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DISCRIMINATION THEORY OF RULE-GOVERNED BEHAVIOR

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In rule-governed behavior, previously established elementary discriminations are combined in complex instructions and thus result in complex behavior. Discriminative combining and recombining of responses produce behavior with characteristics differing from those of behavior that is established through the effects of its direct consequences. For example, responding in instructed discrimination may be occasioned by discriminative stimuli that are temporally and situationally removed from the circumstances under which the discrimination is instructed. The present account illustrates properties of rule-governed behavior with examples from research in instructional control and imitation learning. Units of instructed behavior, circumstances controlling compliance with instructions, and rule-governed problem solving are considered.

Key words: discrimination, rule-governed behavior, contingency-shaped behavior, instructed discrimination, collateral contingencies, performance description, contingency description, compliance, problem solving

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> As a discriminative stimulus, a rule is effective as part of a set of contingencies of reinforcement. A complete specification must include the reinforcement which has shaped the topography of the response and brought it under the control of the stimulus. (Skinner, 1966, p. 148)

In contemporary analyses of human behavior, the term *rule-governed behavior* is used to describe responding determined primarily by instructions; rule-governed behavior is commonly distinguished from *contingency-shaped behavior* that is determined primarily by its direct consequences (Skinner, 1966, 1969). The concept of rule-governed behavior was introduced initially as an example of discriminated responding characterized by the three-term relation of discriminative stimulus, response, and consequence. It has proved difficult, however, to distinguish between rule-governed behavior and contingency-shaped behavior while at the same time regarding both as shaped by their consequences.

The present analysis is based on established distinctions between units of behavior, such as the operant, the discriminated operant, and conditional discrimination, thus remaining consistent with both historical accounts and current experimental findings. Controlling variables that may arise in behavior characterized as rule governed are examined in order to describe and interpret various instances.

Instructional control characterizes rule-governed behavior, yet the two terms are subtly distinct: whereas *rule* suggests control in a broad variety of circumstances, *instruction* suggests situational constraints. In the present account, both are construed as examples of the same behavioral process. A brief history will be presented here concerning the development of the concept of rule-governed behavior, but for etymological reasons, the preferred terminology will be derived from *instruction*. Many instances of instructional control involve complex combinations of elementary discriminations, and the term *instruct,* like *construct* and *structure,* is related to the Latin *struere,* to arrange in piles, pile up, and hence *to build* or *construct.*

Discriminated Responding and Rule-Governed Behavior

The term *contingency-shaped* is used to describe response classes governed by their consequences; such classes form the basis of the concept of the operant (Catania, 1973; Skinner, 1969). The term *discriminated responding* describes responding that is under stimulus control and that has been shaped by a contin-

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gency (Skinner, 1933). Thus, in discriminated responding, a contingency shapes the form of responding in relation to a particular stimulus dimension, producing responses that are then occasioned by stimuli that are correlated with contingencies.

Following his research on discriminated nonverbal responding, Skinner proceeded to identify verbal responses of the same kind in both speakers and listeners (1957, 1966, 1969). The distinction between rule-governed and contingency-shaped responding was introduced in a theoretical paper that characterized problem solving as behavior that also is functionally related to a set of reinforcement contingencies (Skinner, 1966). The distinction is important because, with respect to any problem, an instance of solving may be either rule governed or contingency shaped; however similar in form they may be, their controlling variables and functional properties may be different (Skinner, 1966, p. 247).

In Skinner's basic account, rule-governed behavior is discriminated responding that is shaped by contingent reinforcement of rule following. Characterized in this way, an instructional episode includes the presentation of an instruction, a response occasioned by the instruction, and a consequence delivered by an instructional agent contingent upon compliance. Thus, rule-governed behavior can be modified by altering either its antecedents or its consequences or both. In contrast, contingency-shaped behavior is modified only by the consequences specified by a contingency and by stimulus changes correlated with that contingency versus its absence.

Collateral consequences. Perhaps the most significant feature of rule-governed behavior appears when an instruction produces a single pattern of responding that enters into two contingencies (Zettle & Hayes, 1982). Examples occur when instructed responding is similar in form to contingency-shaped responding. In addition to the instructional contingency on compliance (that establishes the behavior in question), responding may also encounter the contingency of the related contingency-shaped behavior, producing consequences that do not depend upon social mediation (Skinner, 1966, pp. 244, 247). For example, compliance with a teacher's instructions to write structured computer programs may be reinforced by the teacher's approval, but another consequence is that structured programs are easy to read, debug, and modify. The class of consequences arranged by the latter contingency functions independently of instructional contingencies that had previously functioned to shape discriminative control by instructions. These consequences are produced after the behavior is generated, and they can be considered *collateral consequences* in the sense that they accompany instructional consequences, and that their role in determining the initial form of responding is minimal.

In many instances of instructional control, the distinction between instructional and collateral consequences is essential to analysis, especially when these consequences oppose one another as discussed below. But the distinction can be easily blurred because the function of these consequences is often similar, as when collateral consequences play a role in shaping instructional control once compliance has been generated. The difficulty can be resolved by acknowledging that instructed behavior is multiply determined in this way, and that a simple partitioning of independent variables can be problematic when their effects are combined through a complex history.

Insensitivity. A principal function of instructional control is to supplement, as well as to override, the potential reinforcing or punishing effects of consequences that are directly produced by the behavior in question (Skinner, 1966). The possibility then arises that rule-governed behavior, maintained by contingencies on compliance, may sometimes produce collateral consequences without being modified by the latter in any way. An example involves instructing a child to cross a street only when aided by an adult, an instruction that would not be given for responding already under control of its consequences (Ayllon & Azrin, 1964; Catania, 1984, p. 238). This effect of compliance has been identified as a source of *insensitivity* of rule-governed behavior to its direct consequences. This insensitivity refers to the relative absence of control by collateral consequences, because the behavior is assumed to be sensitive to contingencies of rule following that shaped it.

Insensitivity has been demonstrated experimentally in studies finding that instructing a performance sometimes produces responding that persists unaffected by changes in the scheduling of collateral consequences (e.g.,

Galizio, 1979; Harzem, Lowe, & Bagshaw, 1978; Kaufman, Baron, & Kopp, 1966; Lowe, 1979; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981; Skinner, 1966, p. 247; Weiner, 1970a, 1970b). Insensitivity should not be considered a necessary property of rule-governed behavior; rather, it arises when some forms of instructed responding interact with some kinds of contingencies (Galizio, 1979). Collateral consequences often affect the form and likelihood of the responses that produce them, and some of the circumstances that determine insensitivity are presented in a later section.

Definition. There are problems in defining rule-governed behavior. An account of instructional control must deal with many variables, and the variety of instructed response classes does not appear to suggest a set of common features that may define a functionally distinct category. For example, interactions between rule-governed behavior and its collateral consequences have played a prominent role in research and theory (Baron & Galizio, 1983; Catania, 1984; Galizio, 1979; Zettle & Hayes, 1982), but not all instructed responses produce two classes of consequences, as when verbal responses are themselves instructed (e.g., instructions to repeat an utterance). Furthermore, Skinner's functional definition of rule-governed behavior as an example of discrimination supplants, through its greater generality, structural definitions based upon particular classes of responses and stimuli (Catania, 1973; Skinner, 1935, 1977). The present account examines various instances of behavior commonly described in terms of instructional control and attempts to develop a coherent account of them by identifying separate contributions of different types of contingencies.

INSTRUCTIONAL CONTROL

The Repertoire

The novelty and variety in forms of instructed responses suggest that instructional control involves more than a collection of independent discriminations. For example, a child's turning can be reinforced given the vocal stimulus "turn," jumping can be reinforced given "jump," and so on (e.g., Streifel & Wetherby, 1973; Whitman, Zakaras, & Chardos, 1971), and these instructions could then be presented under circumstances appropriate to each of the responses. Some instructions would have greater generality; for example, "Don't" could terminate various ongoing responses. But as a whole, novelty in this simple instructional repertoire would be severely restricted: Novel instructions would not occasion corresponding novel responses without additional shaping. Perhaps the greatest restriction would be that instructions would only function in the situations in which they were given; they could not subsequently control behavior with respect to widely varied situations.

Complex discrimination. An instructional repertoire is considerably more versatile when instructions combine elementary discriminative stimuli that control response properties such as form, stimulus occasion, location, force, and temporal characteristics. Novel variations of instructed responses may then be occasioned when stimulus elements controlling established response properties are combined to form new instructions (Catania, 1980; Catania & Cerutti, 1986; Esper, 1933; Foss, 1968; Goldstein, 1983; Streifel, Wetherby, & Karlan, 1976). For example, in one experiment (Streifel et al., 1976), 2 retarded youths learned to follow two-word instructions derived from a set of nouns (glass, scissors, car) and verbs (push, drop, blow on). After a few verbs had been taught in combination with each of the nouns, teaching a new verb in combination with a single noun was often all that was required for the children to follow instructions comprised of the new verb and the remaining nouns.

