

Logic, Reasoning, and Verbal Behavior

Dudley J. Terrell
Anacapa Sciences, Inc.

J. M. Johnston
Auburn University

This paper analyzes the traditional concepts of logic and reasoning from the perspective of radical behaviorism and in the terms of Skinner's treatment of verbal behavior. The topics covered in this analysis include the proposition, premises and conclusions, logicity and rules, and deductive and inductive reasoning.

Key words: verbal behavior, reasoning, logic, induction, deduction, proposition

Skinner outlined a conceptual framework for the experimental analysis of verbal behavior in 1957 with the publication of his book *Verbal Behavior*. Experimental research based explicitly on this framework has emerged only in recent years, however. This sparse body of work has included research on the verbal operant classes of mands and tacts (Hall & Chase, 1986; Lamarre & Holland, 1985; Simac & Bucher, 1980), echoics (Boe & Winokur, 1978a, 1978b; Neville, 1968), and intraverbals (Braam & Poling, 1983; Chase, Johnson, & Sulzer-Azaroff, 1985; Poon & Butler, 1972). In addition, research on the independence of speaking and listening (Lee, 1981) and on self-editing (Hyten & Chase, 1986) has been based on Skinner's work. This conceptual framework has also been utilized in analyses of verbal discourse in group psychotherapy (McLeish & Martin, 1975), maladaptive verbal behavior of the psychotherapy client (Glenn, 1983), auditory hallucinations (Burns, Heiby, & Sharp, 1983), and instructional design (Johnson & Chase, 1981).

Skinner devoted a chapter of his book to an analysis of logical and scientific verbal behavior (Skinner, 1957, chap. 18), and this general analysis has been eluci-

dated by Creel (1987) and Schnaitter (1980). Human logicity and reasoning have been topics of investigation in psychology for decades (for reviews, see Evans, 1982; Falmagne, 1975; Revlin & Mayer, 1978; Wason & Johnson-Laird, 1968). To the degree that logic and reasoning involve verbal behavior, both interpretative and experimental analyses based on Skinner's framework are therefore appropriate. In the present paper, the concepts of logic and reasoning are analyzed in this conceptual context in order to facilitate experimental treatments of these topics. First, the concept of proposition is described and interpreted in behavioral terms. Then, premises and conclusions, rules of logic, deductive reasoning, and inductive reasoning are analyzed as verbal behavior.

THE PROPOSITION

The proposition is a basic component of logic and reasoning. The proposition has traditionally been conceptualized in the following manner. There are acts in which one may engage that require some sort of object for their execution. These acts are depicted by the transitive verbs. For example, in order to *hit*, there must be *something* to hit. This something, the object of the action, is depicted by the accusative of the transitive verb. Some transitive verbs depict what have customarily been called acts of thinking (e.g., to know, believe, or assume). To know,

The authors would like to thank Bill Buskist, Peter Harzem, and Jorge de Oliveira-Castro for their helpful comments on an earlier draft of this paper. Requests for reprints should be sent to Dudley J. Terrell, P.O. Box 489, Fort Rucker, AL 36362.

believe, or assume requires knowing, believing, or assuming something. These somethings, the accusatives of the acts of thinking, have come to be called propositions by logicians. In other words, a proposition is what it is that one can know, believe, think, judge, assume, opine, and so on (Ryle, 1971). When people state or express what it is that they know, think, or assume, they have emitted behavior that can be analyzed in Skinner's framework (1957). The remainder of this section reinterprets the traditional concept of the proposition from this viewpoint.

To begin this analysis, it is important to consider the behavior-environment relation that Skinner called the tact (1957, chap. 5) because it will later be shown that tacts and propositions are closely related. A particular form of verbal response is consistently reinforced in the presence of a particular object or event (e.g., a ball) or a property of an object or event (e.g., its roundness). If the object or event controls the response, it is typically called a pure tact. If some property of the object or event controls the response, it is called an abstract tact. Therefore, any given object may evoke several verbal responses, some that are pure tacts and others that are abstract tacts controlled by the object's properties.

