An operant analysis of problem solving

B. F. Skinner
Department of Psychology and Social Relations, Harvard University,
Cambridge, Mass. 02138

Abstract: Behavior that solves a problem is distinguished by the fact that it changes another part of the solver’s behavior and is strengthened when it does so. Problem solving typically involves the construction of discriminative stimuli. Verbal responses produce especially useful stimuli, because they affect other people. As a culture formulates maxims, laws, grammar, and science, its members behave more effectively without direct or prolonged contact with the contingencies thus formulated. The culture solves problems for its members, and does so by transmitting the verbal discriminative stimuli called rules. Induction, deduction, and the construction of models are ways of producing rules. Behavior that solves a problem may result from direct shaping by contingencies or from rules constructed either by the problem solver or by others. Because different controlling variables are involved, contingency-shaped behavior is never exactly like rule-governed behavior. The distinction must take account of (1) a system which establishes certain contingencies of reinforcement, such as some part of the natural environment, a piece of equipment, or a verbal community; (2) the behavior shaped and maintained by these contingencies; (3) rules, derived from the contingencies, which specify discriminative stimuli, responses, and consequences; and (4) the behavior occasioned by the rules.

Keywords: contingency-shaped behavior; deduction; discriminative stimuli; hypotheses; induction; model building; operant analysis; problem solving; reinforcement contingencies; rule-governed behavior; verbal behavior

Behavior which solves a problem is distinguished by the fact that it changes another part of the solver’s behavior and is reinforced when it does so. Two stages are easily identified in a typical problem. When hungry we face a problem if we cannot emit any of the responses previously reinforced with food; to solve it we must change the situation until a response occurs. The behavior which brings about the change is properly called problem solving and the response it promotes a solution. A question for which there is at the moment no answer is also a problem. It may be solved by performing a calculation, by consulting a reference work, or by acting in any way which helps in recalling a previously learned answer. Since there is probably no behavioral process which is not relevant to the solving of some problem, an exhaustive analysis of techniques would coincide with an analysis of behavior as a whole.

Contingencies of reinforcement

When a response occurs and is reinforced, the probability that it will occur again in the presence of similar stimuli is increased. The process no longer presents any great problem for either organism or investigator, but problems arise when contingencies are complex. For example, in Thorndike’s experiment the probability that the cat would turn the latch was at first quite low. The box evoked conditioned and unconditioned escape behavior, much of it incompatible with turning the latch, and emotional responses which may have made the food less reinforcing when it was eventually reached. The terminal performance which satisfied the contingencies was a chain of responses: orienting toward and approaching the latch, touching and turning the latch, orienting toward and passing through the opened door, and approaching and eating the food. Some links in this chain may have been reinforced by the food and others by escape from the box, but some could be reinforced only after other reinforcers had been conditioned. For these and other reasons the box presented a problem—for both the cat and Thorndike.

Thorndike thought he solved his problem by saying that the successful cat used trial-and-error learning. The expression is unfortunate. “Try” implies that a response has already been affected by relevant consequences. A cat is “trying to escape” if it engages in behavior which either has been selected in the evolution of the species because it has brought escape from comparable situations or has been reinforced by escape from aversive stimulation during the life of the cat. The term “error” does not describe behavior, it passes judgment on it. The curves for trial-and-error learning plotted by Thorndike and many others do not represent any useful property of behavior—certainly not a single process called problem solving. The changes which contribute to such a curve include the adaptation and extinction of emotional responses, the conditioning of reinforcers, and the extinction of unreinforced responses. Any contribution made by an increase in the probability of the reinforced response is hopelessly obscured.

Even in Thorndike’s rather crude apparatus it should be possible to isolate the change resulting from reinforcement. We could begin by adapting the cat to the box until emotional responses were no longer important. By opening the door repeatedly (while making sure that this event
was not consistently contingent on any response), we could convert the noise of the door into a conditioned reinforcer which we could then use to shape the behavior of moving into a position from which the latch would be likely to be turned. We could then reinforce a single instance of turning the latch and would almost certainly observe an immediate increase in the probability that the latch would be turned again.

This kind of simplification, common in the experimental analysis of behavior, eliminates the process of trial and error and, as we have noted, disposes of the data which are plotted in learning curves. It leaves no problem and, of course, no opportunity to solve a problem. Clearly it is not the thing to do if we are interested in studying or in teaching problem solving.

**Constructing discriminative stimuli**

Consider a simple example not unlike Thorndike's puzzle box. You have been asked to pick up a friend's suitcase from an airport baggage claim. You have never seen the suitcase or heard it described; you have only a ticket with a number for which a match is to be found among the numbers on a collection of suitcases. To simplify the problem let us say that you find yourself alone before a large rotary display. A hundred suitcases move past you in a great ring. They are moving too fast to be inspected in order. You are committed to selecting suitcases essentially at random, checking one number at a time. How are you to find the suitcase?

You may, of course, simply keep sampling. You will almost certainly check the same suitcase more than once, but eventually the matching ticket will turn up. If the suitcases are not identical, however, some kind of learning will take place; you will begin to recognize and avoid cases which do not bear the matching number. A very unusual case may be tried only once; others may be checked two or three times, but responses to them will eventually be extinguished and the corresponding suitcase eliminated from the set.