To the extent that the elementary discriminations in instructions are generalized classes, they can be recombined in novel instructions that produce novel complex responses (Baer, Peterson, & Sherman, 1967; Catania & Cerutti, 1986; Garcia, Baer, & Firestone, 1971). A somewhat more complex example involving generalization in the recombination of elementary discriminations is provided by a dolphin that had been trained to follow acoustic instructions for manipulating toys (Herman, Richards, & Wolz, 1984; Schusterman & Krieger, 1984; Thompson & Church, 1980). After learning responses to instructions that involved some combinations of elementary discriminations such as "Pipe toss," "basket ball fetch" (bring ball to basket), and "bottom hoop through" (go through the bottom hoop, not the

top one), the dolphin then performed correctly in tests with new combinations of elements such as "pipe fetch," and on new relations between elements, such as "ball basket fetch." Thus, the integrity of discriminative elements as generalized classes was shown by the successful transfer of control in novel combinations.

Responses in the dolphin's final performances were integrations in which the several properties of a response were combined through conjoint occurrence of a complex of elements, each of which had been established as a discriminative stimulus. Such a complex instruction is not appropriately called a discriminative stimulus, particularly when it is an instruction for which compliance has never before been reinforced, because the term *discriminative stimulus* implies a history of differential reinforcement in the presence of the stimulus. The effective discriminative stimuli in instructions are instead generalized discriminative classes that maintain their integrity alone in simple instructions, or in combination, as shown when their control over responses or response properties generalizes to new combinations of stimuli in complex instructions (Catania & Cerutti, 1986).

Many kinds of behavior that are not easily contingency shaped can instead be generated by instructions that combine response properties. For example, few drivers would survive learning to stop at red traffic lights if the discrimination could only be negatively reinforced by avoiding collisions. Instead, the control by traffic lights over stopping and going is certain to be instructed: An instruction such as "Step on the brake pedal and come to a stop at a red light" controls a response, stepping; its location, the brake pedal; and its stimulus occasion, a red light; each stimulus element controls one property of the response. More likely, once control by "Stop" has been established over braking, a simplified instruction such as "Stop at red lights" may establish the particular discrimination.

Instructed discrimination. Rule-governed stopping at red lights is noteworthy because it is an instructed response class that involves instructing the control of a stimulus property over responding. Such instructed classes have characteristics that parallel those of the contingency-shaped discriminated operant. To illustrate, in *tacting,* a contingency-shaped discrimination, an event occasions a verbal response because the response has been reinforced in its presence. But stimulus control by an event can also be generated by instruction, such as by saying "This is a . . . ," or in the absence of the event, by describing its occasion in terms of its features (Skinner, 1957, chapter 5, pp. 358–362).

Instructed discriminations permit elements of instructional control, such as response form and stimulus occasion, to be themselves instructed; thus, the instructional repertoire may expand from within itself. For example, the form of a response may be instructed with "This is how you . . . ," accompanied by modeling, and the occasion for a response may be established by describing the features of that occasion; in both cases, instructions serve to create rule-governed responses that are appropriately described as *knowing* (Hineline, 1983). Instructed discriminations have further significance because the circumstances in which the instruction is given and those in which the behavior will occur can be disjointed, both situationally and temporally. For example, following a friend's instructions for getting to her apartment involves reacting to subsequently encountered landmarks that are the occasions for changing direction.

Self-instruction. An instruction for a discrimination contains discriminative elements for a response form and for its stimulus occasion. One variety was illustrated above by performances that combine action–object discriminations, because the object in such an instruction is the occasion for the action (Herman et al., 1984; Streifel et al., 1976). A second variety is suggested in an experiment on self-instruction (Lovaas, 1964). Children in the experiment were first taught the occasions for two self-instructions, to say "Push the girl" in the presence of one light and "Push the boy" in the presence of a second light. The lights were then presented in conjunction with two levers, one with a girl doll's head and a second with a boy doll's head; but the children did not push the relevant levers when the lamps were illuminated. The experimenter then used differential reinforcement to establish instructional control over pushing the girl-lever given the instruction "Push the girl" and pushing the boy-lever given "Push the boy." When the lights were again illuminated, the children pushed the corresponding levers: The final

performance required one discrimination for lights to occasion a response description and another for the description to occasion pushing.

This discrimination is unlike a contingency-shaped discrimination because lights did not occasion pushing by providing the occasion for responding to produce the consequences that had shaped it. It suggests instead that the control of lights over pushing was mediated by self-instructions (Blackwood, 1970; Constantine & Sidman, 1975). But self-instruction may not be essential in the final performance: Once self-instructions were controlled by lights, and pushing by self-instructions, it is possible that lights produced pushing through equivalence with instructions without mediating self-instructions (Sidman, Cresson, & Willson-Morris, 1974; Sidman & Tailby, 1982; Sidman, Willson-Morris, & Kirk, 1986). The likelihood of a role for mediating responses may be determined partly by properties of an instruction such as the duration or complexity of the instructed behavior (e.g., requirements for pressing a lever a specific number of times; see Bem, 1967; Jaynes, 1976; Vaughan, 1985).

Units of Instructional Control

Response properties like those combined in object–property–action instructions (Herman et al., 1984) do not characterize all types of instructions. The instruction to a pianist, "Play it!", sets the occasion for playing a previously heard arrangement, even though it is specified only minimally. Some instructions occasion behavior defined by its consequences rather than form, as in the instruction, "Stay out of trouble." This is somewhat analogous to an operant defined by its consequences. In the Golden Rule, "Do unto others as you would have them do unto you," an instruction modulates a class of responses that is defined by a characteristic of social interaction.

In the instruction for a verbal response, "What time is it?", a complex response is occasioned by an instruction that does not describe response features. Nevertheless, teaching a person to read the face of an analog clock almost demands the ability to instruct complex responses with rules such as "The small hand points to the hour; the large hand points to the minute." Once instructed, complex responses may retain their integrity over time and situations, and may then be occasioned by simplified instructions that describe their consequences, as in requesting the time.

Complex responses, like smaller response units, may become generalized response classes as in the instructed problem-solving strategies in geometry, calculus, and chemistry. For example, once a child is instructed in solving the problem of calculating the area of a particular parallelogram, that solving may generalize to parallelograms the child has never seen before (Wertheimer, 1959) and may then also appear as part of the solution to more complex problems, as in finding the area of a solid. Such instructed problem-solving units are also generalized classes, to the extent that they retain their integrity as they transfer to problems with novel combinations of elementary features (Jenkins, 1984).

Instructions for behavior sequences. Economy and flexibility in the instructional repertoire expand greatly as complex responses, like response elements, are combined and rearranged by instruction. An example of sequential recombination under instructional control is provided by research on imitation in retarded children (Baer et al., 1967). Although different in modality from vocal or written instructions, modeling is a class of discriminative stimuli, and imitation may thus serve to illustrate properties of rule-governed behavior (Catania, 1984; Matthews et al., 1977). In the experiment by Baer et al. (1967), trials were initiated by an experimenter saying "Do this," followed by modeling of a response, such as knocking. Once a number of imitative responses were taught, for example, knocking, turning, and jumping, novel concatenated forms of modeling, such as knock-turn-jump, were presented in conjunction with reinforcement contingent upon the temporal sequence of imitative responses corresponding to that of the modeled sequence. The concatenations produced corresponding complex imitative responses.

The Baer et al. (1967) study demonstrates another way in which complex responses result from recombining stimuli that occasion discrete responses. The process was not a simple concatenating of discriminated operants into a behavior chain, because the children imitated the combination only after it was presented. Completing one response in a sequence did not produce a discriminative stimulus corresponding to the following response in the sequence, the defining characteristic of a chain (Straub,

Seidenberg, Bever, & Terrace, 1979). On the other hand, chaining is involved in following a sequential instruction when completing a step sets the occasion for moving forward to instructions for the next step, and so on. But an instruction that occasions a sequential response without providing the opportunity to move from one discriminative element in the instruction to the next is not an example of chaining.

Shaping and Maintenance

Reinforcement of following instructions provided by the verbal community must act upon integrated responses comparable to those demonstrated by Baer et al. (1967), Herman et al. (1984), and Streifel et al. (1976). The contingencies that shape rule-governed behavior operate on correlations of stimulus elements and response elements: A single reinforcement produced by any instance of instructed responding may shape all of its elementary components, simultaneously reinforcing stimulus control over elements of responding and, as discussed next, stimulus control over relations between response units (Catania, 1980; Foss, 1968; Goldstein, 1983).

