The Behavior Analyst 1995, 18, 99–111 No. 1 (Spring)

A Model of Cause–Effect Relations in the Study of Behavior

Drake C. Chisholm
Bridgewater State College
Donald A. Cook
Cambridge Center for Behavioral Studies

A three-phase model useful in teaching the analysis of behavior is presented. The model employs a "black box" behavior inventory diagram (BID), with a single output arrow representing behavior and three input arrows representing stimulus field, reversible states, and conditioning history. The first BID describes the organism at Time 1, and the second describes it at Time 2. Separating the two inventory diagrams is a column for the description of the intervening procedure. The model is used as a one-page handout, and students fill in the corresponding empty areas on the sheet as they solve five types of application problems. Instructors can use the BID to shape successive approximations in the accurate use of behavior-analytic vocabulary, conceptual analysis, and applications of behavior-change strategies.

Key words: model, diagram, causality, paradigm, notation, procedure

Textbooks in the science of behavior have made use of diagrams at least since Pavlov's *Conditioned Reflexes* (1927). Skinner's *The Behavior of Organisms* (1938) attempts to use a systematic scheme in which such diagrams embody the critical aspects of respondent and operant conditioning. Keller and Schoenfeld (1950) refer to these representations of the conditioning process as "paradigms," and use these paradigms in a careful comparison and contrast of the two major forms of conditioning. These paradigms represent processes or procedures, but often leave unclear, or leave to words alone, the manner of description of the results of the application of the paradigm in the history of an organism.

Notation systems (e.g., Hummel, Kaeck, & Bowes, 1994; Mechner, 1959) have made possible more detailed descriptions of experimental or other sets of contingencies, particularly with reference to operant behavior; however, these notation systems have also left unanswered the questions of how to describe the outcome of the procedures employed.

Graphs and tables summarizing experimental results are useful in capturing the important quantities, but standing alone they do little to show where those quantities belong in the life of the organism. Recent attempts to extend and refine the classification of variables needed in a systematic account (Michael, 1982) have generally not revisited the paradigms in the field, nor have they connected themselves with existing notation systems. Some recent textbooks (e.g., Malott, Whaley, & Malott, 1993) have introduced schematic representations of an organism's state before and after a given behavior. These diagrams help to explicate the detailed structure of contingencies, but do not allow us to describe the effects of those contingencies after they have been applied.

This paper describes a model that permits the visual integration of contingency statements and descriptions of their effects in the life of the organism. It also describes the use of this model

Address correspondence concerning this article (including requests for diagrams showing the application of BID, blank three-phase templates and single BID boxes suitable for making overhead transparencies or for use as exercise handouts) to Drake C. Chisholm, Department of Psychology, Bridgewater State College, Bridgewater, Massachusetts 02325.

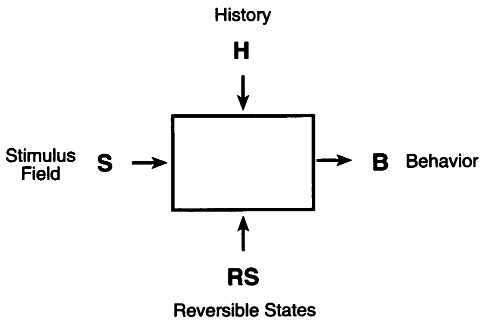

Figure 1. The behavior inventory diagram (BID). The organism is a "black box," which is subject to three inputs: stimulus field (S), reversible states (RS), and history (H). The output, behavior (B), is analyzed in terms of the interplay of the three inputs.

as an active, and even interactive, part of the behavior of students as they learn the basics of a science of behavior.

The key element in the model is the use of a schematic "black box" representing the organism at a moment in time (see Figure 1). We do not say whether the box is to be regarded as empty or not empty. Independent variables are represented by arrows that make "input" to the box. Behavior is represented as an "output" arrow pointing out of the box. The diagram is used as a form whose completion by a student or analyst organizes the description of the state of the organism at any moment in time. As history (biographical, experimental, or clinical) unfolds, new descriptions are necessary, but the diagram forces a parallel organization of the changing information. The model, which we have dubbed the behavior inventory diagram (BID), was developed over many years of teaching courses in psychology, but until recently remained a static diagram. Over the last year, we have modified and extended the BID in a manner that students could use in a number of learning exercises. In this way, the BID came to a new life, no longer merely a diagram on the blackboard that students might (or might not) copy into their notes or reproduce without much thought on exams, but rather in the form of a worksheet handout that could be filled out, handed in, evaluated, and returned to students. It became an organizer of the behavior of students, useful in the process of progressive refinements of basic concepts of the course.

THE BEHAVIOR INVENTORY DIAGRAM

The fundamental element of the BID is the rectangular box, representing the organism at a given point in time. The box has three input arrows and one output arrow, as shown in Figure 1. The inputs are (a) stimulus field, represented by the S input arrow; (b) reversible states, represented by the RS input arrow; and (c) conditioning history, represented by the H input arrow. A single arrow (B) represents the output system and is labeled behavior.

The stimulus field (S-field) represents all stimuli operating at the moment. A full specification of any momentary S-field would include the broad environmental context in which the organism is functioning, including the specific discriminative stimuli, conditioned stimuli, or unconditioned stimuli that are then operative for the organism.