A much more effective strategy is to mark each case as it is checked — say, with a piece of chalk. No bag is then inspected twice, and the number of bags remaining to be examined is reduced as rapidly as possible. Simple as it seems, this method of solving the problem has some remarkable features. Simply checking cases at random until the right one is found is of no interest as a behavioral process; the number of checks required to solve the problem is not a dimension of behavior. It is true that behavioral processes are involved in learning not to check cases which have already been marked because they bear nonmatching numbers, but the time required to find the right case throws no useful light on them. Mathematicians, showing perhaps too much confidence in psychologists, often take this kind of learning seriously and construct theoretical learning curves and design learning machines in which probabilities of responding change in terms of consequences; but the changes actually occurring as extinction and discrimination can be studied much more directly.

It is the use of the chalk which introduces something new. Marking each suitcase as it is checked is a kind of precurrent behavior which furthers the reinforcement of subsequent behavior — by reducing the number of samplings needed to find the right suitcase. Technically speaking, it is constructing a discriminative stimulus. The effect on the behavior which follows is the only reinforcement to which making such a mark can be attributed. And the effect must not be neglected, for it distinguishes the chalk marks from marks left by accident. One could "learn" the Hampton Court maze simply by not entering any path showing footprints leaving it (more precisely, in a maze with no loops — i.e., where all wrong entrances are to culs-de-sac — the right path is marked after one successful passage through the maze by any odd number of sets of prints); it is only when footprints have been found useful and, hence, when any behavior which makes them conspicuous is automatically reinforced that we reach the present case. A well-worn path over difficult terrain or through a forest is a series of discriminative stimuli and hence a series of reinforcers. It reinforces the act of blazing or otherwise marking the trail. Marking a path is, technically speaking, constructing a discriminative stimulus. The act of blazing or otherwise marking a trail thus has reinforcing consequences.

It is much easier to construct useful discriminative stimuli in verbal form. Easily recalled and capable of being executed anywhere, a verbal response is an especially useful kind of chalk mark. Many simple "statements of fact" express relations between stimuli and the reinforcing consequences of responses made to them. In the expression red apples are sweet, for example, the word red identifies a property of a discriminative stimulus and sweet a property of a correlated reinforcer; red apples are "marked" as sweet. The verbal response makes it easier to learn to discriminate between sweet and sour apples, to retain the discrimination over a period of time, and, especially when recorded, to respond appropriately when the original discrimination may have been forgotten. (Whether one must describe or otherwise identify contingent properties in order to form a discrimination is not the issue. Other species discriminate without responding verbally to essential properties, and it is unlikely that the human species gave up the ability to do so. Instead, the additional value of constructing descriptive stimuli which improve the chances of success was discovered.)

**Transmission of constructed stimuli**

A constructed external mark has another important advantage; it affects other people. Strangers can follow a well-worn path almost as well as those who laid it down. Another person could take over the search for the suitcase using our marks — either after being told to ignore cases marked with chalk (that is, after the chalk mark has been made an effective discriminative stimulus through verbal instruction), or after learning to ignore marked cases — in a process which would still be quicker than learning to ignore some cases when all have remained unmarked. Two people could also search for the same case using each other's marks. Something of the sort happens when, for example, a team of scientists is said to be "working on a problem." The stimuli constructed in solving problems can be helpful to other people precisely because the variables...
The accumulation and transmission of folk wisdom is exemplified by a formula once used by blacksmiths’ apprentices. Proper operation of the bellows of a forge was presumably first conditioned by the effects on the bed of coals. Best results followed full strokes, from wide open to tightly closed, the opening stroke being swift and the closing stroke slow and steady. Such behavior is described in the verse:

Up high, down low,
Up quick, down slow –
And that’s the way to blow. (Salaman 1957)

The first two lines describe behavior, the third is essentially a social reinforcer. A blacksmith might have composed the poem for his own use in facilitating effective behavior or in discussing effective behavior with other blacksmiths. By occasionally reciting the poem, possibly in phase with the action, he could strengthen important characteristics of his own behavior. By recalling it upon a remote occasion, he could reinstate an effective performance. The poem must also have proved useful in teaching an apprentice to operate the bellows. It could even generate appropriate behavior in an apprentice who does not see the effect on the fire.

Much of the folk wisdom of a culture serves a similar function. Maxims and proverbs describe or imply behavior and its reinforcing consequences. A penny saved is a penny earned may be paraphrased Not spending, like earning, is reinforced with pennies. Procrastination is the thief of time describes a connection between putting things off at the moment and being unpleasantly busy later. Many maxims describe social contingencies. The reinforcing practices of a community are often inconsistent or episodic, but contingencies which remain relatively unchanged for a period of time may be described in useful ways. It is better to give than to receive specifies two forms of behavior and states that the net reinforcement of one is greater than that of the other. (The golden rule is a curious instance. No specific response is mentioned, but a kind of consequence is described in terms of its effect on those who use the rule. In the negative form one is enjoined not to behave in a given way if the consequence would be aversive to oneself. In the positive form one is enjoined to behave in a given way if the consequences would be reinforcing to oneself. The rule may have been discovered by someone particularly sensitive to effects on others, but once stated it should have proved generally useful.) Maxims usually describe rather subtle contingencies of reinforcement, which must have been discovered very slowly. The maxims should have been all the more valuable in making such contingencies effective.