Grammar and Syntax

The simple contingency on the sequential integration of responses in the Baer et al. (1967) study falls short of the complex contingencies that integrate rule-governed responses outside the laboratory. A laboratory example that more closely approaches such complexity comes from the synthetic-language learning of Sarah, a chimpanzee whose verbal repertoire was based formally on plastic chips of various shapes and colors (Premack, 1970; Terrace, 1979). Paraphrasing her language and its contingencies, her training was such that the instruction, "Sarah insert banana pail apple dish," functioned as a complex hierarchically arranged discriminative stimulus: The element, "Sarah insert," indicated a contingency on her action of inserting; "banana pail" indicated a contingency on one consequence of inserting, putting a banana in a pail, and "apple dish," a second consequence to result from inserting, putting an apple in a dish. By the simple syntactical recombination of existing discriminations in her repertoire, her behavior could be instructed to produce novel consequences. These consequences cannot be considered reinforcers at the moment of instruction because they could be produced only after instructional control was established.

Verbal stimuli, such as "and," "or," "if," "then," "next," and "otherwise," often function to combine and coordinate the units of complex instructed responses. It is likely that relational autoclitic behavior is reinforced by the effects that result from integrating classes of rule-governed responses (Catania, 1980; Skinner, 1957, chapter 12), perhaps with the additional effect that responding may produce particular collateral consequences.

COLLATERAL CONTINGENCIES, PERFORMANCE DESCRIPTIONS AND CONTINGENCY DESCRIPTIONS

Collateral Contingencies

Perhaps the most interesting case of instructional control is that in which responding is related to two sets of contingencies. One contingency produces the initial form of responding through instructional control. The second contingency produces collateral consequences only after compliance is generated. The two contingencies are distinct, yet each may contribute to the final form of a pattern of behavior; the relative influence that either class of consequences has on particular responses, and assessment of their respective roles in the development of the repertoire as a whole, must be considered an empirical issue.

Numerous experiments with college students participating for money or to satisfy course requirements suggest interactions between features of instructed responding and collateral contingencies: Instructed responding is less likely to be suppressed by the addition of a collateral punishment contingency than is uninstructed responding that produces the same consequences (Scobie & Kaufman, 1969); it is less likely to be modified by changes in the scheduled collateral contingencies (Matthews et al., 1977; Shimoff et al., 1981; Skinner, 1969, p. 141); and it is more likely to be maintained in cases in which a collateral contingency is removed (Kaufman et al., 1966; Matthews et al., 1977; Weiner, 1970b). These findings imply independent and often incompatible effects of contingencies on compliance and collateral contingencies, but many other findings suggest the contrary.

Contingency interactions. The form of instructed responding is often susceptible to shaping by contact with collateral reinforcing

or punishing consequences. Likely outcomes appear to depend upon at least three independent variables that must be considered conjointly, as follows:

1. Collateral contingencies should be more likely to shape responding when contingencies on compliance are absent following its first occasion, either by withdrawing an instruction (Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986), by withdrawing discriminated contingencies on compliance, or by making them inconsistent (Peterson, Merwin, Moyer, & Whitehurst, 1971). When contingencies on compliance are removed and collateral consequences are neutral in reinforcement value or are punishers, responding would not be expected to persist. But the presence of contingencies on compliance, or a long history of reinforced compliance, should result in greater control by instructions and less sensitivity to collateral contingencies.

2. When contingencies on compliance are effective, insensitivity to collateral consequences will depend on the relative magnitude of the consequences on compliance versus the magnitude of the collateral consequences. Insensitivity is likely with weak collateral consequences, but not with those that are strong. An example involving punishment is suggested by an experiment in which soldiers' observing responses established by instruction occasionally produced high-intensity noise (Azrin, 1958; cf. Miller, 1970). At noise intensities below 105 dB, responding decreased in only 2 of 16 soldiers; however, at intensities of 105 to 120 dB, response rates decreased in 7 of 7 soldiers. An example involving reinforcement comes from an experiment on payment contingencies in which subjects' pressing produced points on a fixed-ratio schedule (Weiner, 1972): The highest rates were seen when points were worth money; lower rates occurred when subjects earned a fixed wage, and the lowest rates occurred when no money was earned.

3. The third variable is the compatibility of the form of instructed responding and the form of responding affected by the collateral contingency (Baron & Galizio, 1983; Galizio, 1979; Hayes et al., 1986; Kaufman et al., 1966). If instructed responding is compatible with a collateral contingency, that is, if responding overlaps the function of the collateral contingency, the response should be strengthened. For example, in soldiers' instructed observing (Azrin, 1958), response rate increased when responses also functioned to terminate occasional noise presentations. Compatibility is a problem in instructed avoidance when an avoidance contingency is discontinued, because that discontinuation is compatible with successful avoidance. For example, when an avoidance contingency involving the prevention of monetary loss was removed, students' instructed avoidance performances were unaffected over several sessions (Galizio, 1979). Conversely, instructed responding that is incompatible with the function of a collateral contingency is more liable to be modified by it (Miller, 1970; Scobie & Kaufman, 1969). For example, in students' instructed avoidance, control by inaccurate instructions for a low-rate avoidance performance was overridden by a high-rate avoidance contingency (Galizio, 1979).

Compatibility between instructed responding and collateral contingencies is a special problem because compliance in such circumstances prevents opportunities for discriminating the incompatibility. This kind of insulation may help to maintain instructional control of superstitious behavior. In such a case, compliance with an inaccurate instruction may appear to produce its described consequences, and the compatible relation between compliance and its described consequences may further set the occasion for the individual to wrongly believe that ("knowing that": Hineline, 1983) an instruction is accurate. Instructional control may similarly maintain classes of culture-typical behavior that are described erroneously as superstitious because the contingency descriptions of responses and their consequences are in error, but for which compliance has immediate social consequences for the individual that are maintained, in turn, through remote consequences for the culture (e.g., dietary instructions in India and the Middle East: Harris, 1974).

These three variables represent different dimensions of interaction between instructed responding and collateral contingencies. For any response, each variable might be represented on a different continuum denoting its contribution to insensitivity. The point clarifies that insensitivity is not a property of instructed responding but an outcome of its interaction with collateral contingencies.

Practical issues. Insensitivity appears to detract from the utility of the instructional repertoire, but instructions also can be useful pre-

cisely because the behavior they generate can make contact with collateral contingencies. Much complex behavior in schools is economically generated by instruction, whereas most of that behavior would be unlikely to be shaped by noncontrived contingencies that may be both weak and remote. The dilemma appears to arise when sensitivity is desirable in an instructed performance but a history of reinforcement for compliance leads to insensitivity (Catania, 1984). Whenever possible, solutions must be found in well-contrived instructions that maximize the control by collateral consequences.

Discriminative Function of Collateral Consequences

Some collateral consequences may be neutral events that have no role as reinforcers or punishers. The form of instructed responding is then largely controlled by the contingency on compliance. For example, for a production-line worker who is instructed to perform an assembly, the collateral consequences are the assembled items that are neither reinforcers nor punishers; much like a bar press, it is their production that is reinforced (Miller, 1970). As defined by the pay schedule, however, the items enter into a discriminative relation with reinforcement. Thus, parts set the occasion for assembly, a completed item occasions another assembly, and so on to reinforcement. The sequence resembles a behavior chain (Kelleher, 1966), but responses in the sequence are also instructed, and properties of responding seen in such schedules with animals, such as attenuated responding in links furthest from reinforcement, may be masked.

To the extent that instructional control may supplement or override control by collateral consequences, it may also introduce corresponding control over their discriminative functions. For example, instructions may establish reinforcer-like stimulus functions in neutral stimuli. In one experiment (Kaufman et al., 1966), students were instructed to earn points by pressing a button, and they participated only as a course requirement. Points in one condition were scheduled on a variable-interval (VI) schedule but students were instead informed that the points were scheduled on a fixed-interval (FI) schedule (cf. Lippman & Meyer, 1967). Several students' responding initially took the form of a typical contingency-shaped FI pattern, a pause after reinforcement followed by positively accelerated responding to the end of the interval (Lowe, 1979). This performance was determined by the FI description that established the discriminative function of point deliveries: Point deliveries set the occasion for pausing followed by positively accelerated responding.

With prolonged VI schedule exposure, the students' FI response pattern was replaced by the steady low-rate response pattern typical on a VI schedule. In the long run the FI contingency description was incompatible with the discriminably unequal intervals between VI point deliveries. Possibly, responding controlled by the VI discrimination could have been prevented if the scalloped FI performance had been instructed rather than occasioned by a description of the contingency, a description that did not contain a description of a performance.