Reversible states may refer to any operational procedure (e.g., deprivation of food, water, sex, etc.) or to the state of the organism said to result from that procedure (e.g., hunger drive, thirst, sex drive). For Skinner (1938) both drives and emotion were seen as states, in that the operation altered the strength of groups of responses, and were also seen as reversible, in that alterations in these states were parameters of the conditioning history taking place, but were not necessarily the source of permanent changes in the state of the organism. More recently, following Michael (1982), behavior analysts may think of reversible states in terms of establishing operations. It is possible to segment this concept further into the motivating condition and motivational level (Malott et al., 1993).

The history input represents the full scope of the organism's effective interactional and conditioning history to date. Such past exposure to pairings, contingencies, and other variables may have resulted in complex combinations of operant and respondent conditioning, whose cumulative impact creates predisposed response sets, building perhaps on innate mechanisms but incorporating exposure to a culture, and to all aspects of resulting conditioning and socialization. What aspect of history will be evident at any given moment will be a result not of history alone but of the current status of both S and RS variables.

One way of formulating the subject matter of the field is to specify the manner in which S, RS, and H interact to result in behavior (B) at any given moment. Exactly how the formulation is made is a blend of what we know at a given state of the science, as refracted through one's theoretical dispositions (resulting, no doubt, from the reinforcement history of the theorist).

Behavior, the single output of the system, is a result derived from and directed by the interaction of the three classes of inputs. Although represented by a single arrow, upon further analysis B can bifurcate into respondent behavior and acts that we see as precursors of operant behavior, described apart from their possible consequences upon the environment. Respondents are mostly localized in smooth muscle, glands, and the autonomic nervous system, and affect the internal state of the organism. Acts, involving striated musculature, may in turn be filtered by an operant layer of contingencies that translate acts, through their consequences in the environment, into operants.

The "state description" of the organism as described above can be filled out by writing the appropriate descriptions on the BID diagram in the four locations provided by the space in the four positions on the sheet. We have used the diagram shown in Figure 1 to introduce and explain the concepts, and then faded to handout sheets in which only the box and the four symbols (S, RS, H, and B) are shown. This gives students plenty of room to write on the four corresponding empty areas of the sheet.

Once students are familiar with the BID, we progress to a form that permits study of the same organism at two points in time, and also includes the description of the intervening procedure that has separated the two moments in the organism's history. This arrangement thus includes a BID at Time 1, a procedure, and a BID at Time 2, as shown in Figure 2. This figure shows the complete model, in which the data from one specific study have been entered by a student. (The issues illustrated by this case will be discussed in the next section.)

In the left panel of the figure the student enters a description of the state of the organism at Time 1 by filling out all four components of that description. In a typical experiment, this description represents the baseline situation at the inception of the experiment. In a clinical analysis, the Time 1 panel may represent the functioning organism prior to a particular traumatic event.

In the center column is entered the increment to the history that is being studied. This may be a detailed description of an intervention or a conditioning procedure; it may be a description of a traumatic event, or it may describe an ongoing process that lasts for a protracted period of time. It may even be a program of contingencies that shift in nature as the behavior evolves under the impact of the contingencies. (The distinction between contingencies and program may be difficult for the beginning student, but it arises quickly in most practical areas.) Any course of skill development may be said to depend upon a program whose contingencies shift at the attainment of each successive stage in the development of the skill.

The procedure section of the sheet is intentionally unstructured. It may be filled in with a purely verbal and in-