Rather than simply emitting the different forms of tacts separately (e.g., "ball," "round"), an additional response is often emitted that connects the tacts (e.g., "The ball *is* round"). Skinner called this additional response, "is," the assertive autoclitic and stated that its function is to enjoin the listener to "accept a given state of affairs" (1957, p. 326). One might say that the roundness of the ball is the state of affairs asserted by the speaker. It may be more useful to consider that the proposition, "The ball is round," tacts a relation between the pure and abstract tacts "ball" and "round." It is not the roundness of the ball that evokes the entire response, "The ball is round." It is the *relations* between objects and each of their properties, as well as the respective tacts controlled by them, that evoke the utterance of propositions. This is essentially what Skinner proposed in his dis-

cussion of predication (1957, pp. 334-335).

The concept of tact relates verbal behavior to nonverbal characteristics of the environment (e.g., objects and properties of objects). A substantial portion of the human environment, however, includes verbal stimuli (e.g., the verbal behavior of other individuals). Verbal behavior related to these aspects of the environment is called intraverbal (see Skinner, 1957, pp. 71-78). Sometimes, subjects and predicates of propositions may be related to the environment as intraverbals, rather than as tacts. The emission of such a response tacts the relation between the intraverbals and their stimulating circumstance (e.g., "'John' is a proper noun").

Finally, it is not unusual for the proposition to include a quantifying autoclitic (see Skinner, 1957, pp. 329-330). Under certain circumstances, the tact "swan" becomes "the swan" or "a swan." Other circumstances may evoke the responses "some swans," "all swans," or "no swans." Skinner asserted that, as autoclitic components, these responses do not modify the subject of the proposition. Instead, their effect is to modify the reaction of the listener to the responses they accompany. "All" is "more appropriately taken as equivalent to *always* or *always it is possible to say*" (Skinner, 1957, p. 329). Schoenfeld (1969) has noted a similarity between the universal proposition (e.g., "All swans are white") and the behavioral tendency toward generalization. Such a response cannot possibly be under the control of all the swans in the universe. Yet, enough exposure to reinforcing consequences in the presence of variations of stimulus conditions may result in highly generalized stimulus control. The universal proposition tacts the relation between stimuli, responses, and generalization of stimulus control.

In summary, the proposition is a complex verbal response that comprises tacts or intraverbals modified by particular autoclitics, such as "is," "all," or "some." As a unit of behavior, the proposition functions as a tact in that it is controlled by the objects of simple tacts or intraverbals and the relations between verbal

behavior and its environmental control. In other words, when we say, "The ball is round," we tact not only the ball and its roundness, but our tendency to predicate roundness to the ball (Skinner, 1957, pp. 334–335).

Having described the speaker's verbal behavior involved in uttering a proposition, we may now examine the effects of such behavior on a listener. If behavior produces reinforcing consequences, we may say that it is *effective*. Responses producing consequences that reduce the likelihood of future occurrences of a response class may be considered *ineffective*. This argument is analogous to the adaptiveness of characteristics exhibited during the evolution of a species (Skinner, 1984a). The verbal utterance of a proposition may or not produce reinforcing consequences. The emission of a proposition may be reinforced when a listener *accepts* or *believes* it. According to Skinner, "Our belief in what someone tells us is . . . a function of, or identical with, our tendency to act upon the verbal stimuli which he provides" (1957, p. 160). Therefore, the utterance of a proposition may be effective (i.e., accepted or believed by a listener) regardless of its correspondence to any state of affairs. Likewise, an utterance may be ineffective (i.e., rejected or ignored by a listener) regardless of its truth.

Additionally, the listener's behavior in response to the proposition may also be classified as effective or ineffective. Again, behavior that produces reinforcement is considered effective. Whether the behavior of accepting or rejecting a proposition produces reinforcing consequences may have something to do with the "truth" of the statement. Skinner stated that "a proposition is true to the extent that with its help the listener responds effectively to the situation it describes" (1974, p. 235). This statement applies to tacts in general. Again, according to Skinner, "behavior in the form of the tact works for the benefit of the listener by extending his contact with the environment, and such behavior is set up in the verbal community for this reason" (1957, p. 85).

In summary, the utterance of a proposition has been defined as effective in

two ways. First, if the listener accepts or acts upon the proposition as a verbal stimulus, it has been effective. Second, if the behavior of accepting it produces reinforcing consequences for the listener, the proposition is again effective. A precise definition of truth as an epistemological issue is not required by a behavioristic analysis of the utterance of propositions. According to Zuriff (1980):

Because of a specific phylogenetic and cultural history, humans have evolved so that they are affected in certain ways by verbal behavior, that is they believe certain verbal behavior to be true. For the most part they do so without applying any explicit criteria of truth. (p. 348).