Performance Description and Contingency Description

The contributions of collateral contingencies are an important feature of much rule-governed behavior, and instructions may describe these contingencies, just as they describe other features of responding such as form and stimulus occasions. This feature of instructions has led to the distinction between a *performance description* and a *contingency description* (Matthews, Catania, & Shimoff, 1985; cf. the discussion of instructions as "contingency-specifying stimuli" in Skinner, 1966, p. 243, and "tracking" in Zettle & Hayes, 1982). Both types of instructions may generate behavior that encounters collateral contingencies, but the term *contingency description* identifies instructions that explicitly describe collateral contingencies.

Stimulus elements in a contingency description may be correlated with properties of a collateral contingency such as its stimulus occasions and time or number of responses to produce an outcome. A simple contingency description may describe the form of a response and its collateral consequences. When response form is less critical, describing a stimulus property may occasion appropriate behavior, as in the admonition, "Sun is the enemy of fair skin," a description of a stimulus-event contingency. Examples of contingency descriptions are found in warnings and advice, rules

for games, strategies of war, advertising testimonials, maps, and in scientific reporting (see Skinner, 1966, pp. 231–236). Conceivably, a contingency description can be formulated for any set of collateral contingencies that may be produced by an instructed class, or for that matter, for any relation between events.

The present formulation of a contingency description is consistent with previous usage (e.g., Matthews et al., 1985). A complication arises with regard to some instructions that describe instructional contingencies, such as in a parent's warning, "Stop teasing your sister or Mommy will spank you." These resemble contingency descriptions, but are considered below as a stimulus class that indicates contingencies on compliance and that are distinct from collateral contingencies.

The Form of Instructed Behavior

Both performance descriptions and contingency descriptions control responses by combining response properties. In either case the behavior may bear little resemblance to responding shaped exclusively by a collateral contingency (e.g., Matthews et al., 1977; Shimoff, Matthews, & Catania, 1986; Skinner, 1966, p. 247). For example, an experiment on correspondence between verbal and nonverbal behavior (Matthews et al., 1985; Catania, Matthews, & Shimoff, 1982) found that shaping students' guesses about response rate on random-ratio (RR) and random-interval (RI) schedules, such as "Press slowly" and "Press quickly," consistently produced corresponding rates opposite to the rates usually shaped by these schedules. But students' shaped contingency descriptions about the RR and RI schedules, such as "Variable ratio" and "Variable interval," inconsistently produced corresponding high- and low-rate pressing or schedule sensitivity. These guesses differ importantly from performance descriptions by omitting a rate description: Contingency descriptions, as in those of reinforcement schedules, need not include descriptions of response form. As with performance descriptions, behavior occasioned by contingency descriptions is unlikely to be controlled by features of the collateral contingency in the same way as behavior exclusively shaped by the contingency.

Another difference between these instructions is related to variables that will set the occasion for following instructions. With contingency descriptions, such as warnings and advice, instructed responding may be occasioned by the component of the description that indicates its collateral reinforcers. As described in the next section, instructed behavior occasioned in this manner may not require social contingencies such as those that must operate for compliance with a performance description.

OCCASIONS FOR FOLLOWING INSTRUCTIONS

Instructions are fundamental in society. Gutenberg's printing press forever revolutionized society because it provided for the mass dissemination of quality-controlled discriminative stimuli. But not everyone who has read the *Bible* has since followed the Ten Commandments. It is one thing to call an instruction a Commandment and a different thing to follow it.

The Instructional Episode

Several controlling variables may be identified in an instructional episode: Collateral contingencies are indicated in contingency descriptions, and contingencies that reinforce compliance, considered here, are represented in the form of agencies such as friends, parents, teachers, and police. The consequences provided by these agencies can also be indicated in instructions by autoclitics such as ". . . and then you can have dessert" and ". . . or Mommy will send you to bed," descriptions of consequences for compliance that actually indicate previously established reinforcers.

Without agencies to reinforce compliance, the occasions for compliance are left to other variables. One of these may be collateral reinforcers indicated in a contingency description, or similarly, collateral consequences whose production will be reinforcing. For example, the term "gold" in the description, "There's gold in the Yukon," may set the occasion for a prospector to search for gold in the Yukon.

In addition to an instruction, an episode may include an indication that a stimulus is an instruction as well as an indication of the person or class of persons for whom compliance will be reinforced. It seems redundant to indicate an instruction, but autoclitic classes such as the imperative mood in language serve to differentiate instructions from other verbal

classes (Skinner, 1957, pp. 321–322); and indicating a person's name or a description of the class of people who must comply narrows the range of instructional control over an audience of more than one (Jaynes, 1976). At some point in the development of instructional control, stimuli indicating response form, both classes of contingencies, instructions, and the people for whom instructions are intended are likely to become discriminated classes. Furthermore, given the appropriate supportive repertoire, stimulus control of these features of instructions may itself be instructed.

Indicators for Instructions

Instructions are as often made conspicuous as they are concealed. Autoclitics that identify instructions for verbal and nonverbal instructions include interrogative pronouns such as "who," "which," and "what," as in "What is your name?", and the imperative mood in utterances such as "come" and "go," as in "Go home!" A concealed instruction may take the form, "I'm thirsty" and "It's hot in here," setting the occasion for a listener's corrective actions by describing a state of affairs aversive to the speaker and thus the occasion under which the speaker may reinforce the action of the listener (Skinner, 1957, chapter 3).

The context of a stimulus may identify it as an instruction in some circumstances. For example, "water" can be occasioned by events, such as a pool of water or a sign reading "WATER," that would not lead a listener to respond to it as an instruction. But it would be recognized as such if uttered by a person attempting to put out a fire. Even the simplest instruction, a response specifying its reinforcer (e.g., "Water!"; the concept of "mand" in Skinner, 1957), requires an additional stimulus element identifying it as an instruction if it is to occasion compliance.

Stimuli indicating instructions are apparent at the outset of children's instructing. For example, a child requesting a nearby object may stereotypically reach towards the object with an open hand and name the object, indicating *that* something is wanted and *what* is wanted (Bruner, Roy, & Ratner, 1982). Thus, the child's open hand sets the occasion for the listener to respond to the naming as a request and not as a tact. In the case of imitation, the autoclitic stimulus, "Do this," in the study by Baer et al. (1967) served to indicate an instance of modeling. Without making imitation conditional on "Do this," the child could not have discriminated modeling from the rest of the experimenter's ongoing behavior.

Agencies of Instruction

Compliance is not invariably reinforced. Agencies must shape compliance, and a history of following instructions leads to discriminations of presence versus absence of those agencies. Compliance is always conditional upon stimuli indicating agencies of reinforcement: Response form is determined by an instruction, but responding will occur only when the occasion for compliance is indicated, such as when drivers' compliance with speed-limit signs is occasioned by the presence of marked patrol cars (Galizio, Jackson, & Steele, 1979).

Agencies that are not immediately present may also generate compliance by identifying themselves in instructions with descriptive autoclitics such as "I . . . ," "We . . . ," and "Police!" In all, the various stimuli that set the occasions for compliance comprise a class of discriminations defined by their common effect (cf. "pliance" in Zettle & Hayes, 1982). A single discriminated reinforcement contingency on compliance may occasion instructional control by any number of instructions. For example, the threat of a parent's censure may occasion compliance with instructions to a child for tidying a bedroom, eating a nutritious food, and interacting with siblings in a prosocial manner.

Consequences on compliance. Agents do not always explicitly indicate positive reinforcers for compliance or punishers for noncompliance. Whether such an indication is necessary depends on the control exerted by the agent. An indication is redundant when an agent consistently reinforces compliance; such circumstances will produce generalized compliance in which compliance with all instructions is guaranteed. For example, at the outset of the experiment by Baer et al. (1967), all instances of imitation were reinforced. As the repertoire grew, novel instances of modeling occasioned novel imitative responses, a small number of which were maintained unreinforced over repeated trials, showing that imitation was a generalized class of responding. Similar arrangements were provided for instructional

control in the experiment by Streifel et al. (1976); however, the variables responsible for generalized compliance have been examined systematically only in imitation (Burgess, Burgess, & Esveldt, 1970; Garcia et al., 1971; Martin, 1972; Peterson et al., 1971).

Generalized compliance is probably rare. For example, with a small imitative repertoire, children quickly stop imitating particular models for which imitation is not reinforced (Peterson et al., 1971). Compliance and noncompliance can also be instructed. For example, children do not imitate when told "Don't do this" (Martin, 1972). Other occasions for compliance might be learned by observing compliance and its reinforcement (cf. the concept of vicarious reinforcement in Bandura, 1965).