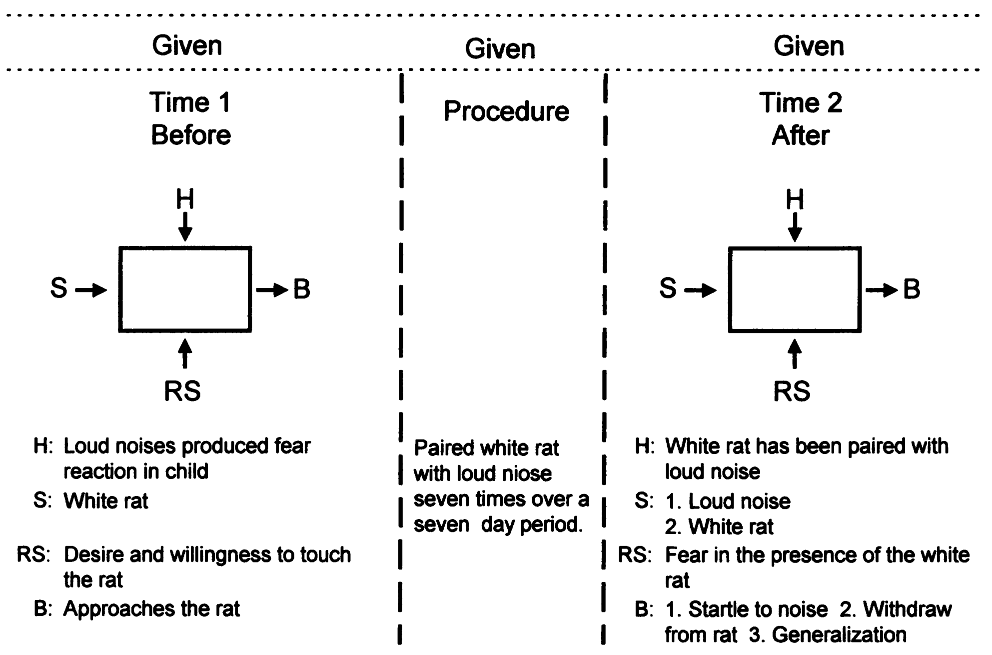

Figure 2. Use of BID to analyze the impact of a specific procedure, conditioning process, or experience on an organism. The organism at Time 1 is subjected to the events in the procedure column, and as a result is a modified organism at Time 2. If all information is known, both the BIDs and the procedure can be filled in. If only some of the information is known, the missing information is predicted, specified, conjectured on the basis of the principles of behavior. The entries in this example are those made by students analyzing the Watson and Raynor (1920) case of "little Albert."

formal description of the critical events and interactions in the life of the organism, or with detailed paradigms; or it may employ a notation system such as Mechner's (1959). Entries in the procedure column should specify the pairings and the contingencies applied, any rules that might describe programmatic shifting of the contingencies, and also the scale of application over time, the number of presentation trials, or description of episodes in which the contingencies prevail.

Into the right panel, representing the state of affairs at Time 2, goes a description of the organism as altered from Time 1 by the experiences and interactions described in the procedure. There are again the same four components (S, RS, H, and B) to describe.

We emphasize that the BID system is atheoretical and will accommodate different perspectives, vocabularies, and formalizations of basic behavioral processes. It can thus serve as a device for shaping the student, from his or her initial uses of the form, in his or her own language, through the successive approximations arranged by the instructor in introducing a theory, vocabulary, or notation system. The BID will serve the instructor who wants to fill the box with short-term memories as they encode themselves into long-term memories, schema as they equilibrate, or expectations as they are violated. It does, however, gently remind all users that the main space for descriptions lies outside the boxes. As for the procedure column, it is again suggested that the teacher let students begin with their own entering vocabulary for describing significant events. These can be gradually shaped to suit the instructor. A specific symbolism for the main contingencies of conditioning can be taught, if desired, using a notation system designed to aid introductory students as described by Hummel et al. (1994). More advanced students may move to the more comprehensive systems (e.g., Mechner, 1959; Schoenfeld et al., 1972; Snapper, Kadden, & Inglis, 1982; Woods, 1974).

INTRODUCING BID IN THE CLASSROOM

Classroom study with the BID should begin with instances in which data are available for completing all components of the diagram. This approach provides discrimination training in the classification of the full range of elements to which the model refers.

In introducing the BID to a class, a short practice use of BID is recommended. We present an example based upon the introduction of the model to a class of 25 students in a behavior modification course at Bridgewater State College. After a brief initial explanation, we divided the class into small groups, handed out BID templates, and asked each group to complete a case analysis of the Watson and Raynor (1920) "little Albert" study described in their texts.

In this account of the conditioning of infant fears, all three components are available; however, the description is presented in a disorganized manner. The student's task is to take an inventory of the events that have been described and to fill in a BID handout with these events and conditions. To do this, the student has to decide how to distribute events among the T1, procedure, and T2 phases, as well as to sort events into history, stimuli, reversible states, and behavior.

The resulting forms were collected, and between class meetings responses were tallied and ranked by frequency of occurrence, and a listing of the responses was placed on an overhead transparency for the next class. A large and interesting variety of ways of completing the analysis was exhibited. As we examined this variety, students voted for the responses that they as a group agreed to keep in each category. Having them vote to keep, delete, or transfer responses to another position (e.g., from T1 to T2 or from RS to B) required an explanation and rationale of many points of analysis. After such an exercise, students can more readily focus on the details describing stimuli, establishing operations, behavior, and history; and they can clearly state relations among T1, the procedure, and the descriptions at T2. Figure 2 shows the form as completed by one group in the exercise, which closely resembled the final version produced after class discussion. The language is that of the students in the group.

In the course of this training, students began to show appropriate use of terms such as *pairing* (as an element in the procedure), *generalization* (in discussing the range of stimulus control in T2), and other terms and concepts. Some unexpected insights arose, such as the statement from one student that "The procedure step is repeated in the description of H at T2, isn't it? Couldn't we say that H2 = H1 + P?"

Even with a relatively straightforward application such as the Albert case, interesting and important ambiguities arose. Is the rat, after conditioning, both a conditioned stimulus (CS) (eliciting fear reflexes) and a discriminative stimulus S^D (in which withdrawal is reinforced)? Does the presentation of the rat by the experimenter create a reversible state, or must the RS be described independently of any stimulus?

Another ambiguity: Without guidance, about half of the students will consider T1 to include the first few trials of conditioning; some even allow the T1 value to drift, resulting in important and misleading changes in the analysis.

Initial training will make possible the effective use of the BID, but the instructor must be prepared to deal with questions generated by students who are trying to make decisions, rather than merely taking notes that can be echoed back on exams in undigested form. Some instructors will welcome the uncertainties that inevitably arise when instruction departs from one-way presentation and rote reproduction.