The formal laws of governmental and religious institutions also specify contingencies of reinforcement involving the occasions upon which behavior occurs, the behavior itself, and the reinforcing consequences. The contingencies were almost certainly in effect long before they were formulated. Someone who took another’s property, for example, would often be treated aversively. Eventually people learned to behave more effectively under such contingencies by formulating them. A public formulation must have had additional advantages; with its help authorities could maintain the contingencies more consistently and members of the group could behave more effectively with respect to them – possibly without direct exposure. The codification of legal practices, justly recognized as a great advance in the history of civilization, is an extraordinary example of the construction of discriminative stimuli.

A well-known set of reinforcing contingencies is a language. For thousands of years men spoke without benefit of codified rules. Some sequences of words were effective, others were less so or not at all. The discovery of grammar was the discovery of the fairly stable properties of the contingencies maintained by a community. The discovery may have been made first in a kind of personal problem solving, but a description of the contingencies in the form of rules of grammar permitted people to speak correctly by applying rules rather than through long exposure to the contingencies. The same rules became helpful in instruction and in maintaining verbal behavior in conformity with the usages of the community.

Scientific laws also specify or imply responses and their consequences. They are not, of course, obeyed by nature but by those who deal effectively with nature. The formula $s = 1/2gt^2$ does not govern the behavior of falling bodies, it governs those who correctly predict the position of falling bodies at given times.

As a culture produces maxims, laws, grammar, and science, its members find it easier to behave effectively without direct or prolonged contact with the contingencies of reinforcement thus formulated. (We are concerned here only with stable contingencies. When contingencies change and rules do not, rules may be troublesome rather than helpful.) The culture solves problems for its members, and it does so by transmitting discriminative stimuli already constructed to evoke solutions. The importance of the process does not, of course, explain problem solving. How do people arrive at the formulas which thus prove helpful to themselves and others? How do they learn to behave appropriately under contingencies of reinforcement for which they have not been prepared, especially contingencies which are so specific and ephemeral that no general preparation is possible?

**Problem-solving behavior**

The question, Who is that just behind you? poses a problem which, if the person is known by name, is solved simply by turning around and looking. Turning and looking are precurrent responses which generate a discriminative stimulus required in order to emit a particu-
which divert attention from behavior to mental events; direct analysis of the reinforcing systems found in nature; contingencies they maintain. Science is in large part a result of what would be generated by prolonged responding under the same conditions. This result is useful to others if, in public form, it leads them to see the same thing in the same way. The reactions of others which are reinforcing to those who describe vague situations may shape their descriptions, often exerting a control no less powerful than the situations themselves.

Behavior of this sort is often observed as a kind of running comment on contingencies of reinforcement to which one is being exposed. Children learn to describe both the world to which they are reacting and the consequences of their reactions. Situations in which they cannot do this become so aversive that they escape from them by asking for words. Descriptions of their own behavior are especially important. The community asks: *What did you do? What are you doing? What are you going to do? And why?* and the answers describe behavior and relate it to effective variables. The answers eventually prove valuable to the children themselves.

The expression: *I grabbed the plate because it was going to fall* refers to a response (grabbing) and a property of the occasion (it was going to fall) and implies a reinforcer (its falling would have been aversive to the speaker or others). It is particularly helpful to describe behavior which fails to satisfy contingencies, as in *I let go too soon or I struck too hard.* Even fragmentary descriptions of contingencies speed the acquisition of effective terminal behavior, help to maintain the behavior over a period of time, and reinstate it when forgotten. Moreover, they generate similar behavior in others not subjected to the contingencies they specify. As a culture evolves, it encourages running comments of this sort and prepares its members to solve problems most effectively. Cultures which divert attention from behavior to mental events said to be responsible for the behavior are notably less helpful.

It is possible to construct discriminative stimuli without engaging in the behavior. A piece of equipment used in the study of operant behavior is a convenient example of a reinforcing system. One may arrive at behavior appropriate to the contingencies it maintains through prolonged responding under them and in doing so may formulate maxims or rules. But the equipment itself may also be examined. One may look behind the interface between organism and apparatus and set down directions for behaving appropriately with respect to the system there discovered. The environment is such a reinforcing system, and parts of it are often examined for such purposes. By analyzing sample spaces and the rules of games, for example, we compose instructions which evoke behavior roughly resembling the behavior which would be generated by prolonged responding under the contingencies they maintain. Science is in large part a direct analysis of the reinforcing systems found in nature; it is concerned with facilitating behavior which will be reinforced by them.

(When prescriptions for action derived from an analysis of a reinforcing system differ from prescriptions derived from exposure to the contingencies maintained by the system, the former generally prevail. There are many reasons for this. A system is usually easier to observe than a history of reinforcement. The behavior summarized in a running comment may not be the terminal behavior which most adequately satisfies a given set of contingencies. A terminal performance may be marked by permanent though unnecessary features resulting from coincidental contingencies encountered en route. And so on.)