Exactly how and why any given proposition comes to be accepted as true by a listener is a problem for empirical psychology (Popper, 1959).

REASONING

Premises and Conclusions

If a listener's behavior of accepting a proposition reinforces a speaker's behavior, the speaker may respond in ways that will increase the probability of that reinforcing consequence. This supplementary behavior may be considered verbal to the extent that it is also reinforced by the listener's response. For example, a speaker may increase the probability of a listener accepting a proposition (i.e., reinforcing the speaker's behavior) by emitting other propositions that are more readily accepted by the listener. In the traditional language of logicians, these more readily accepted propositions are called premises, and the proposition whose acceptability is subsequently enhanced is called the conclusion. The acceptance of the premises is assumed to be at a greater strength in the listener's behavioral repertoire than the acceptance of the unpremissed conclusions. In some cases, the speaker may preface the premises with the mand "Suppose that . . ." This utterance may then facilitate the acceptance of the conclusion.

In colloquial language, the speaker is attempting to prove a point, support a conclusion, or convince the listener of a proposition's truth, viability, or possibility. For example, a prosecutor may as-

sert or propose that a defendant is guilty of some crime. The acceptance of this proposition by the members of a jury will be reinforcing to the prosecutor. By itself, the single proposition may have a minimal effect on the jury members' behavior. Therefore, the prosecutor produces other assertions that members of the jury readily accept as true. These assertions essentially describe the "evidence" for the conclusion (e.g., defendant was present at scene of crime; weapon was found in defendant's possession; defendant's alibi is weak, etc.). If these premises have the intended effect on the jury, it is more likely that a verdict of guilty will be returned. Thus, the members of the jury will have accepted the prosecutor's original proposition and probably reinforced that verbal behavior.

The emission of propositions in such a manner constitutes a pattern of verbal behavior that is called *reasoning*. Speakers reason with listeners when they emit verbal behavior that alters the probability of the listener accepting certain propositions. In the previous example, the prosecutor provides reasons for the jury to accept the proposition that the defendant is guilty. Speakers are also said to reason when they emit propositions with higher levels of acceptability (premises) and thereby produce verbal stimuli that facilitate the *emission* of a concluding proposition. Premises may be emitted in spoken or written form and may occur in different orders or sequences. The products of this behavior, the verbal stimuli, may then set the occasion for new propositions to be emitted. We say that conclusions have been drawn or inferred from the premises. Acceptance of conclusions or, rather, effective behavior in response to conclusions may reinforce the pattern of behavior that produced them.

Examples of this kind of behavior are ubiquitous in science. The behavior of the scientific theoretician includes a "set of manipulative responses directed, not at the natural subject matter of the science, but at the verbal record of that subject matter, the data" (Schnaitter, 1980, p. 159). Verbal responses tacting the results of experimental manipulations set

the occasion for the emission of other verbal responses (i.e., conclusions are drawn and theories are proposed). Similarly, some scientists may respond to a number of different theories by emitting a proposition that must be true if the theories (or premises) are true (i.e., a hypothesis). The research scientist then goes on to test this proposition experimentally.

Nonscientific verbal behavior may also involve inferring or drawing conclusions. For example, a salesperson may provide reasons for buying a particular product at a particular time. The reasons may be acceptable to a potential buyer and ultimately occasion the emission of the conclusion, "Now is the time to buy this item."

In summary, a speaker may emit statements in ways that influence a listener's acceptance or emission of other statements. Specifically, the emission of the premises affects the acceptance or emission of conclusions. Two senses of such verbal reasoning have been described in terms of the behavior of speaker and listener. In one sense, a listener's behavior of accepting a conclusion is modified when a speaker emits more readily accepted premises. In another sense, a listener's behavior of emitting a conclusion is modified when premises are emitted in a particular manner. In either case, the speaker and listener may be two (or more) different people or may be the same person. One may "prove" a point to oneself as well as to someone else. Likewise, one may draw one's own inferences, as well as inspire someone else to draw them.