After experience in the analysis and diagramming of cases in which all three components are known, the instructor can then move to situations in which two components are known and one must be predicted, designed, or inferred. These applications require the student to go beyond sorting and summarizing, and demand the active construction of components of the diagram. We now examine these applications.

APPLICATIONS OF THE MODEL

The model may be used to develop skill in several types of applications. We cover five types. The first of these is a formal restatement of the case we have examined, in which all components are known. The remaining four examples present information regarding two of the three components of the model and ask for the completion of the missing component. For each of these applications we present a typical instance as it might be diagrammed, along with comments on issues germane to that case.

Case analysis. Given that one has complete information about an experiment or an unusually full description of a case history, a detailed and systematic analysis can be undertaken in terms of the three BID components. The Watson and Raynor study (1920; described in Figure 2) illustrates this situation. The basic experiments that describe the functional relations in the field of behavior analysis can all be presented in this manner. Conditioning and extinction, schedules of reinforcement, shaping, chaining, drive and emotion, and other areas can be summarized in terms of key experiments diagrammed according to the three-phase model. In such cases, all three elements are given in the description, and the analytic task is one of representing the information in an appropriate summary in the diagram.

Future prediction analysis. Given a T1 description and information about the procedure, what type of T2 organism will emerge? This is the standard prediction problem, and presumably is the standard exercise in the application of the principles of a science based in the laboratory and summarized in a series of case analyses. As a pedagogical device, a series of diagrams of complete case analyses can be presented on an overhead projector with the T2 column blocked out, with the request that this third component be described by the student. In the example in Figure 3, the outcome could be debated, but the ideal outcome might be described roughly as follows:

H: play and fun with puppy
S: presentation of dogs
RS: absence of fear
B: approach dogs; play with dogs

The likely intent of parents or therapist here is that the small dog will elicit few respondents, and will extinguish effects of past conditioning as it grows and slowly comes to resemble the feared dog. Also, operant processes may take place as the child plays with and trains the new dog. Success may depend on details not specified in a loose description. If the young puppy snaps and bites, the plan may fail and even make matters worse. At critical moments, fear may reemerge if RS values are unusual, such as the child being left alone in a strange setting with the dog.

Analysis of production problems. Often in the areas of education, training, and conditioning, one has a description of a T1 organism and must determine what procedure is needed to bring it to a T2 organism. In this case, T1 and the desired T2 are given, and the analytic task is that of specifying an effective procedure.

A challenging production problem is presented in Figure 4. A likely procedure would be: Establish a discrimination with green light as the S^D and red as the S^Δ. Add a "limited hold" (in which the reinforcing contingency lasts

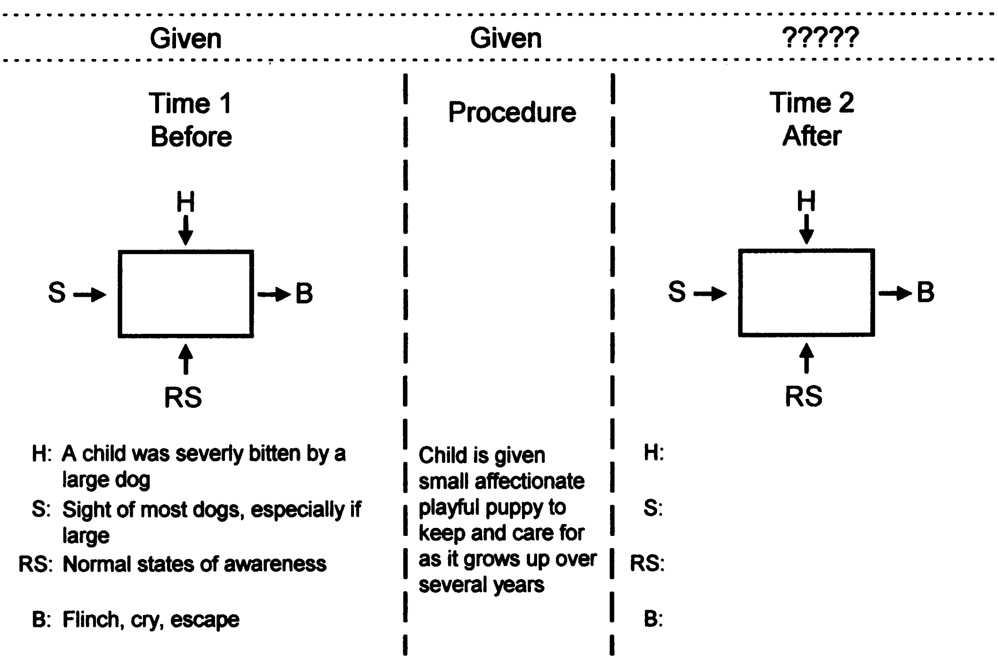

Figure 3. Prediction of outcomes of a procedure. The state of the organism at T1 and the procedure are given, and the outcome at T2 is to be predicted. If the procedure is described in everyday terms, the outcome may be uncertain. In this case, the intent is that interactions with the puppy extinguish fears conditioned to large dogs.

for a brief period of time) to the S^D so the pigeon must peck quickly in green to obtain the reinforcement. Add a punishing time-out for pecking the key when red by turning off houselights for 30 s. Richard Herrnstein is reputed to have prepared such a demonstration and puzzled visiting ethologists such as Tindbergen by demonstrating the final result and asking for an explanation.