Contingencies are sometimes studied by constructing a model of a reinforcing environment. One may react to the model in simpler ways (for example, verbally) and acquire appropriate behavior more quickly. If rules derived from exposure to the model are to prove helpful in the environment, however, the contingencies must be the same, and a model is helpful therefore only if the reinforcing system has already been described. It is helpful simply in facilitating exposure to the contingencies and in studying the resulting changes in behavior.

Many instances of problem-solving behavior would be called induction. The term applies whether the stimuli which evoke behavior appropriate to a set of contingencies are derived from an exposure to the contingencies or from inspection of the reinforcing system. In this sense induction is not deriving a general rule from specific instances but constructing a rule which generates behavior appropriate to a set of contingencies. Rule and contingency are different kinds of things; they are not general and specific statements of the same thing.

Deduction is still another way of constructing discriminative stimuli. Maxims, rules, and laws are physical objects, and they may be manipulated to produce other maxims, rules, and laws. Second-order rules for manipulating first-order rules are derived from empirical discoveries of the success of certain practices or from an examination of the contingency-maintaining systems which the first-order rules describe. In much of probability theory first-order rules are derived from a study of reinforcing systems. Second-order rules are discovered inductively when they are found to produce effective first-order rules or deductively (possibly tautologically) from an analysis of first-order rules or of the contingencies they describe.

Many rules which help in solving the problem of solving problems are familiar. "Ask yourself "What is the unknown?" is a useful bit of advice which leads not to a solution but to a modified statement to which a first-order rule may then be applied. Reducing the statement of a problem to symbols does not solve the problem, but, by eliminating possibly irrelevant responses, it may make first-order problem solving more effective. Second-order, "heuristic" rules are often thought to specify more creative or less mechanical activities than the rules in first-order (possibly algorithmic) problem solving, but once a heuristic rule has been formulated, it can be followed as "mechanically" as any first-order rule (Skinner 1968).

Solving a problem is a behavioral event. The various kinds of activities which further the appearance of a solution are all forms of behavior: The course followed in
moving toward a solution does not, however, necessarily reflect an important behavioral process. Just as there are almost as many “learning curves” as there are things to be learned, so there are almost as many “problem-solving curves” as there are problems. Logic, mathematics, and science are disciplines which are concerned with ways of solving problems, and the histories of these fields record ways in which particular problems have been solved. Fascinating as this may be, it is not a prime source of data about behavior. Strategies and instances in which strategies have actually been used have the same status whether a problem is solved by an individual, a group, or a machine. Just as we do not turn to the way in which a machine solves a problem to discover the electrical, mechanical, optical, or chemical principles on which it is constructed, so we should not turn to the way in which an individual or a group solves a problem for useful data in studying individual behavior, communication, or coordinated action. This does not mean that we may not study individual, group, or machine behavior in order to discover better ways of solving problems or to reveal the limits of the kind of strategies which may be employed or the kinds of problems which may be solved.

Contingency-shaped versus rule-governed behavior

The response which satisfies a complex set of contingencies, and thus solves the problem, may come about as the result of direct shaping by the contingencies (possibly with the help of deliberate or accidental programming), or it may be evoked by contingency-related stimuli constructed either by the problem solver or by others. The difference between rule-following and contingency-shaped behavior is obvious when instances are pretty clearly only one or the other. The behavior of a baseball outfielder catching a fly ball bears certain resemblances to the behavior of the commander of a ship taking part in the recovery of a reentering satellite. Both move about on a surface in a direction and with a speed designed to bring them, if possible, near a falling object at the moment it reaches the surface. Both respond to recent stimulation from the position, direction, and speed of the object, and they both take into account effects of gravity and friction. The behavior of the baseball player, however, has been almost entirely shaped by contingencies of reinforcement, whereas the commander is simply obeying rules derived from the available information and from analogous situations. As more and more satellites are caught, it is conceivable that an experienced commander, under the influence of successful or unsuccessful catches, might dispense with or depart from some of the rules thus derived. At the moment, however, the necessary history of reinforcement is lacking, and the two cases are quite different.

Possibly because discriminative stimuli (as exemplified by maxims, rules, and laws) are usually more easily observed than the contingencies they specify, responses under their control tend to be overemphasized at the expense of responses shaped by contingencies. One resulting mistake is to suppose that behavior is always under the control of prior stimuli. Learning is defined as “finding, storing, and using again correct rules” (Clark 1963), and the simple shaping of behavior by contingencies which have never been formulated is neglected. When the brain is described as an “organ for the manipulation of symbols,” its role in mediating changes in behavior resulting from reinforcement is not taken into account.

Once the pattern has been established, it is easy to argue for other kinds of prior controlling entities such as expectancies, courses, maps, intentions, and plans. We refer to contingency-shaped behavior alone when we say that an organism behaves in a given way with a given probability because the behavior has been followed by a given kind of consequence in the past. We refer to behavior under the control of prior contingency-specifying stimuli when we say that an organism behaves in a given way because it expects a similar consequence to follow in the future. The “expectancy” is a gratuitous and dangerous assumption if nothing more than a history of reinforcement has been observed. Any actual formulation of the relation between a response and its consequences (perhaps simply the observation, “Whenever I respond in this way such and such an event follows”) may, of course, function as a prior controlling stimulus.