Consequences for compliance may have to be explicitly indicated in instructions when the cost of compliance is high and reinforcement, or its magnitude, is inconsistent. A contractual agreement between an agent and subject is a formalized description of an instruction and consequences for compliance. Compliance with a contract may be occasioned to the extent that it appears equitable given previous experience. In a salaried job, compliance with a job description is reinforced at fixed periods of time, such that generating compliance by indicating a forthcoming reinforcer may not be as effective as indicating its removal by threatening dismissal.

The probability of reinforcement by an agent is sometimes indicated on a graded scale by the volume and inflection of a vocal instruction. An example appears at a supermarket checkout counter when a mother asks her child to keep his hands away from the candy counter. If the child disobeys, the mother may then repeat the instruction with an increased volume: Colloquially, the mother "is getting angry," but it can also be said that the change in volume indicates an increased likelihood of punishing noncompliance.

Monitoring. Agents must actively monitor compliance if they are to reinforce it, thus giving rise to opportunities for a subject of instruction to discriminate occasions when an agent is monitoring and when the agent's "back is turned." Continuous monitoring is unnecessary when an outcome of behavior, rather than a form of behavior, is instructed, as in a contractual agreement, because an agent can observe whether the job has been completed as instructed and reinforce accordingly.

Discriminations of monitoring are clearly apparent in a study of children's imitation established by instructions (Peterson et al., 1971). In one condition, the experimenter was present at all times, and the children consistently imitated models; in another condition, the experimenter left the room after presenting the model, and all of the children soon stopped imitating. Another example is found in research on self-commitment, a situation in which a person is both the source and subject of an instruction. Hayes et al. (1985) recruited college students for a course designed nominally to improve study skills. Some students set achievement goals that they believed were to remain private, others were required to make their goals public to the experimenter, and others did not set goals. The only students who met self-set standards were those whose goal setting had been made public; their mean posttest scores were 2½ times greater than those of the other groups (cf. Risley & Hart, 1968; Paniagua & Baer, 1982).

Classes of agencies. Subjects in the Peterson et al. (1971) and Hayes et al. (1985) experiments had the opportunity to discriminate the absence of a contingency on compliance. But reinforcement in those settings was not necessary for the experimenters to function as a discriminative occasion for compliance. It was sufficient that the experimenters were members of classes of agencies that had previously reinforced compliance (e.g., Milgram, 1963), as demonstrated in the Baer et al. (1967) study by children's generalized imitation of new experimenters.

Classes of agencies may also be tied to discriminable classes of instructions over which agents may reinforce compliance. For example, an employee's job description is in part a set of boundaries for the kinds of instructions over which supervisors may reinforce compliance or punish noncompliance.

Instructed compliance. To the extent that agencies are discriminable, their control over compliance may be established by instruction rather than by experience. For example, to a new employee, the statement, "I am Ms. X, your supervisor," sets the occasion for the employee to follow the instructions provided by

Ms. X; perhaps, her instructions will be to follow the instructions of others. Such an instruction serves to establish an occasion for compliance, in which agents' names, uniforms, and badges are effective discriminanda.

The instructional coordination of large social institutions suggests that there is no necessary relation between the source of an instruction and persons who monitor and reinforce compliance. For example, compliance with federal tax laws is monitored by accountants and informers and enforced by agents with the power to incarcerate; compliance with religious laws of conduct is monitored and reinforced by both clergy and laity.

Contingency Descriptions

A contingency description will occasion responding when compliance is monitored and reinforced (e.g., Kaufman et al., 1966), but it may also do so if the collateral consequences it indicates are reinforcers as in the description, "There's gold in the Yukon," a description that determines the location of prospecting. In this case, response form is determined by the description of response properties (e.g., location) and occasioned by the indicated collateral reinforcers. Another example is provided by the students that enrolled in the Hayes et al. (1985) experiment because of the nominal collateral contingencies, learning better study habits, without receiving credits or grades for participating. Contingencies on compliance acted only after students enrolled: Although all students studied the same quantity of material, monitored students were more likely to reach self-set standards; thus, the nominal collateral reinforcers were sufficient to generate compliance, but monitoring enhanced the form of studying.

Under some conditions, the consequences indicated in a contingency description may occasion compliance not because they are reinforcers, but rather because they are necessary to engage in other behavior that will be reinforced (cf. Michael, 1982; Premack, 1971). For example, in following an electronic circuit diagram to build a device that records an organism's responding, the diagram may indicate voltage requirements without providing further information. The voltage requirements may occasion compliance with other instructions to build or purchase a power supply, but the supply is not a reinforcer for compliance with the latter instructions; rather, obtaining the supply is reinforced by the opportunity to do the recording in research that will be reinforced.

Sources. The probability that a contingency description will generate compliance may depend in part on its source. Expertise on collateral contingencies is generally domain-specific, and thus a contingency description coming from an expert, perhaps identified in an instruction by name and profession, is more likely to describe accurately a set of collateral contingencies. Lawyers' advice is sought for legal problems, doctors' advice for health problems, and so on; experts are revisited and recommended to the extent that compliance with the contingency descriptions they provide is reinforced. In commercial advertising, sponsors appeal to expert witnesses for testimonials: Headache sufferers evaluate aspirin, gourmets evaluate frozen dinners, and so on. Generally speaking, contingency descriptions generated by scientific methods have special status because they are tied closely to systematic empirical observations.

Faulty contingency descriptions. One might expect that instructed responding should be most sensitive to its collateral consequences when compliance is occasioned by a contingency description. But instructed behavior is unlikely to be controlled solely by its collateral consequences; sensitivity to consequences may depend in part on the compatibility of a response and its collateral contingencies. For example, rule-governed superstitions, such as dancing for rain, may be maintained long after they are instructed because rain inevitably will follow the behavior. Similarly, gambling may continue into a losing streak when governed by the verbally stated supposition that repeated losses indicate a greater likelihood of winning (the "Monte Carlo fallacy").

Failure to discriminate between the described and actual effects of behavior occasioned by a contingency description is suggested by some placebo responses that are not due to classical conditioning (Marlatt & Rohsenow, 1980). In the placebo response, the administration of a substance or procedure produces an effect on behavior that is determined by an antecedent description of its action and not by its specific effect (Gallimore &

Turner, 1977; Grings & Lockhart, 1963; Jospe, 1978; Kirsh, 1985; Pfefferbaum, 1977). An example involves the administration of a nominal pain-relief pill that relieves pain (Rachlin, 1985). The description of the pill's action determines the form of responding, whereas the circumstances necessary for compliance may include discriminanda of technical expertise by the source of the description (e.g., a medical degree: Jospe, 1978; Moerman, 1981), and that the description constitutes a class of events known to produce the nominal collateral consequences (e.g., drug-taking to cure illness). Thus, the placebo response is compliance occasioned by the consequence described in a contingency description, and both the patient and the doctor will be more than likely to attribute mistakenly the response to the pill.

Observation of Reinforced Compliance

Imitation is sometimes considered an example of instructional control (Baer et al., 1967; Matthews et al., 1977; Skinner, 1969, p. 163); it is a class of discriminated responding that exhibits some of the properties of behavior occasioned by vocal or written instructions (e.g., insensitivity: Matthews et al., 1977). Nevertheless, imitation lacks some of the flexibility of a repertoire based upon arbitrary stimuli. A discrimination generated by modeling must be established under the same circumstances that are to occasion imitation; thus, for example, giving directions that would enable one to reach a house requires modeling the trip rather than describing its features. Another limitation is in the absence of autoclitics, such as "Don't . . . ," a qualifying autoclitic of negation for instructions not to act (Skinner, 1957). Not surprisingly, the strength of each repertoire is combined as suggested in the instructions to imitate and not imitate: "Watch how I do it," and "Don't plagiarize," respectively.

A number of experiments have shown that imitation may be occasioned by observing social reinforcers produced by modeled behavior (Bandura, 1965; Deguchi, 1984; Ollendick, Dailey, & Shapiro, 1983; Thelen & Rennie, 1972), suggesting that compliance with instructions may be occasioned by observing reinforced compliance. For the observer, an instance of reinforced compliance contains an instruction, compliance, its consequences, and perhaps an agent. The agent may be present to reinforce compliance in the episode, particularly when the instruction is a performance description, and in any circumstances, the instructed responding may be seen to produce collateral consequences.

Observers may witness complex episodes in which consequences for compliance are delivered by an agent and compliance produces additional collateral consequences. Compliance in the observer might be occasioned if both consequences were reinforcing but not if both were punishing. In cases in which one consequence is reinforcing and the other is punishing, compliance is conditional upon the operation of the reinforcement contingency, assuming greater relative control by the reinforcer (cf. Ayllon & Azrin, 1964).