This problem illustrates the fact that in more complex cases the relevant procedures are not single contingencies, nor are they even repetitions of contingencies; rather they are "programs" in which the contingencies shift as the behavior of the organism develops. Such procedures will require statements that include a sequence of contingencies, together with the criteria for shifting from one segment of the program to the next. Notation systems that can handle such programs of contingencies may be worth introducing as more complex cases are offered for consideration.

Retrospective analysis. Given a T1 description and a T2 description, what procedures could have occurred to account for these results? Here the problem is not one of designing a procedure that will work, but of guessing at what procedure did in fact produce the results observed at T2.

This type of case is illustrated in the following description: At Time 1, a laboratory rat has been handled by humans until gentle, and has been exposed to laboratory equipment to extinguish fears. It is placed on a feeding rhythm, fed each day for 1 hr (deprivation is 23 hr). Under these condition, the rat actively explores the laboratory equipment during its daily session before feeding. The procedure employed is not described.

At Time 2, when placed in the experimental equipment, the rat climbs ladders, pulls chains, enters boxes, and operates levers, in a repetitive and well-organized sequence, obtaining and eating at the end of each such

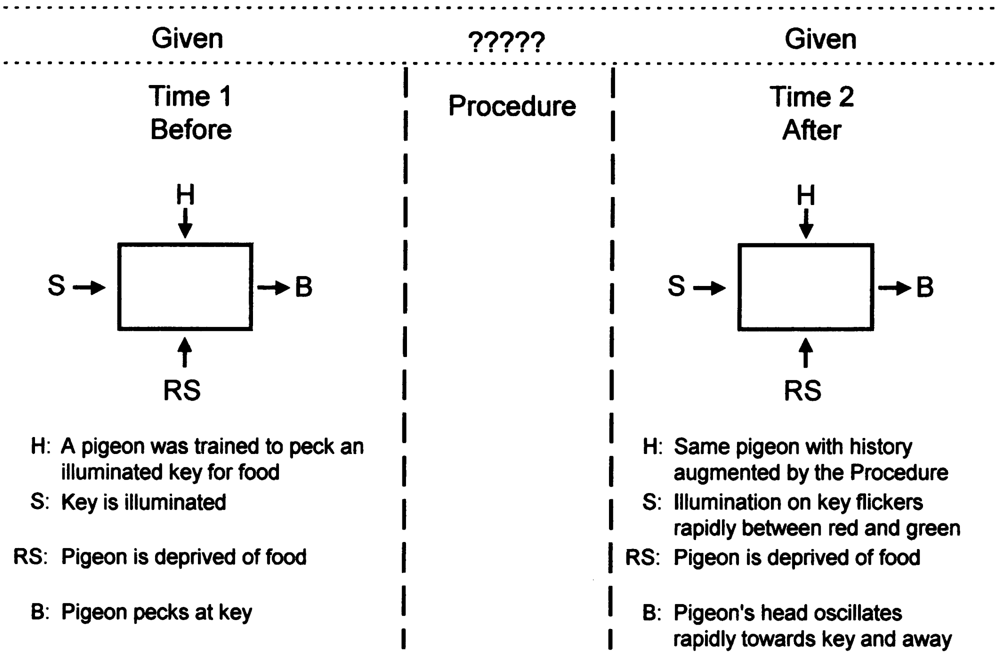

Figure 4. Production problem. The organism at T1 is known, and the desired outcome at T2 is specified. The task is to design a procedure that will successfully produce the outcome. The required procedure may be a complex "program" of procedures that change as early stages successfully produce their effects on the organism's behavior. The pigeon's T2 behavior could be produced by a program of reinforcement for pecking, discrimination of colors, intermittent schedules, limited-hold contingencies, and time-out punishers, with gradually tightening performance criteria.

complex sequence a small amount of food. The situation resembles that shown in Figure 4, in that two state descriptions (at T1 and T2, respectively) are known, and the procedure columns must be filled in. But in this case, rather than specify a procedure that has been judged to be effective and that will be used, the problem is to surmise a procedure that might have been used to produce the already-known T2 situation.

The analyst is thus presented with a given T2 description and must attempt to reconstruct a procedure that is likely to have produced the observed outcome. A plausible procedure must have a sound behavioral basis, but it may not be possible to determine the precise details regarding events that have already transpired. Historical verification may or may not be possible. The complex behavior sequence of the rat almost certainly resulted from backward chaining, in a program of contingencies whose details changed as the animal learned new segments of the final performance and as new segments were added to existing parts of the chain. We cannot reconstruct precise details such as the composition of each segment of the chain, but we can be sure that responses close to reinforcement were established first, then put under discriminative control, with the new S^D used to reinforce a more remote response in the sequence. This procedure is then repeated to add even more remote new links to the chain as it goes backwards. (The "educated" rat described above is now a famous demonstration in many courses.)