The contingency-specifying stimuli constructed in the course of solving problems never have quite the same effects as the contingencies they specify. One difference is motivational. Contingencies not only shape behavior, they alter its probability; but contingency-specifying stimuli, as such, do not do so. Though the topography of a response is controlled by a maxim, rule, law, or statement of intention, the probability of its occurrence remains undetermined. After all, why should a person obey a law, follow a plan, or carry out an intention? It is not enough to say that people are so constituted that they automatically follow rules — as nature is said, mistakenly, to obey the laws of nature. A rule is simply an object in the environment. Why should it be important? This is the sort of question which always plagues the dualist. Descartes could not explain how a thought could move the pineal gland and thus affect the material body; Adrian (1928) acknowledged that he could not say how a nerve impulse caused a thought. How does a rule govern behavior?

As a discriminative stimulus, a rule is effective as part of a set of contingencies of reinforcement. A complete specification must include the reinforcer which has shaped the topography of a response and brought it under the control of the stimulus. The reinforcers contingent on prior stimulation from maxims, rules, or laws are sometimes the same as those which directly shape behavior. When this is the case, the maxim, rule, or law is a form of advice (Skinner 1957). Go west, young man is an example of advice when the behavior it specifies will be reinforced by certain consequences which do not result from action taken by the adviser. We tend to follow advice because previous behavior in response to similar verbal stimuli has been reinforced. When maxims, rules, and laws are commands, they are effective only because special reinforcers have been made contingent upon them. Governments, for example, do not trust to the natural advantages of obeying the law to ensure obedience. Grammatical rules are often followed not so much because the behavior is then particularly effective as because social punishers are contingent upon ungrammatical behavior.

Rule-governed behavior is obviously unmotivated in
this sense when rules are obeyed by machines. A machine can be constructed to move a bellows up high, down low, up quick, and down slow, remaining forever under the control of the specifying rules. Only the designer and builder are affected by the resulting condition of the fire. The same distinction holds when machines follow more complex rules. A computer, like a mechanical bellows, does only what it was constructed and instructed to do. Mortimer Taube (1961) and Ulrich Neisser (1963) are among those who have argued that the thinking of a computer is less than human, and it is significant that they have emphasized the lack of "purpose." But to speak of the purpose of an act is simply to refer to its characteristic consequences. A statement of purpose may function as a contingency-specifying discriminative stimulus. Computers merely follow rules. So do people at times — for example, the blacksmith's apprentice who never sees the fire or the algorithmic problem solver who simply follows instructions. The motivating conditions (for machines and people alike) are irrelevant to the problem being solved.

Rules are particularly likely to be deficient in the sovereignty needed for successful government when they are derived from statistical analyses of contingencies. It is unlikely that anyone will ever stop smoking simply because of the aversive stimulation associated with lung cancer, at least not in time to make any difference. The actual contingencies have little effect on behavior under the control of contingency-specifying facts or rules. A formal statement of contingencies (cigarette smoking causes lung cancer) needs the support of carefully engineered aversive stimuli involving sanctions quite possibly unrelated to the consequences of smoking. For example, smoking may be classified as shameful, illegal, or sinful and punished by appropriate agencies.

Some contingencies cannot be accurately described. Old family doctors were often skillful diagnosticians because of contingencies to which they had been exposed over many years, but they could not always describe these contingencies or construct rules which evoked comparable behavior in younger doctors. Some of the experiences of mystics are ineffable in the sense that all three terms in the contingencies governing their behavior (the behavior itself, the conditions under which it occurs, and its consequences) escape adequate specification. Emotional behavior is particularly hard to bring under the control of rules. As Pascal put it, "the heart has its reasons which reason will never know." Nonverbal skills are usually much harder to describe than verbal ones. Verbal behavior can be reported in a unique way by instructing the subject in the operation of the equipment (Skinner 1963b), the resulting behavior may resemble that which follows exposure to the contingencies and may be studied in its stead for certain purposes, but the controlling variables are different, and the behavior will not necessarily change in the same way in response to other variables — for example, under the influence of a drug.

The difference between rule-following and contingency-shaped behavior may be observed as one passes from one to the other in "discovering the truth" of a rule. We may have avoided postponing necessary work for years either because we have been taught that procrastination is the thief of time and therefore avoid procrastination as we avoid thieves, or because we dutifully obey the injunction do not put off until tomorrow what you can do today. Eventually our behavior may come under the direct influence of the relevant contingencies — in doing something today we actually avoid the aversive consequences of having it to do tomorrow. Though our behavior may not be noticeably different (we continue to perform necessary work as soon as possible) we now behave for different reasons, which must be taken into account. When at some future time we say procrastination is the thief of time, our response has at least two sources of strength; we are reciting a memorized maxim and emitting a contingency-specifying statement of fact.