INSTRUCTIONAL CONTROL IN PROBLEM SOLVING

Problems are a pervasive feature of the environment. Perhaps the most common appear when highly probable behavior is prevented, impeded, or if it is available, conditions indicate that it is to be restricted (Skinner, 1953, 1966). For the organism, the problem is the absence of a repertoire that will terminate these conditions; according to Skinner (1953, p. 247), "Problem solving may be defined as any behavior which, through the manipulation of variables, makes the appearance of a solution more probable." Problem solving may occur when equipment breaks or gives unexpected results, when a procedure is inefficient, or when contingency descriptions are incomplete or inaccurate.

The distinction between rule-governed and contingency-shaped behavior is central to an operant analysis of problem solving (Skinner, 1966). Problem features may control instructed or contingency-shaped discriminations, and solutions or answers (i.e., the behavior occasioned by the features) may have consequences that shape solving. Several variables evident in rule-governed behavior, such as those controlling insensitivity and compliance, also arise in problem solving. For example, problem features often occasion rule-governed solutions with characteristics that sharply differ from contingency-shaped prob-

lem solving in infants and animals (e.g., Bentall, Lowe, & Beasty, 1985; Lowe, 1979; Lowe, Beasty, & Bentall, 1983; Lowe, Harzem, & Bagshaw, 1978; Lowe, Harzem, & Hughes, 1978).

Problems and the Occasions for Solving

As with instructional control, the function of contingencies that occasion problem solving is separate from the function of problem features that determine the form of a solution: An occasion for solving is set by stimuli indicating events such as the likely availability of reinforcers or the absence or possible restriction of highly valued behavior, and the form of solving is occasioned by the features presented by a problem. Thus, a single discriminated reinforcement contingency may occasion problem solving controlled by any variety of problem situations, each presenting its own unique set of features.

Events that occasion problem solving may be like the descriptions of consequences that occasion compliance with contingency descriptions. Moreover, the outcomes of solving can also be considered its collateral consequences whenever they do not shape its initial form. In some cases, the consequences are a discriminated class of reinforcers (Skinner, 1966); in others, they provide opportunities for other more probable responses, such that producing them is reinforced by other consequences (cf. Michael, 1982; Skinner, 1953). The consequences that generate problem solving can also be distinct from the problem solution, as when solving is occasioned by instructions that are accompanied by social contingencies on compliance.

Problems are sometimes formally presented as incomplete contingency descriptions in which the features of a problem are described but the form of the solution is not. Such problem statements may be identified by autoclitics such as, "Is . . . ," "Find . . . ," "Discover . . . ," "Solve . . . ," and "Why . . . ." And because contingency descriptions may be derived from or related to theoretical systems, clarifying them may result in their rejection or modification, in the improved precision of prediction and control of the subject matter, and in social recognition.

Informal occasions for problem solving appear whenever the availability of reinforcement is discriminable but the form of reinforced responding is unspecified. Such occasions arise by necessity in psychology experiments that provide subjects with a situation in which responding will be reinforced, but in which the effective properties of responding remain uninstructed in order that they may remain free to be determined by independent variables (e.g., as in some analyses of reinforcement schedules).

Solving

The solution to a novel problem is not itself entirely novel in that response components of that solution must have been established before solving can occur. Problems that cannot be dealt with in terms of current repertoires can be solved only partially if they can be solved at all (Birch, 1945; Epstein, 1981; Skinner, 1953, 1972). Responses in a solution may be verbal and nonverbal (e.g., imaginal manipulations of problem features), and rather than being primary solutions, they may clarify the parameters of a problem by generating stimuli upon which subsequent problem-solving behavior is based (e.g., counting: Bem, 1967; Vaughan, 1985).

Contingency descriptions govern a large variety of problem solving. For example, once the component functions of a machine have been described, then in fixing the machine, describing the loss of a function may occasion the name of the faulty component. Or similarly, in constructing a new machine, a description of the component functions it must combine can be the basis for assembling a set of familiar corresponding components (e.g., as in Edison's motion-picture projector: Jenkins, 1984). Yet more complex problem solving may be instructed in larger units of branching sequences of discriminated responses that determine behavior at different problem states (e.g., as in solving differential equations or problems in mechanics: Larkin & Reif, 1979).

Once problem solving proceeds, stimulus control by problem features at any point in a solution may be determined in part by a solver's past behavior. For example, observing a limitation or weakness in the component function of a newly constructed machine may lead to refinements, and if an attempted solution fails, another attempt may be controlled by the same problem features, and so on, leading to the step-wise development of a problem solution (Weisberg, 1986). Failed or inefficient

solutions may also be a basis for constructing the correct solution to a problem, and they may determine the course that the solution takes. One way of preventing failed attempts is to eliminate features that control them; for example, finding a friend's luggage in a rotary display at an airport by marking rejected cases with a piece of chalk (Skinner, 1966).

Problem-solving instructions produce response classes in which problem features control response properties such as their occasion and form. For example, in an experiment on the development of self-instruction (Bem, 1967), children were instructed in solving a problem that required counting one to five lights in an array, and then without the lights, to press a lever once for every light that had been lit. Presumably, the children could generalize the solution to any number of lights that they could count. A similar solution is suggested by some college students' performances under FI schedules in which pausing from responding was timed by counting, thereby increasing the efficiency of responding by converting the simple FI to a signaled FI (Bentall et al., 1985; Leander, Lippman, & Meyer, 1968; Lippman & Meyer, 1967; Lowe, 1979; Lowe, Harzem, & Hughes, 1978; Lowe et al., 1983; Matthews et al., 1977).

The FI counting performance is correlated with students' postsession reports identifying the FI requirement (Brewer, 1974; Leander et al., 1968; Lippman & Meyer, 1967; Lowe, Harzem, & Bagshaw, 1978). Such reports suggest that responding was controlled by self-instruction (Lowe, 1979). But problem features sufficient to occasion self-instruction might instead directly occasion the corresponding instructed behavior without mediation by self-instruction (cf. Sidman et al., 1974; Sidman & Tailby, 1982; Sidman et al., 1986). In such a case, students' postsession descriptions may be controlled by the same task features that occasioned responding, rather than being antecedent events that controlled responding (Shimoff, 1986).

Instructed problem solutions can resemble contingency-sensitive responding. But like other rule-governed behavior, such solutions can be insensitive to changes in contingencies (Shimoff et al., 1986). Problem solving is also hampered when a problem's features consistently occasion behavior that is incompatible with its solution (Duncker, 1945; cf. Weisberg & Alba, 1981), or when a problem occasions responding that is inefficient but still compatible with solving (e.g., high-rate responding on FI tasks: Bentall et al., 1985; Leander et al., 1968; Lippman & Meyer, 1967; Lowe, 1979).

A general feature of problem solving is that it is differentially effective in dealing with a problem situation: Some type of behavior constitutes a better way to deal with a problem than another type does; still other types of behavior may not result in a solution at all. So long as responses are under stimulus control of problem features and the responses constitute solving, stimulus control will be reinforced and the responses may remain essentially unchanged. The same holds when problem features occasion behavior that is incompatible with solving. Stimulus control by problem features can be altered only by differential reinforcement of variations in solving that arise from incidental changes in the features of a problem, from properties of responding such as extinction, or from new instructions.

CONCLUSION

Instructional control is perhaps the oldest and most central function of verbal behavior (Catania, 1985; Jaynes, 1976). Details of its evolution are for speculation. It is likely, however, that its origins lay in situations where stimuli provided by one individual were correlated with contingencies that affected the behavior of other individuals in important ways. The consequences of such interactions must have promoted the well-being of both speakers and listeners. In time, as the repertoire grew, individuals could instruct one another on the basis of reliable personal experiences, and instructions could supplant learning through direct exposure to natural contingencies.

The present analysis delineates several variables that determine features of instructional control. It describes how discriminations established by social contingencies on compliance can be combined in complex forms to produce collateral consequences in collateral contingencies. Both contingencies may contribute to the final form of behavior. However, insensitivity to collateral consequences can result when the instructed form of behavior is compatible with the somewhat different form of behavior shaped directly by collateral contingencies. Stimuli correlated with both con-

tingencies also set the occasions for following instructions: Occasions are set by agencies that reinforce compliance and by the reinforcers indicated in contingency descriptions. These several variables combine in ways that produce a broad variety of instructional phenomena, including the compelling illusions that characterize rule-governed superstitions and placebo responding.