Retrospective analysis is a characteristic of many clinical investigations. A special problem often arises when, in the T2 state, the verbal behavior of a human subject includes his or her own accounts of either T1 or the inter-

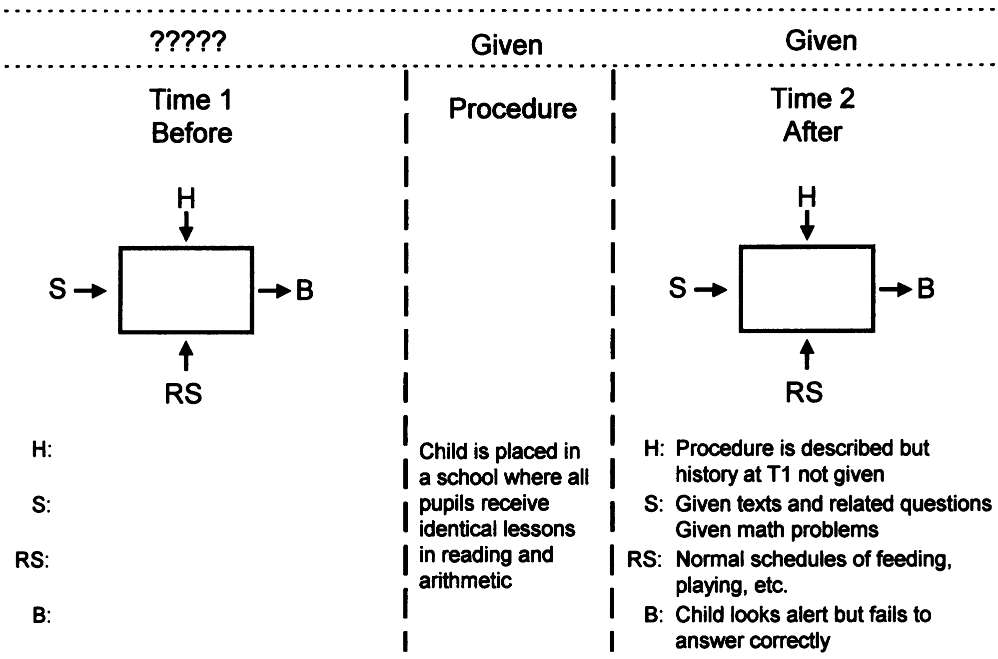

Figure 5. Prerequisites analysis. When a procedure that usually produces standard T2 performances fails to do so, the explanation may be sought in variations in the T1 prerequisites necessary for the procedure to work. But certainty that the correct prerequisites have been identified may be difficult to obtain without follow-up studies with similar organisms.

vening procedures. Should these accounts be taken at face value, or should they be seen as T2 behavior and thus as part of what needs to be explained? Many dilemmas of therapeutic practice, malpractice, and cultish belief systems rest upon varying positions on this issue.

Interesting issues arise when it can be argued that more than one procedure might bring a T1 organism to a T2 state. As an example, an albino rat in a laboratory demonstration may be seen to carry a poker chip in its paws as it walks around the cage. Is this because the chip has been exchanged for drops of water in a chain with a "vending machine," or is it because touching and then carrying the chip has resulted in escape from an aversive flashing light? Are both histories possible? It is possible, by examining the animal's behavior more closely, to improve one's guess as to the likely causal procedure? Retrospective analysis resembles production analysis, except that verification, if any, is historical, and may be evanescent. This stands in sharp contrast to a design approach that can be tested by its fruits.

Prerequisites analysis. Given a T2 description and a description of the procedure, what can you say about the T1 state (environment, events, behavior) of the organism? This is an important kind of problem that has not been given focused attention. For example, the failure of a given instructional system may be ascribed to a lack of the prerequisite skills assumed by the system. If this analysis is correct, the suggested corrective strategy would be to add, to the procedure step, additional history that would generate those skills. Or, in a more sophisticated instructional system, a diagnostic assessment could determine for each learner whether a given prerequisite unit should be assigned. Figure 5 presents a typical problem, in which the search for missing prerequisites is difficult because the absence of expected

TABLE 1

Typical Procedures and Examples in Order of Complexity

Procedure type	Example
One-time application	Traumatic pairing as in war neurosis
Repeated pairings	Pavlovian experiments
Repeated contingencies	Regular reinforcement
Two-phase procedures	Reinforcement followed by extinction
Repeated two-phase procedures	Regular reinforcement followed by extinction in continued alternations (will extinction become more rapid?)
Schedule contingencies	Interval and ratio schedules
Stimulus-shift contingencies	All three-term or discrimination schedules
Shaping contingencies	The differentiation of skilled or complex responses
Adjusting schedules	Interval or ratio patterns adjust to organism's behavior
Programs	Contingencies evolve to later patterns as organism's behavior develops under the earlier contingencies

behavior has many possible causes. The child may not speak the language of instruction, may be deaf, may not have a repertoire of listening skills, or may not have the usual social reinforcers operating. Sometimes family histories, diagnostic tests, or the observation of collateral behavior can help to pinpoint specific deficiencies. For example, a deaf child would exhibit problems and deficiencies in addition to the absence of reading or arithmetic.