The manner in which premises have such effects on conclusions is the topic of the remaining sections of this paper. After a discussion of rules as descriptions of regularity in patterns of behavior, we will present analyses of the concepts of deductive and inductive reasoning.

Logicity and Rules

The temporal sequence in which events occur may be described as a pattern of events. As a subset of physical events, behavior occurs in temporal sequences or patterns. Some patterns come to be

recognized as regularities or consistencies in nature. Verbal behavior may tact patterns of events in the same way that it tacts single events. Verbal behavior that tacts consistent patterns in nature generally results in statements that are typically called rules. For example, certain forms of verbal behavior described as grammatical are patterns of behavioral regularities with which we are familiar as rules. As verbal responses, rules tact not specific events, but the relationships among the events (i.e., the consistent or regular patterns in which the events occur).

These verbal responses (rules) may originate as descriptions of regularity; however, they may very often become prescriptive by aiding in the verbal control of human behavior. For example, the rules of grammar describe some consistencies in the reinforcement practices of members of a verbal community (Skinner, 1957). These descriptions of reinforcement contingencies do not necessarily affect the events they describe. They are verbal descriptions, not the contingencies themselves. However, the rules may be "helpful in instruction and in maintaining verbal behavior in conformity with the usages of the community" (Skinner, 1984b, p. 585).

It is important to distinguish between rule-governed or rule-following behavior and rule-characterized behavior. Although any given set of responses may be described as corresponding to some rule, the rule, as a description of the contingency, does not necessarily control the behavior. The contingency itself may control the behavior. For example, an individual may be described as speaking grammatically, although the verbal behavior is entirely under the control of the prevailing social contingencies. This behavior may be called rule-corresponding or rule-characterized, but it is not rule-following or rule-governed. On the other hand, the cautious writer or a speaker of a foreign language may consult a rule book, such as a style manual or dictionary, before emitting a statement. Such verbal behavior may be considered rule-following to the extent that the verbal stimuli, the rules, control the behavior;

however, additional control exerted by prevailing social contingencies is not to be understated.

Furthermore, the degree of control exerted by a verbal statement of contingencies may shift in the development and refinement of behavior (Buskist & Miller, 1986; although cf. Hayes, Brownstein, Haas, & Greenway, 1986). An individual learning a second language may first learn the rules of grammar for that language, and for some time those rules may be meticulously consulted before each utterance. Once fluent, however, the speaker usually no longer consults the rules before speaking. Rather, the verbal behavior comes under the control of the foreign verbal community's reinforcement contingencies.

With regard to reasoning, certain consistencies may exist in the way premises might be emitted in altering the probability that a conclusion will be emitted or accepted. Certain patterns or arrangements of premises are more effective than others in facilitating the emission or enhancing the acceptability of conclusions. A description of these consistencies may be stated in terms of the reinforcement practices of a particular verbal community, such as the logical/scientific or the lay verbal community. Furthermore, descriptions of consistencies in reinforcement practices with regard to the emission and acceptance of propositions might be called the rules of logicity.

The rules of logic, sometimes called the rules of deductive inference (which are discussed more extensively in the next section), may be considered a more formalized subset of the rules of logicity. At this point, the rules of logicity may be described as the broad set of verbal responses that tact regularities in patterns of proposition utterances (see examples below). When the emission of propositions corresponds to such rules, the probability of reinforcement (i.e., the acceptance of the conclusion or the emission of an effective conclusion) is maximal. Since arranging and emitting propositions is a verbal process, the rules of logicity may, along with the rules of grammar, be considered a subset of the rules of language (i.e., the descriptions of con-

sistencies and regularities in the general reinforcement practices of a verbal community).

Again, any given set of responses, such as those constituting a logical discourse, may be considered rule-characterized or rule-governed depending on the nature of the controlling variables. A student of logic may consult the rules of deductive inference to draw a conclusion from a set of premises; yet, an experienced logician may derive conclusions from premises much in the same way that the experienced poet thinks in a particular poetic meter (see Skinner, 1957, p. 422). In fact, it seems likely that logical verbal behavior emerges or develops in the normal course of human development under processes similar to those in the development of verbal behavior in general (e.g., Inhelder & Piaget, 1958, 1969).

