. 119–150). New York: Plenum Press.
Crisafi, M. A., & Brown, A. L. (1986). Analogical transfer in very young children: Combining two separately learned solutions to reach a goal. *Child Development, 57,* 953–968.
Engelmann, S., & Carnine, D. (1982). *Theory of instruction: Principles and applications.* New York: Irvington Publishers.
Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87,* 215–251.
Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution.* New York: Basic Books.
Gick, M. L., & Holyoak, K. J. (1987). The cognitive basis of knowledge transfer. In S. M. Cormier & J. D. Hagman (Ed.), *Transfer of learning: Contemporary research and applications* (pp. 9–47). San Diego: Academic Press.
Hall, G., & Sundberg, M. L. (1987). Teaching mands by manipulating conditioned establishing operations. *The Analysis of Verbal Behavior, 5,* 41–53.
Haring, T. G. (1985). Teaching between-class generalization of toy play behavior to handicapped children. *Journal of Applied Behavior Analysis, 18,* 127–139.
Haughton, E. (1972). Aims—Growing and sharing. In J. B. Jordan & L. S. Robbins (Eds.), *Lets try doing something else kind of thing: Behavioral principles and the exceptional child* (pp. 20–39). Arlington, VA: CEC.
Hayes, S. C. (1986). The case of the silent dog—Verbal reports and the analysis of rules: A review of Ericsson and Simon's *Protocol Analysis: Verbal Reports As Data. Journal of the Experimental Analysis of Behavior, 45,* 351–363.
Hunt, E. (1988). A case study of how a paper containing good ideas, presented by a distinguished scientist to an appropriate audience, had almost no influence at all. In A. C. Catania & S. Harnad (Eds.), *The selection of behavior* (pp. 250–252). New York: Cambridge University Press.
Kent, D. (1991). Simon delivers inspired perspective on psychology as a successful science. *APA Observer, 4*(4), 19–20.
Klahr, D., & Carver, S. M. (1988). Cognitive objectives in a LOGO debugging curriculum: Instruction, learning, and transfer. *Cognitive Psychology, 20,* 362–404.
LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6,* 293–323.
Michael, J. (1982). Distinguishing between discriminative and motivational functions of stimuli. *Journal of the Experimental Analysis of Behavior, 37,* 149–155.
Michael, J. (1993). Establishing operations. *The Behavior Analyst, 16,* 191–206.
Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 125–141). New York: Academic Press.
Nelson, T. O., & Narens, L. (in press). Why investigate metacognition? In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing.* Boston: Bradford Books.
Neuringer, A. (1986). Can people behave "randomly"? The role of feedback. *Journal of Experimental Psychology: General, 115,* 62–75.
Neuringer, A. (1991). Humble behaviorism. *The Behavior Analyst, 14,* 1–13.
Newell, A., & Simon, H. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.
Page, S., & Neuringer, A. (1985). Variability is an operant. *Journal of Experimental Psychology: Animal Behavior Processes, 11,* 429–452.
Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1,* 117–175.
Pressley, M., Borkowski, J. G., & O'Sullivan, J. (1985). Children's metamemory and the teaching of memory strategies. In D. L. Forrest-Pressley, G. E. Mackinnon, & T. G. Waller (Eds.), *Metacognition, cognition, and human performance* (pp. 111–153). Orlando, FL: Academic Press.
Pryor, K. W., Haag, R., & O'Reilly, J. (1969). The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior, 12,* 654–661.
Reese, H. W. (1989). Rules and rule governance: Cognitive and behavioral views. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 3–84). New York: Plenum.
Reese, H. W. (1992). Rules as nonverbal entities. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 121–134). Reno, NV: Context.
Resnick, L. B., Levine, J. M., & Teasley, S. D. (Eds.). (1991). *Perspectives on socially shared cognition.* Washington, DC: American Psychological Association.
Roitblat, H. L. (1982). The meaning of representation in animal memory. *The Behavioral and Brain Sciences, 5,* 353–406.
Schnaitter, R. (1986). A coordination of differences: Behaviorism, mentalism, and the foundations of psychology. In T. R. Knapp & L. C. Robertson (Eds.), *Approaches to cognition: Contrasts and controversies* (pp. 291–315). Hillsdale, NJ: Erlbaum.
Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skill.* Cambridge, MA: Harvard University Press.
Skinner, B. F. (1935). The generic nature of the concepts of stimulus and response. *Journal of General Psychology, 12,* 40–65.
Skinner, B. F. (1938). *The behavior of organisms.* Acton, MA: Copley Publishing Group.
Skinner, B. F. (1966). An operant analysis of problem solving. In B. Klienmutz (Ed.), *Problem solving: Research, methods, and theory* (pp. 225–257). New York: Wiley.
Skinner, B. F. (1977). Why I am not a cognitive psychologist. *Behaviorism, 5,* 1–10.

Skinner, B. F. (1988). Response to Terrace. In A. C. Catania & S. Harnad (Eds.), *The selection of behavior* (pp. 212–213). New York: Cambridge University Press.

Skinner, B. F. (1989). The behavior of the listener. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 85–96). New York: Plenum Press.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis, 10,* 349–367.

Todd, J. T., & Morris, E. K. (1992). Case histories in the great power of steady misrepresentation. *American Psychologist, 47,* 1441–1453.

Zhu, X., & Simon, H. A. (1987). Learning mathematics from examples and by doing. *Cognition and Instruction, 4,* 137–166.