The eventual occurrence of a planned event works a similar change. Plans for a symposium are drawn up and followed. Eventually, almost incidentally it may seem, the symposium is held and certain natural consequences follow. The nature of the enterprise as an instance of behavior and, in particular, the probability that similar behavior will occur in the future have been changed. In the same way those half-formed expectancies called "premonitions" suddenly become important when the premonitored events occur. A similar change comes about when actors, starting with memorized words and prescribed actions, come under the influence of simulated or real reactions by other members of the cast, under the shaping effect of which they begin to "live" the role.

The classical distinction between rational and irrational or intuitive behavior is of the same sort. The "reasons" which govern the behavior of rational people describe relations between the occasions on which they behave, their behavior, and its consequences. In general we admire intuitive people, with their contingency-shaped behavior, rather than mere followers of rules. For example, we admire those who are "naturally" good rather than the merely law abiding, the intuitive mathematician rather than the mere calculator. Plato discusses the difference in the Charmides, but he confuses matters by supposing that what we admire is speed. It is true that contingency-shaped behavior is instantly available, whereas it takes time to consult rules and examine reasons; but irrational behavior is more likely to be wrong and therefore we have reason to admire the deliberate and rational person. We ask the intuitive mathematician to behave like one who calculates — to construct a proof which will guide others to the same conclusion even though the intuitive mathematician did not need it. We insist, with Freud, that the reasons people give in explaining their actions should be accurate accounts of the contingencies of reinforcement which were responsible for their behavior.
The objectivity of rules

In contrasting contingency-shaped and rule-governed behavior we must take account of four things:

1. A system which establishes contingencies of reinforcement, such as some part of the natural environment, a piece of equipment used in operant research, or a verbal community.

2. The behavior which is shaped and maintained by these contingencies or which satisfies them in the sense of being reinforced under them.

3. Rules derived from the contingencies, in the form of injunctions or descriptions which specify occasions, responses, and consequences.

4. The behavior evoked by the rules.

The topography of (4) is probably never identical with that of (2) because the rules in (3) are probably never complete specifications of the contingencies in (1). The behaviors in (2) and (4) are also usually under the control of different states of deprivation or aversive stimulation.

Items (2) and (4) are instances of behavior and as such, ephemeral and insubstantial. We observe an organism in the act of behaving, but we study only the records which survive. Behavior is also subjective in the sense that it is characteristic of a particular person with a particular history. In contrast, (1) and (3) are objective and durable. The reinforcing system in (1) exists prior to any effect it may have upon an organism, and it can be observed in the same way by two or more people. The rules of (3) are more or less permanent verbal stimuli. It is not surprising, therefore, that (2) and (4) often take second place to (1) and (3); (1) is said to be what a person acquires "knowledge about" and (3) is said to be possessed as "knowledge."

Maps. In finding one's way about a complex terrain, the relation between the behavior and its reinforcing consequences can be represented spatially, and "purposive" comes to mean "goal directed." A special kind of rule is then available - a map. A city is an example of item (1). It is a system of contingencies of reinforcement: When one proceeds along certain streets and makes certain turns, one arrives at certain points. One learns to get about in a city when behavior (2) is shaped by these contingencies. The reinforcing system in (1) exists prior to any effect it may have upon an organism, and it can be observed in the same way by two or more people. The rules of (3) are more or less permanent verbal stimuli. It is not surprising, therefore, that (2) and (4) often take second place to (1) and (3); (1) is said to be what a person acquires "knowledge about" and (3) is said to be possessed as "knowledge."

The extent to which behavior is contingency shaped or rule governed is often a matter of convenience. When a trail is laid quickly (as at Hampton Court after a fresh fall of snow), there is no need to learn the maze at all; it is much more convenient simply to learn to follow the trail. If the surface leaves no mark, the maze must be learned as such. If the trail develops slowly, the maze may be learned first as if no path were available and the path which is eventually laid down may never be used. If the maze is difficult, however - for example, if various points in it are very much alike - or if it is easily forgotten, a slowly developing path may take over the ultimate control. In that case one eventually "discovers the truth" in a trail as one discovers the truth of a maxim.

It is the contingencies, not the rules, which exist before the rules are formulated. Behavior shaped by the contingencies does not show knowledge of the rules. One may speak grammatically under the contingencies maintained by a verbal community without "knowing the rules of grammar" in any other sense, but once these contingencies have been discovered and grammatical rules formulated, one may upon occasion speak grammatically by applying rules.

Concepts. The items on our list which seem objective also tend to be emphasized when reinforcement is contingent upon the presence of a stimulus which is a member of a set defined by a property. Such a set, which may be found in nature or explicitly constructed, is an example of (1). Behavior is shaped by these contingencies in such a way that stimuli possessing the property evoke responses while other stimuli do not. The defining property is named in a rule (3) extracted from the contingencies. (The rule states that a response will be reinforced in the presence of a stimulus with that property.) Behavior (4) is evoked by stimuli possessing the property, possibly without exposure to the contingencies. The "concept" is "in the stimulus" as a defining property in (1) and it is named or otherwise specified in the rule of (3). Since the topography of the response at issue is usually arbitrary, it is quite likely that the behaviors in (2) and (4) will be similar, and it is then particularly easy to suppose that one responds to (1) because one "knows the rule" in (3).