Deductive Reasoning

In the language of logicians, propositions may be arranged in such a manner that the conclusion is necessarily true given premises that are true. That is, given an arrangement of propositions that may be said to correspond to a particular state of affairs, a concluding proposition can be formulated that also corresponds to the particular state of affairs. The form and arrangements these propositions must take are characterized by the formal rules of logic, sometimes called the rules of deductive inference.

Behavioristically restated, patterns of verbal response forms may consistently produce effective behavior on the part of the listener (i.e., acceptance or emission of effective conclusions). The rules of deductive inference describe the patterns of behavior that have a high probability of reinforcement. As a subset of the rules of logicity, these rules are verbal responses that tact the relations among behavioral events of emitting premises and emitting and accepting conclusions (i.e., verbal reasoning).

To illustrate, consider three ways that logicians describe the relations among propositions: conjunction, disjunction,

and implication. A conjunction is a combination of two propositions. The verbal response "and" functions to connect two responses that may just as easily have been emitted separately (e.g., "It is Friday and I am writing"). The emission of two propositions connected in such a manner constitutes a more complex propositional response, if only for the effect it has on the listener. If a listener accepts any two simple propositions, it is most probable that a conjunctive proposition (i.e., the two simple propositions connected by the response "and") will be accepted. This is the deductive inference rule called conjunction. Alternatively, if a listener accepts a conjunctive proposition, the behavior of emitting any one of the conjuncts will most likely be accepted. This is the rule of simplification.

Two propositions are said to be disjuncted when they are connected by the response "or" (e.g., "Either class has been cancelled, or I'm in the wrong room"). If a disjunctive proposition is accepted as a premise, and if a second premise negating one of the disjuncts is also accepted, it is most probable that a conclusion in the form of the other disjunct will be accepted. This is the rule of disjunctive syllogism. Acceptance of the premises "Class has been cancelled or I'm in the wrong room" and "I'm not in the wrong room" facilitates the acceptance or emission of the conclusion "Class has been cancelled."

Another pattern of behavior is described in the deductive rule called addition. According to the rule of addition, any single true proposition may be disjunctively connected to any other proposition. This pattern of behavior may not occur very often in ordinary discourse. According to Braine, "If p is already established, there is no reason to want to infer the weaker statement, p or q , which suggests doubt about p " (1978, p. 14). It may be true that anyone who accepts the simple proposition will also accept the disjunctive proposition (although it is an empirical issue), but it is unclear what function such a pattern of verbal behavior might have.

An implication is another case of two

simple propositions connected by an additional verbal response. The responses that make this connection take various forms, such as "If . . . , then . . ." or "implies." This kind of proposition may function as a tact of intraverbal relations, such as class inclusion (e.g., "If you have a cat, then you have a pet") or definition (e.g., "If one of the angles is 90 degrees, then it is a right triangle"). It may also tact a contingency (e.g., "If you are late, then I'll leave without you") or a causal relation (e.g., "Combustion implies the presence of oxygen"). If a listener accepts such a proposition, and if the listener further accepts a simple proposition which constitutes the antecedent of the implication, it is most probable that the listener will accept the simple proposition which constitutes the consequent of the implication. This is the rule of *modus ponens*. Acceptance of the proposition that combustion implies oxygen and that combustion is present facilitates the acceptance of the proposition that oxygen is present. Alternatively, if a listener accepts an implication and further accepts a proposition negating the consequent, it is most probable that the listener will accept a conclusion negating the antecedent. This is the rule of *modus tollens*. Acceptance of the premises that combustion implies oxygen and that oxygen is not present will facilitate the acceptance of the conclusion that combustion is not present.

Other rules of deductive inference (e.g., hypothetical syllogism, De Morgan's theorem, exportation) may be described in a similar manner. A person reasons deductively when the emission of propositions corresponds to these formal rules of logic. Again, deductive reasoning is not necessarily an instance of rule-governed behavior. An individual's behavior may be partially under the control of verbal stimuli constituting these rules. "Rules of evidence in a court of law restrict the verbal behavior of witnesses, the rules of chess restrict the movements of the pieces, logical rules have a comparable effect on the logician" (Skinner, 1957, p. 423). Evidence of rule-following is not required. The reasoning is deduc-

tive simply if the behavior can be characterized or described by these rules.