Some instructions determine response occasion and form, producing instructed stimulus control by the events they describe. These instructed discriminations may appear in the activity of science, for example, when a phenomenon is described and the problem is that of identifying its components and the relations that may exist between them. Thus, elementary units of behavior are identified in the systematic relations between classes of stimuli and responses (Skinner, 1935, 1969), and sometimes one can explain complex behavior by describing how it may arise from the interaction of elementary units (Catania, 1983). Such problem solving is rule governed, and therefore it is appropriate that the concept of rule-governed behavior has emerged in the context of a theoretical account of problem solving.

REFERENCES

Ayllon, T., & Azrin, N. H. (1964). Reinforcement and instructions with mental patients. *Journal of the Experimental Analysis of Behavior,* **7,** 327–331.

Azrin, N. H. (1958). Some effects of noise on human behavior. *Journal of the Experimental Analysis of Behavior,* **1,** 183–200.

Baer, D. M., Peterson, R. F., & Sherman, J. A. (1967). The development of imitation by reinforcing behavioral similarity to a model. *Journal of the Experimental Analysis of Behavior,* **10,** 405–416.

Bandura, A. (1965). Influence of models' reinforcement contingencies on the acquisition of imitative responses. *Journal of Personality and Social Psychology,* **1,** 589–595.

Baron, A., & Galizio, M. (1983). Instructional control of human operant behavior. *Psychological Record,* **33,** 495–520.

Bem, S. L. (1967). Verbal self-control: The establishment of effective self-instruction. *Journal of Experimental Psychology,* **74,** 485–491.

Bentall, R. P., Lowe, C. F., & Beasty, A. (1985). The role of verbal behavior in human learning: II. Developmental differences. *Journal of the Experimental Analysis of Behavior,* **43,** 165–181.

Birch, H. G. (1945). The relation of previous experience to insightful problem-solving. *Journal of Comparative Psychology,* **38,** 367–383.

Blackwood, R. O. (1970). The operant conditioning of verbally mediated self-control in the classroom. *Journal of School Psychology,* **8,** 251–258.

Brewer, W. F. (1974). There is no convincing evidence for operant or classical conditioning in adult humans. In W. B. Weimer & D. S. Palermo (Eds.), *Cognition and the symbolic processes* (pp. 1–42). Hillsdale, NJ: Erlbaum.

Bruner, J., Roy, C., & Ratner, N. (1982). The beginnings of request. In K. E. Nelson (Ed.), *Children's language* (Vol. 3, pp. 91–138). Hillsdale, NJ: Erlbaum.

Burgess, R. L., Burgess, J. M., & Esveldt, K. C. (1970). An analysis of generalized imitation. *Journal of Applied Behavior Analysis,* **3,** 39–46.

Catania, A. C. (1973). The concept of the operant in the analysis of behavior. *Behaviorism,* **1**(2), 103–116.

Catania, A. C. (1980). Autoclitic processes and the structure of behavior. *Behaviorism,* **8,** 175–186.

Catania, A. C. (1983). Behavior analysis and behavior synthesis in the extrapolation from animal to human behavior. In G. C. L. Davey (Ed.), *Animal models of human behavior* (pp. 51–69). Chichester, England: Wiley.

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

Catania, A. C. (1985). Rule-governed behaviour and the origins of language. In C. F. Lowe, M. Richelle, D. E. Blackman, & C. M. Bradshaw (Eds.), *Behaviour analysis and contemporary psychology* (pp. 135–156). London: Erlbaum.

Catania, A. C., & Cerutti, D. T. (1986). Some nonverbal properties of verbal behavior. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and integration of behavioral units* (pp. 185–211). Hillsdale, NJ: Erlbaum.

Catania, A. C., Matthews, B. A., & Shimoff, E. (1982). Instructed versus shaped human verbal behavior: Interactions with nonverbal responding. *Journal of the Experimental Analysis of Behavior,* **38,** 233–248.

Constantine, B., & Sidman, M. (1975). Role of naming in delayed matching-to-sample. *American Journal of Mental Deficiency,* **79,** 680–689.

Deguchi, H. (1984). Observational learning from a radical-behavioristic viewpoint. *Behavior Analyst,* **7,** 83–95.

Duncker, K. (1945). On problem-solving (L. S. Lee, Trans.). *Psychological Monographs,* **58**(5, Whole No. 270).

Epstein, R. (1981). On pigeons and people: A preliminary look at the Columban Simulation Project. *Behavior Analyst,* **4,** 43–55.

Esper, E. A. (1933). Studies in linguistic behavior organization: I. Characteristics of unstable verbal reactions. *Journal of General Psychology,* **8,** 346–381.

Foss, D. J. (1968). An analysis of learning in a miniature linguistic system. *Journal of Experimental Psychology,* **76,** 450–459.

Galizio, M. (1979). Contingency-shaped and rule-governed behavior: Instructional control of human loss avoidance. *Journal of the Experimental Analysis of Behavior,* **31,** 53–70.

Galizio, M., Jackson, L. A., & Steele, F. O. (1979). Enforcement symbols and driving speed: The overreaction effect. *Journal of Applied Psychology,* **64,** 311–315.

Gallimore, R. G., & Turner, J. L. (1977). Contempo-

rary studies of placebo phenomena. In M. E. Jarvik (Ed.), *Psychopharmacology in the practice of medicine* (pp. 47–57). New York: Appleton-Century-Crofts.

Garcia, E., Baer, D. M., & Firestone, I. (1971). The development of generalized imitation within topographically determined boundaries. *Journal of Applied Behavior Analysis,* **4,** 101–112.

Goldstein, H. (1983). Training generative repertoires within agent-action-object miniature linguistic systems with children. *Journal of Speech and Hearing Research,* **26,** 76–89.

Grings, W. W., & Lockhart, R. A. (1963). Effects of "anxiety-lessening" instructions and differential set development on the extinction of GSR. *Journal of Experimental Psychology,* **66,** 292–299.

Harris, M. (1974). *Cows, pigs, wars and witches: The riddles of culture.* New York: Random House.

Harzem, P., Lowe, C. F., & Bagshaw, M. (1978). Verbal control in human operant behavior. *Psychological Record,* **28,** 405–423.

Hayes, S. C., Brownstein, A. J., Zettle, R. D., Rosenfarb, I., & Korn, Z. (1986). Rule-governed behavior and sensitivity to changing consequences of responding. *Journal of the Experimental Analysis of Behavior,* **45,** 237–256.

Hayes, S. C., Rosenfarb, I., Wulfert, E., Munt, E. D., Korn, Z., & Zettle, R. D. (1985). Self-reinforcement effects: An artifact of social standard setting? *Journal of Applied Behavior Analysis,* **18,** 201–214.

Herman, L. M., Richards, D. G., & Wolz, J. P. (1984). Comprehension of sentences by bottlenosed dolphins. *Cognition,* **16,** 129–219.

Hineline, P. N. (1983). When we speak of knowing. *Behavior Analyst,* **6,** 183–186.

Jaynes, J. (1976). *The origin of consciousness in the breakdown of the bicameral mind.* Boston: Houghton Mifflin.

Jenkins, R. V. (1984). Elements of style: Continuities in Edison's thinking. *Annals of the New York Academy of Sciences,* **424,** 149–162.

Jospe, M. (1978). *The placebo effect in healing.* Lexington, MA: Lexington Books.

Kaufman, A., Baron, A., & Kopp, R. E. (1966). Some effects of instructions on human operant behavior. *Psychonomic Monograph Supplements,* **1,** 243–250.

Kelleher, R. T. (1966). Chaining and conditioned reinforcement. In W. K. Honig (Ed.), *Operant behavior: Areas of research and application* (pp. 160–212). New York: Appleton-Century-Crofts.

Kirsh, I. (1985). Response expectancy as a determinant of experience and behavior. *American Psychologist,* **40,** 1189–1202.

Larkin, J. H., & Reif, F. (1979). Understanding and teaching problem solving in physics. *European Journal of Science Education,* **1,** 191–203.

Leander, J. D., Lippman, L. G., & Meyer, M. E. (1968). Fixed interval performance as related to subjects' verbalizations of the reinforcement contingency. *Psychological Record,* **18,** 469–474.

Lippman, L. G., & Meyer, M. E. (1967). Fixed interval performance as related to instructions and to subjects' verbalizations of the contingency. *Psychonomic Science,* **8,** 135–136.

Lovaas, O. I. (1964). Cue properties of words: The control of operant responding by rate and content of verbal operants. *Child Development,* **35,** 245–256.

Lowe, C. F. (1979). Determinants of human operant behaviour. In M. D. Zeiler & P. Harzem (Eds.), *Advances in analysis of behaviour: Vol. 1. Reinforcement and the organization of behaviour* (pp. 159–192). Chichester, England: Wiley.