Other kinds of problems

To define a problem, etymologically, as something explicitly put forth for solution (or, more technically, as a specific set of contingencies of reinforcement for which a response of appropriate topography is to be found) is to exclude instances in which the same precurrent activities serve a useful function although the topography of a response is already known. The distinction between contingency-shaped and rule-following behavior is still required. When the problem is not what to do but whether to do it, problem-solving behavior has the effect of strengthening or weakening an already identified response. Conflicting positive and negative consequences,
of either an intellectual or ethical nature, are especially likely to raise problems of this sort — for example, when a strongly reinforced response has deferred aversive consequences or when immediate aversive consequences conflict with deferred reinforcers.

A relevant problem-solving practice is to emit the questionable response in tentative form — for example, as a hypothesis. Making a hypothesis differs from asserting a fact in that the evidence is scanty and punishment for being wrong more likely to follow. The emitted response is nevertheless useful, particularly if recorded, because it may enter into other problem-solving activities. For rather different purposes one acts verbally before acting in other ways when one makes a resolution. It is easier to resolve than to act, but the resolution makes the action more likely to take place. (A promise specifies a response and creates social contingencies which strengthen it, and contingencies of social origin are invoked when one "promises oneself" to do something in making a resolution.) A statement of policy is also a description of action to be taken. (Resolutions and statements of policy are often made because action itself is at the moment impossible, but they are relevant here only when the action they strengthen or weaken is not under physical constraint.) A joint secret statement of policy is a conspiracy; it describes cooperative action to be undertaken by a group.

Like the rules and plans appropriate to problems in which the topography of the solution is not known, hypotheses, statements of policy, and so on, are not to be inferred in every instance of behavior. People act without making resolutions or forming policies. Different people or groups of people (for example, "capitalists" in socialist theory) act in the same way under similar contingencies of reinforcement, even cooperatively, without entering into a conspiracy. The conclusion to which a scientist comes at the end of an experiment was not necessarily in existence as a hypothesis before or during the experiment.

Sometimes the problem is to decide which of two or more responses to emit, the topographies of all alternatives being known. The concepts of choice and decision making have been overemphasized in psychological and economic theory. It is difficult to evaluate the probability that a single response will be made, but when two or more mutually exclusive responses are possible, the one actually emitted is presumably stronger than the others. For this reason early psychological research emphasized situations and devices in which only relative strength was observed (the rat turned right rather than left or jumped toward a circle rather than a square). Efforts to assess the separate probabilities of the competing responses were thus discouraged. Single responses were treated only as decisions between acting and not acting, within the time limits set by a "trial." The notion of relative strength is then practically meaningless, and "choose" simply means "respond." The problem of whether to act in one way or another differs from the problem of whether or not to act only because one of the aversive consequences of acting in one way is a loss of the opportunity to act in another. The same problem-solving activities are relevant. A decision announced before acting is essentially a resolution or statement of policy. The mere emission of one response rather than another, however, does not mean that a decision has been formulated.

The notion of a problem as something set for solution is even less appropriate when neither the topography of the behavior strengthened by precurrent activity nor its consequences are known until the behavior occurs. Artists, composers, and writers, for example, engage in various activities which further the production of art, music, and literature. (Sometimes they are required to produce works meeting quite narrow specifications, and their behaviors then exemplify explicit problem solving, but this is by no means always the case.) The artist or composer explores a medium or a theme and comes up with an unforeseen composition having unforeseen effects. A writer explores a subject matter or a style and comes up with a poem or a book which could not have been described or its effects predicted in advance. In this process of "discovering what one has to say," relevant precurrent behavior cannot be derived from any specification of the behavior to follow or of the contingencies which the behavior will satisfy. The precurrent behavior nevertheless functions by virtue of the processes involved in solving storable problems. For example, crude sketches and tentative statements supply stimuli leading to other sketches and statements, moving toward a final solution. Here again, it is a mistake to assume that the artist, composer, or writer is necessarily realizing some prior conception of the work produced. The conditions under which Renoir was reinforced as he painted The Boating Party must have been as real as those under which a mathematician or scientist is reinforced for solving a set problem, but much less could have been said about them in advance.

Problem solving is often said to produce knowledge. An operant formulation permits us to distinguish between some of the things to which this term has been applied. What is knowledge, where is it, and what is it about? Michael Polanyi (1958; 1960) and P. W. Bridgman (1952; 1959) have raised these questions with respect to the apparent discrepancy between scientific facts, laws, and theories (as published, for example, in papers, texts, tables of constants, and encyclopedias) and the personal knowledge of the scientist. Objective knowledge transcends the individual; it is more stable and durable than private experience, but it lacks color and personal involvement. The presence or absence of "consciousness" can scarcely be the important difference, for scientists are as "conscious" of laws as they are of the things laws describe. Sensory contact with the external world may be the beginning of knowledge, but contact is not enough. It is not even enough for "conscious experience," since stimuli are only part of the contingencies of reinforcement under which an organism distinguishes among the aspects and properties of the environment in which it lives. Responses must be made and reinforced before anything can be seen.