Inductive Reasoning

We have suggested that rules of deductive inference are descriptions of reinforcement contingencies for effective sequences of proposition utterances. Premises can be constructed and arranged in ways that may enhance the acceptability of a conclusion, but that do not correspond to the rules of deductive inference. This kind of verbal behavior may be called inductive reasoning. We do not argue for a functional distinction between inductive and deductive patterns of verbal behavior. The distinction originated in the writings of logicians, but from a behavioral perspective the distinction seems formal or nominal in nature. Behavior is called deductive reasoning simply if it can be related to the rules of deductive inference, whether legitimate or fallacious. Although logicians find the definition of inductive reasoning difficult, behavior is generally labeled as inductive if it leads to conclusions that are only *probably* true. In other words, inductive reasoning is not defined in terms of a set of formal rules. There are consistencies in the patterns of behavior called inductive reasoning, and these consistencies may be described as rules from a behavioristic perspective.

Consider, for example, two of J. S. Mill's (1973/1843) methods of inductive inference. Mill maintained that consistencies exist in the way one discovers and demonstrates causal relations in scientific investigation. If one observes a common variable in several otherwise disparate circumstances, that variable may be inferred to be the cause, or effect, of the phenomenon under investigation. This is Mill's Method of Agreement. If a number of people all exhibit some similar disease symptomatology, and these people have no common history except a deficit of fresh fruit and vegetables in their diet, one might infer that the lack of fresh fruit and vegetables is a cause of their illness.

Mill's Method of Differences may be considered in a similar manner. If an event occurs in the presence of some other event, and never in its absence, one may infer that the two events are causally related. This kind of causality may be more widely accepted as necessary conditionality. Combustion may occur in the presence of oxygen (as well as additional necessary conditions), but never in the absence of it.

Another inductive practice is reasoning by analogy. A number of events, objects, or circumstances are described as having a number of common properties or characteristics. If several of these events, objects, or circumstances have an additional common characteristic, one may infer by analogy that the remaining circumstances also have the additional characteristic. For example, if John, Bob, and Paula are all graduates of the same school and have all attained satisfying careers, and Jane is also a graduate of that school, one may conclude that Jane is likely to attain a satisfying career. This kind of reasoning may be the result of the behavioral phenomenon of stimulus generalization. If verbal responses are reinforced in the presence of a particular discriminative stimulus, other stimuli that have physical characteristics or relations in common with the discriminative stimulus may also control similar verbal responding.

Other patterns of verbal behavior in which premises affect the acceptability of conclusions are described as logical fallacies. It is common for the affirmed consequent of an implication to increase the acceptability of an affirmed antecedent as a conclusion. Logicians call this pattern of discourse *illicit modus ponens*. For instance, "If it rained last night, then the ground will be wet this morning. The ground is wet, therefore it must have rained last night." *Illicit modus tollens*, known as denying the antecedent, is similar. "If it rained last night, then the ground will be wet this morning. It did not rain last night, therefore the ground is not wet."

Although these patterns do not correspond to the rules of deductive inference,

they may occasionally, if not frequently, produce reinforcement (i.e., effective behavior of accepting the conclusion). These patterns of behavior are considered to be cases of fallacious reasoning, although sometimes what superficially appears to be a case of illicit *modus ponens* (or *tollens*) is actually deductively legitimate. For example, denying the antecedent or affirming the consequent of an implication that functions as a definitional tact is deductively valid (e.g., "If 90 degrees, then right angle").

Mill's methods, analogical reasoning, and some of the deductive fallacies are examples of verbal behavior that may have a high probability of reinforcement. The legitimacy of inductively derived conclusions, in terms of correspondence with actual states of affairs, has been an epistemological controversy since the time of Hume (1955/1748). The probability that such conclusions are accepted by a listener and the effects of various propositional manipulations on that probability are empirical issues suitable for experimental psychology.

If some pattern of behavior produces more reinforcement than other patterns, we may expect that pattern to be of greater strength than other patterns in the behavioral repertoire of an individual. The behavior is explained or justified by referring to the reinforcement process that maintains it. To say that deductive reasoning is justified by the rules of deductive inference may mean nothing more than that the behavior is adequately reinforced in the verbal community, and the rules of inference describe the reinforcement contingencies. If patterns of inductive reasoning are similarly maintained by the verbal community, they are similarly justified. We may call this justification psychological rather than logical.