Ambiguous cases. In the first of the above applications (case analysis), all three components of the inventory are given, and the problem is one of accurate representation. In the remaining four applications, two components are given, and the problem is one of specifying or surmising the missing element. Ambiguous cases, in which only one element is given, can also arise, but such cases pose great difficulties to the behavior analyst. Problems of social, clinical, and practical importance often consist of situations in which T2 state descriptions are given and constitute problems, either because destructive behavior takes place under inappropriate conditions, or because expected or normative behavior does not occur. The pressing nature of the problem motivates the search for plausible T1 states and histories. Examples of social importance are often controversial and remain unsettled, as with arguments about the locus of poor cognitive performance: What are the responsible variables, when did they operate, and what degree of remediation is possible?

BID AND THE SEQUENCE OF ANALYSIS

In designing a sequence of paradigmatic cases for analysis, at least two organizing principles suggest themselves; these are not, however, mutually exclusive. One is to move from the most empirically grounded sequences, in which complete data for T1 and a well-defined procedure lead to experimentally demonstrated T2 organisms, and later take up the more speculative cases in which earlier history or procedure is missing and must be surmised. The cases above are discussed in the suggested sequence.

But in addition, the nature of the procedures discussed can also be ordered along a different but equally important dimension of complexity. Most textbooks are implicitly or explicitly organized in terms of some pattern of increasingly complex procedures and their effects. An explicit use of BID analyses may assist in organizing the progress of the analysis. A few examples of procedures arranged in order of complexity are shown in Table 1. As students become more sophisticated at the analysis of behavioral processes as expressed in filled-out diagrams, more challenging examples can be presented. For example, schedules containing uncontingent events may be presented, as in analogues to superstition (Morse & Skinner, 1957; Skinner, 1948). Complex cases, containing both contingent and uncontingent events, might be discussed.

Popular sayings may also be worth analysis, beginning with simpler aphorisms, such as "The burnt child fears the flame" and "Once burned, twice shy," and moving on to more complex statements such as Yeats' "Too long a sacrifice may make of the heart a stone."

Operant–respondent overlap can be explored. What is the effect of a reinforced bar press upon the rat's heart rate? Or what is the effect of news that one's application to medical school has been rejected upon the likelihood of smiling or laughing when a joke is told?

Adjunct behavior is also worth diagramming. If two animals in the same cage are on fixed-ratio schedules, when is fighting more likely to take place between them?

In general, when contingencies exist between specified behavior and its consequences, are there effects on other behavior not specified in the contingency? Classic problems of drive, emotion, and other frontier areas can be examined in this manner.

Cultural practices may be worth a look. What supports the custom of placing milk on a cat's paw after moving into a new place of residence? Or of putting a drop of honey on the page when a child is first introduced to books?

It is worth recognizing that some cultural practices may be supported not primarily by their actual effect upon the behavior of the recipient of the practice (the cat or the child in the above examples). Possibly they are rituals, whose support comes from their resemblance to other practices that have been effective, or from the effect of the ritual upon the participants themselves.

ISSUES RAISED BY USE OF THE MODEL

Sustained use of the model over a series of applications will raise a number of issues, as questions about the correct use of the model, or of its adequacy, become questions about a science of behavior. Our experience suggests that these questions are of greatest teaching utility when they arise from students as they work. The instructor might be prepared to discuss the following issues as they arise.

On the specificity of the stimulus field. Can the organism be characterized in its entirety by a single BID? Certainly not, thanks primarily to the specificity of any given S-field as described. If the S contains patriotic music, goose-pimples and singing behavior may be observed; but in the presence of math homework problems, such behavior is unlikely. Thus, a complete characterization of even a rather simple organism at a given time will require many BID sheets, each describing distinctive situations. Because stimuli are not punctate, but are effective within ranges of generalization or even learned equivalence, the problem of stimulus description even on a single sheet is not simple. (A sense of this problem seems to lie behind a common class of criticisms of behaviorism.) How many BID sheets might be necessary to describe, say, Tom Sawyer? Holden Caulfield? Lady Macbeth? We do not know, but questions of this kind might provoke useful discussion.

On the specificity of reversible states. How tied to a given deprivation is behavior originally controlled by that deprivation? We may not usually eat when satiated, but we may shop at the supermarket. The concept of *anticipated deprivation* begins to lose contact with clear establishing operations and seems close to tautology, in that the presumed state is inferred only on the basis of the observed behavior of purchasing food when not hungry. The possibility of generalized reinforcers complicates the issue still further. If one works for money, is it because some fundamental deprivation is present for which money is relevant? Or does a generalized reinforcer exhibit a clear-cut *functional autonomy* (as defined by Woodworth, 1918, and elaborated by Allport, 1937), operating independently of specific RS values? This is a perennial problem in the study of behavior, and the BID model does not solve it. On the contrary, it might serve to raise, early and often, issues of what we know and don't know.

Behavior with stimulus-field attributes. When a pilot flies a plane, the environment consists of not only cloud formations and landscape below, but also the stimulation from an extensive array of instruments. A shopper moving through a supermarket may be consulting a list that may radically change the course of the behavior among the shelves and rows of produce. Because any given BID describes an organism at a moment in time, it does not easily capture the process by which an organism's own behavior becomes part of the S-field for behavior at a subsequent moment. It is important to realize that the environment consists not simply of the physical environment, but also the verbal environment, and sometimes especially stimuli produced by the organism's own behavior. All these are candidates for inclusion in a description of S-fields. Further editions of the BID model may contain additional prompts for these special types of stimuli.