Lowe, C. F., Beasty, A., & Bentall, R. P. (1983). The role of verbal behavior in human learning: Infant performance on fixed-interval schedules. *Journal of the Experimental Analysis of Behavior,* **39,** 157–164.

Lowe, C. F., Harzem, P., & Bagshaw, M. (1978). Species differences in temporal control of behavior: II. Human performance. *Journal of the Experimental Analysis of Behavior,* **29,** 351–361.

Lowe, C. F., Harzem, P., & Hughes, S. (1978). Determinants of operant behaviour in humans: Some differences from animals. *Quarterly Journal of Experimental Psychology,* **30,** 373–386.

Marlatt, G. A., & Rohsenow, D. J. (1980). Cognitive processes in alcohol use: Expectancy and the balanced placebo design. In N. K. Mello (Ed.), *Advances in substance abuse: Behavioral and biological research* (Vol. 1, pp. 159–199). Greenwich, CT: JAI Press.

Martin, J. A. (1972). The effect of incongruent instructions and consequences on imitation in retarded children. *Journal of Applied Behavior Analysis,* **5,** 467–475.

Matthews, B. A., Catania, A. C., & Shimoff, E. (1985). Effects of uninstructed verbal behavior on nonverbal responding: Contingency descriptions versus performance descriptions. *Journal of the Experimental Analysis of Behavior,* **43,** 155–164.

Matthews, B. A., Shimoff, E., Catania, A. C., & Sagvolden, T. (1977). Uninstructed human responding: Sensitivity to ratio and interval contingencies. *Journal of the Experimental Analysis of Behavior,* **27,** 453–467.

Michael, J. (1982). Distinguishing between discriminative and motivational functions of stimuli. *Journal of the Experimental Analysis of Behavior,* **37,** 149–155.

Milgram, S. (1963). Behavioral study of obedience. *Journal of Abnormal and Social Psychology,* **67,** 371–378.

Miller, L. K. (1970). Some punishing effects of response-force. *Journal of the Experimental Analysis of Behavior,* **13,** 215–220.

Moerman, D. E. (1981). Edible symbols: The effectiveness of placebos. *Annals of the New York Academy of Sciences,* **364,** 256–268.

Ollendick, T. H., Dailey, D., & Shapiro, E. S. (1983). Vicarious reinforcement: Expected and unexpected effects. *Journal of Applied Behavior Analysis,* **16,** 485–491.

Paniagua, F. A., & Baer, D. M. (1982). The analysis of correspondence training as a chain reinforceable at any point. *Child Development,* **53,** 786–798.

Peterson, R. F., Merwin, M. R., Moyer, T. J., & Whitehurst, G. J. (1971). Generalized imitation: The effects of experimenter absence, differential reinforcement, and stimulus complexity. *Journal of Experimental Child Psychology,* **12,** 114–128.

Pfefferbaum, A. (1977). The placebo. In J. D. Barchas, P. A. Berger, R. D. Giaranello, & G. R. Elliot (Eds.), *Psychopharmacology: From theory to practice* (pp. 493–503). New York: Oxford University Press.

Premack, D. (1970). A functional analysis of language. *Journal of the Experimental Analysis of Behavior,* **14,** 107–125.

Premack, D. (1971). Catching up with common sense or two sides of a generalization: Reinforcement and punishment. In R. Glaser (Ed.), *The nature of reinforcement* (pp. 121–150). New York: Academic Press.

Rachlin, H. (1985). Pain and behavior. *Behavioral and Brain Sciences,* **8,** 43–83. (Includes commentary)

Risley, T. R., & Hart, B. (1968). Developing correspondence between the non-verbal and verbal behavior of preschool children. *Journal of Applied Behavior Analysis,* **1,** 267–281.

Schusterman, R. J., & Krieger, K. (1984). California sea lions are capable of semantic comprehension. *Psychological Record,* **34,** 3–23.

Scobie, S. R., & Kaufman, A. (1969). Intermittent punishment of human responding maintained by intermittent reinforcement. *Journal of the Experimental Analysis of Behavior,* **12,** 137–147.

Shimoff, E. (1986). Post-session verbal reports and the experimental analysis of behavior. *Analysis of Verbal Behavior,* **4,** 19–22.

Shimoff, E., Catania, A. C., & Matthews, B. A. (1981). Uninstructed human responding: Sensitivity of low-rate performance to schedule contingencies. *Journal of the Experimental Analysis of Behavior,* **36,** 207–220.

Shimoff, E., Matthews, B. A., & Catania, A. C. (1986). Human operant performance: Sensitivity and pseudosensitivity to contingencies. *Journal of the Experimental Analysis of Behavior,* **46,** 149–157.

Sidman, M., Cresson, O., Jr., & Willson-Morris, M. (1974). Acquisition of matching to sample via mediated transfer. *Journal of the Experimental Analysis of Behavior,* **22,** 261–273.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior,* **37,** 5–22.

Sidman, M., Willson-Morris, M., & Kirk, B. (1986). Matching-to-sample procedures and the development of equivalence relations: The role of naming. *Analysis and Intervention in Developmental Disabilities,* **6,** 1–19.

Skinner, B. F. (1933). The rate of establishment of a discrimination. *Journal of General Psychology,* **9,** 302–350.

Skinner, B. F. (1935). The generic nature of the concepts of stimulus and response. *Journal of General Psychology,* **12,** 40–65.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1966). An operant analysis of problem solving. In B. Kleinmuntz (Ed.), *Problem solving: Research, method, and theory* (pp. 225–257). New York: Wiley.

Skinner, B. F. (1969). An operant analysis of problem solving, Notes 6.1–6.4. In B. F. Skinner, *Contingencies of reinforcement: A theoretical analysis* (pp. 157–171). New York: Appleton-Century-Crofts.

Skinner, B. F. (1972, July 15). On "having" a poem. *Saturday Review,* pp. 32–35. Reprinted in B. F. Skinner, *Cumulative record* (3rd ed., 1972, pp. 345–355). New York: Appleton-Century-Crofts.

Skinner, B. F. (1977). Herrnstein and the evolution of behaviorism. *American Psychologist,* **32,** 1006–1012.

Straub, R. O., Seidenberg, M. S., Bever, T. G., & Terrace, H. S. (1979). Serial learning in the pigeon. *Journal of the Experimental Analysis of Behavior,* **32,** 137–148.

Streifel, S., & Wetherby, B. (1973). Instruction-following behavior of a retarded child and its controlling stimuli. *Journal of Applied Behavior Analysis,* **6,** 663–670.

Streifel, S., Wetherby, B., & Karlan, G. R. (1976). Establishing generalized verb–noun instruction-following skills in retarded children. *Journal of Experimental Child Psychology,* **22,** 247–260.

Terrace, H. S. (1979). Is problem-solving language? *Journal of the Experimental Analysis of Behavior,* **31,** 161–175.

Thelen, M. H., & Rennie, D. L. (1972). The effect of vicarious reinforcement on imitation: A review of the literature. In B. A. Maher (Ed.), *Progress in experimental personality research* (Vol. 6, pp. 83–108). New York: Academic Press.

Thompson, C. R., & Church, R. M. (1980). An explanation of the language of a chimpanzee. *Science,* **208,** 313–314.

Vaughan, M. E. (1985). Repeated acquisition in the analysis of rule-governed behavior. *Journal of the Experimental Analysis of Behavior,* **44,** 175–184.

Weiner, H. (1970a). Human behavioral persistence. *Psychological Record,* **20,** 445–456.

Weiner, H. (1970b). Instructional control of human operant responding during extinction following fixed-ratio conditioning. *Journal of the Experimental Analysis of Behavior,* **13,** 391–394.

Weiner, H. (1972). Human fixed-ratio responding as a function of the type of reinforcer (money vs. points) and the presence or absence of a noncontingent monetary wage. *Psychological Record,* **21,** 497–500.

Weisberg, R. W. (1986). *Creativity: Genius and other myths.* New York: Freeman.

Weisberg, R. W., & Alba, J. W. (1981). An examination of the alleged role of "fixation" in the solution of several "insight" problems. *Journal of Experimental Psychology: General,* **110,** 169–192.

Wertheimer, M. (1959). *Productive thinking.* New York: Harper & Row.

Whitman, T. L., Zakaras, M., & Chardos, S. (1971). Effects of reinforcement and guidance procedures on instruction-following behavior of severely retarded children. *Journal of Applied Behavior Analysis,* **4,** 283–290.

Zettle, R. D., & Hayes, S. C. (1982). Rule-governed behavior: A potential theoretical framework for cognitive-behavioral therapy. In P. C. Kendall (Ed.), *Advances in cognitive-behavioral research and therapy* (Vol. 1, pp. 73–118). New York: Academic Press.

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