In other words, the psychological justification of behavior lies in an understanding of reinforcement contingencies. The reinforcement contingencies for inductive behavior have been studied in the context of generalization. In fact, "inductive inference" and "induction" are expressions that have been used traditionally to describe the same phenomena

that we now call generalization from experience or stimulus generalization. Consider Mill's observation, "The child, who having burnt his fingers, avoids to thrust them again into the fire, has reasoned or inferred, though he has never thought of the general maxim, Fire burns" (1973/1843, p. 188). Skinner described it in behavioristic language: "The spread of effect to other stimuli is called generalization or induction" (1953, p. 132). Finally, Sidman explicitly stated, "Induction is a behavioral process. . . . Whether or not we make an inductive inference, and the degree of tenacity to which we cling to that inference, will depend upon our behavioral history (experience)" (1960, p. 59).

The patterns of nonverbal behavior that may be called inductive reasoning or inference are the same patterns that are explained in the body of knowledge constituting the science of behavior. Skinner (1957) has proposed that verbal behavior be analyzed in the same manner as nonverbal behavior, and there is no reason to account for verbal inductive reasoning in any other way. The present analysis extends this approach to the deductive patterns that have been the subject of traditional logical investigation.

SUMMARY

An analysis of verbal reasoning and logical verbal behavior begins with an analysis of the proposition. Stating propositions involves emitting verbal responses that are related as tacts to their environmental circumstances and to typical relations between similar circumstances and verbal behavior in general. This kind of verbal behavior may be considered effective if it produces reinforcing consequences, such as acceptance by a listener.

Some propositions may be rendered more acceptable to a listener when they accompany other, more readily acceptable propositions called premises. Verbal reasoning involves altering the probability that conclusions will be accepted or emitted by emitting and manipulating premises. Any consistencies in patterns

of reasoning that have high probabilities of reinforcement may be described by a set of contingencies that might be called the rules of logic. Behavior that corresponds to such rules, but is not necessarily under the control of verbal descriptions of the contingencies, has a high probability of producing reinforcement.

One subset of the rules of logic is the set of rules of deductive inference. Logicians say that correspondence to these rules guarantees the truth of conclusions given the truth of premises. The rules may describe patterns of reasoning that have a high probability of being accepted by a listener. There are no formal rules of inductive inference, but consistencies in patterns of inductive reasoning can be described and related to basic principles of behavior. Consistencies in the reinforcement practices for verbal inductive reasoning remain a topic for behavior analysis.

An experimental analysis of the verbal behavior involved in logic and reasoning may uncover functional relations that will enhance a person's effectiveness with regard to the reinforcing environment. Some of the relevant behavioral issues have already been raised. How does logic develop in the human repertoire? How do propositions develop or emerge from simple tacts and intraverbals? What factors control the acceptance of the premises of a logical discourse? How well do the rules of deductive inference describe the behavioral effects of deductive reasoning? What are the variables that affect the acceptance (or emission) of inductive conclusions? These are only a few of the questions that the science of behavior might address in the study of reasoning and logical verbal behavior.

REFERENCES

- Boe, R., & Winokur, S. (1978a). A procedure for studying echoic control in verbal behavior. *Journal of the Experimental Analysis of Behavior*, *33*, 495-520.
- Boe, R., & Winokur, S. (1978b). Echoic control in conversational speech. *Journal of General Psychology*, *99*, 299-304.
- Braam, S. J., & Polling, A. (1983). Development of intraverbal behavior in mentally retarded individuals through transfer of stimulus control