SOME IMPLICATIONS

The teaching of behavior analysis has traditionally relied upon the lecture and the laboratory as the nodal points on an instructional continuum. The typical lecture is barely interactive and there are few economic limits upon class size. In a laboratory course, an instructor or graduate assistant may spend many hours each week processing student reports. Limits to this time are soon reached, but it is in those dozen or more exchanges over the span of an academic year that the science major is shaped.

As enrollments become larger and laboratories disappear, the opportunity to shape refined skills in behavior analysis erodes. The use of the BID as a transactional instructional shaper falls on a continuum somewhere between a laboratory course and an unadorned and noninteractive lecture. The BID offers some of the characteristics of a laboratory course, with opportunities for interaction and shaping, but the number of exchanges possible is limited if enrollment is large. Alternatives exist that make fewer demands on instructor time. One is to present brief cases in class for students to analyze on BID forms on the spot with discussion taking place immediately. A second is to give longer BID assignments for homework, with discussion of analyses in the next class. A third is to form small groups that prepare BID analyses during the class, then present and discuss results in the same class. For such purposes, transparencies of BID forms and overhead projectors are helpful. Transparencies can be developed with all three portions filled out, and by means of selective blacking out of one of the portions (covering the relevant portion of the transparency as remaining sections are projected), the transparency can serve in any or all of the applications described in this paper. In this way a high degree of interactivity can be generated, with respect to a standard stimulus that organizes the basic cause–effect relations in a science of behavior.

FINAL COMMENTS

No element of the BID model is novel. The notion of representation of inputs and outputs by arrows pointing into and out of a black box, in which unknown or unspecified interactions take place, seems to have originated in the study of electrical circuits (Keister, Ritchie, & Washburn, 1951). This type of diagram then migrated in the 1950s into cybernetics and general systems theory (e.g., Ashby, 1956). A relatively early use of similar diagrams in psychology can be found in the writings of Tolman (1941, 1951). It is also employed in Brunswik's volume in the ambitious *International Encyclopedia of Unified Science* (1952).

If the reader notes a heterodox flavor to these citations, that fact is consonant with a point of interest from a teaching perspective: The black box with inputs and outputs is not the consequence of a theoretical position. The black box is not necessarily an empty organism. It is a classifier and a tool for clarification meant for use prior to any theoretical analysis. Any discussion of how the arrows interact, or what can be known or should be known about the interior of the black box, can take place after (not before) the variables we want to study have been specified.

The application of BID to the analysis of behavior is coherent, can be developed gradually as a course progresses, and is useful in organizing vocabulary, concepts, and causal paths. We welcome feedback from users, will use it to improve the BID, and will include such improvements in later reports on the use of the system.

REFERENCES

Allport, G. W. (1937). *Personality: A psychological interpretation.* New York: Holt.

Ashby, W. R. (1956). *Introduction to cybernetics.* New York: John Wiley.

Brunswik, E. (1952). *The conceptual framework of psychology.* In *International encyclopedia of unified science* (Vol. 1, No. 10). Chicago: University of Chicago Press.

Hummel, J. H., Kaeck, D. J., & Bowes, R. L. (1994). Diagramming operant processes. *The ABA Newsletter, 17*(2), 4–5.

Keister, W., Ritchie, A. E., & Washburn, S. H. (1951). *The design of switching circuits.* New York: Van Nostrand.

Keller, F. S., & Schoenfeld, W. N. (1950). *Principles of psychology: A systematic analysis.* New York: Appleton-Century-Crofts.

Malott, R. W., Whaley, D. L., & Malott, M. E. (1993). *Elementary principles of behavior.* Englewood Cliffs, NJ: Prentice-Hall.

Mechner, F. (1959). A notation system for the description of behavioral procedures. *Journal of the Experimental Analysis of Behavior, 2,* 133–150.

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

Morse, W. H., & Skinner, B. F. (1957). A second type of "superstition" in the pigeon. *American Journal of Psychology, 70,* 308–311.

Pavlov, I. P. (1927). *Conditioned reflexes.* London: Oxford University Press.

Schoenfeld, W. N., Cole, B. K., Blaustein, J., Lachter, G. D., Martin, J. M., & Vickery, C. (1972). *Stimulus schedules.* New York: Harper & Row.

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1948). "Superstition" in the pigeon. *Journal of Experimental Psychology, 38,* 168–172.

Snapper, A. G., Kadden, R. M., & Inglis, G. B. (1982). State notation of behavioral procedures. *Behavior Research Method and Instrumentation, 14,* 329–342.

Tolman, E. C. (1941). Discrimination vs. learning and the schematic sowbug. *Psychological Review, 48,* 367–382.

Tolman, E. C. (1951). A psychological model. In T. Parsons & E. A. Shils (Eds.), *Toward a general theory of action* (pp. 239–361). Cambridge, MA: Harvard University Press.

Watson, J. B., & Raynor, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology, 3,* 1–14.

Woods, P. J. (1974). A taxonomy of instrumental conditioning. *American Psychologist, 29,* 584–597.

Woodworth, R. S. (1918). *Dynamic psychology.* New York: Columbia University Press.