The world which establishes contingencies of reinforcement of the sort studied in an operant analysis is presumably "what knowledge is about." A person comes to know that world and how to behave in it in the sense of acquiring behavior which satisfies the contingencies it maintains. Behavior which is exclusively shaped by such contingencies is perhaps the closest one can come to the "personal knowledge" of Polanyi and Bridgman. It is the directed "purposive" behavior of the blacksmith who operates his bellows because of its effect on the fire. But there is another kind of behavior which could be...
called knowledge of the same things — the behavior controlled by contingency-specifying stimuli. These stimuli are as objective as the world they specify, and they are useful precisely because they become and remain part of the external world. Behavior under their control is the behavior of the apprentice who never sees the fire but acts as if he instructs himself to act by reciting a poem. So far as topography goes, it may resemble behavior directly shaped by contingencies, but there remains an all important difference in controlling variables. (To say that the behaviors have different "meanings" is only another way of saying that they are controlled by different variables; Skinner 1957).

The distinction which Polanyi (1960) in particular seems to be trying to make is between contingency-shaped and rule-governed behavior rather than between behaviors marked by the presence or absence of "conscious experience." Contingency-shaped behavior depends for its strength upon "genuine" consequences. It is likely to be nonverbal and thus to "come to grips with reality." It is a personal possession which dies with the possessor. The rules which form the body of science are public. They survive the scientist who constructed them as well as those who are guided by them. The control they exert is primarily verbal, and the resulting behavior may not vary in strength with consequences having personal significance. These are basic distinctions, and they survive even when, as is usually the case, the scientist's behavior is due both to direct reinforcement and to the control exercised by the contingency-specifying stimuli which compose facts, laws, and theories.

Differences between contingency-shaped and rule-governed behavior

We may play billiards intuitively as a result of long experience, or we may determine masses, angles, distances, frictions, and so on, and calculate each shot. We are likely to do the former, of course, but there are analogous circumstances in which we cannot submit to the contingencies in a comparable way and must adopt the latter. Both kinds of behavior are plausible, natural, and effective; they both show "knowledge of the contingencies," and (apart from the precurrent calculations in the second case) they may have similar topographies. But they are under different kinds of stimulus control and hence are different operants. The difference appears when we examine our behavior. In the first case we feel the rightness of the force and direction with which the ball is struck; in the second we feel the rightness of calculations but not of the shot itself (Skinner 1963a).

It is the control of nature in the first case with its attendant feelings which suggests to Polanyi and Bridgman a kind of personal involvement characteristic only of direct experience and knowledge. The point of science, however, is to analyze the contingencies of reinforcement found in nature and to formulate rules or laws which make it unnecessary to be exposed to them in order to behave appropriately. What one sees in watching oneself following the rules of science is therefore different from what one sees in watching oneself behave as one has learned to do under the contingencies which the rules describe. The mistake is to suppose that only one of these kinds of behavior represents knowledge. Polanyi argues that "tax-it knowing is . . . the dominant principle of all knowledge, and . . . its rejection would therefore automatically involve the rejection of any knowledge whatever" (Polanyi 1960). It is true that an apprentice blacksmith may not know why he is operating the bellows as he does — he may have no "feel" for the effect on the fire — but the rule, together with its effect on his behavior, is still a "form of knowledge."

Rogers (1961) and Maslow (1962) have tried to reverse the history of psychological science and return to a kind of knowledge generated by personal contingencies of reinforcement. They presumably do not question the effectiveness of the rules and prescriptions drawn from a consideration of the circumstances under which people behave or can be induced to behave, but they give preference to personal knowledge which has the feeling of contingency-shaped behavior. It is not too difficult to make this feeling seem important — as important as it seemed to Polanyi and Bridgman in attempting to evaluate what we really know about the world as a whole.

Rogers and Maslow feel threatened by the objectivity of scientific knowledge and the possible absence of personal involvement in its use; but the personal and social behavior shaped by social contingencies has, except in rare instances, been as cold, scheming, or brutal as the calculated behavior of a Machiavelli. We have no guarantee that personal involvement will bring sympathy, compassion, or understanding, for it has usually done just the opposite. Social action based upon a scientific analysis of human behavior is much more likely to be humane. It can be transmitted from person to person and from epoch to epoch, it can be freed of personal predilections and prejudices, it can be constantly tested against the facts, and it can steadily increase the competence with which we solve human problems. If need be, it can inspire in its devotees a feeling of rightness. Personal knowledge, whether contingency shaped or rule governed, is not to be judged by how it feels but by the help it offers in working toward a more effective culture.

ACKNOWLEDGMENT


Open Peer Commentary

Commentaries submitted by the qualified professional readership of this journal will be considered for publication in a later issue as Continuing Commentary on this article. Integrative overviews and syntheses are especially encouraged.

On the depth and fit of behaviorist explanation

L. Jonathan Cohen
The Queen's College, Oxford University, Oxford OX1 4AW, England

To a relatively dispassionate philosopher of science two interconnected weaknesses in Professor Skinner's account of prob-