- procedures: Classification of verbal responses. *Applied Research in Mental Retardation*, 4, 279–302.
- Braine, M. D. S. (1978). On the relation between the natural logic of reasoning and standard logic. *Psychological Review*, 85, 1–21.
- Burns, C. E. S., Heiby, E. M., & Tharp, R. G. (1983). A verbal behavior analysis of auditory hallucinations. *The Behavior Analyst*, 6, 133–143.
- Buskist, W. F., & Miller, H. L. (1986). Interactions between rules and contingencies in the control of human fixed-interval performance. *The Psychological Record*, 36, 109–116.
- Chase, P. N., Johnson, K. R., & Sulzer-Azaroff, B. (1985). Verbal relations within instruction: Are there subclasses of the intraverbal? *Journal of the Experimental Analysis of Behavior*, 43, 301–313.
- Creel, R. (1987). Skinner on science. In S. Modgil & C. Modgil (Eds.), *B. F. Skinner: Consensus and controversy* (pp. 103–111). New York: Falmer.
- Evans, J. St. B. T. (1982). *The psychology of deductive reasoning*. London: Routledge & Kegan Paul.
- Falmagne, R. J. (1975). *Reasoning: Representation and process in children and adults*. Hillsdale, NJ: Lawrence Erlbaum.
- Glenn, S. S. (1983). Maladaptive functional relations in client verbal behavior. *The Behavior Analyst*, 6, 47–56.
- Hall, G. A., & Chase, P. N. (1986, May). *Functional transfer between mands and tacts*. Poster presented at the meeting of the Association for Behavior Analysis, Milwaukee, WI.
- Hayes, S. C., Brownstein, A. J., Haas, J. R., & Greenway, D. E. (1986). Instructions, multiple schedules, and extinction: Distinguishing rule-governed from schedule-controlled behavior. *Journal of the Experimental Analysis of Behavior*, 46, 137–147.
- Hume, D. (1955/1748). *An inquiry concerning human understanding*. New York: Liberal Arts Press.
- Hyten, C., & Chase, P. N. (1986, May). *Experimental analysis of self-editing*. Poster presented at the meeting of the Association for Behavior Analysis, Milwaukee, WI.
- Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York: Basic Books.
- Inhelder, B., & Piaget, J. (1969). *The early growth of logic in the child*. New York: W. W. Norton.
- Johnson, K. R., & Chase, P. N. (1981). Behavior analysis in instructional design: A functional typology of verbal tasks. *The Behavior Analyst*, 4, 103–121.
- Lamarre, J., & Holland, J. G. (1985). The functional independence of mands and tacts. *Journal of the Experimental Analysis of Behavior*, 43, 5–19.
- Lee, V. L. (1981). Prepositional phrases spoken and heard. *Journal of the Experimental Analysis of Behavior*, 35, 227–242.
- McLeish, J., & Martin, J. (1975). Verbal behavior: A review and experimental analysis. *Journal of General Psychology*, 93, 3–66.
- Mill, J. S. (1973/1843). *A system of logic*. In F. F. McRae (Ed.), *Collected works of John Stuart Mill* (Vols. 7 & 8). Toronto: University of Toronto Press.
- Neville, M. H. (1968). Effects of oral and echoic responses in beginning reading. *Journal of Educational Psychology*, 59, 362–369.
- Poon, W., & Butler, K. G. (1972). Evaluation of intraverbal responses in five- to seven-year old children. *Journal of Speech and Hearing Research*, 15, 303–307.
- Popper, K. R. (1959). *The logic of scientific discovery*. New York: Basic Books.
- Revlín, R., & Mayer, R. E. (1978). *Human reasoning*. Washington, DC: V. H. Winston.
- Ryle, G. (1971). *Collected papers* (Vol. 2). London: Hutchinson.
- Schnaitter, R. (1980). Science and verbal behavior. *Behaviorism*, 8, 153–160.
- Schoenfeld, W. N. (1969). J. R. Kantor's *Objective psychology of grammar and Psychology and logic: A retrospective appreciation*. *Journal of the Experimental Analysis of Behavior*, 12, 329–347.
- Sidman, M. (1960). *Tactics of scientific research*. New York: Basic Books.
- Simac, J., & Bucher, B. (1980). Development of spontaneous manding in language deficient children. *Journal of Applied Behavior Analysis*, 13, 523–528.
- Skinner, B. F. (1953). *Science and human behavior*. New York: The Free Press.
- Skinner, B. F. (1957). *Verbal behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Skinner, B. F. (1974). *About behaviorism*. New York: Knopf.
- Skinner, B. F. (1984a). The phylogeny and ontogeny of behavior. *Behavioral and Brain Sciences*, 7, 669–711.
- Skinner, B. F. (1984b). An operant analysis of problem solving. *Behavioral and Brain Sciences*, 7, 583–613.
- Wason, P. C., & Johnson-Laird, P. N. (1968). *Thinking and reasoning*. Middlesex, England: Penguin Books.
- Zuriff, G. E. (1980). Radical behaviorist epistemology. *Psychological Bulletin*, 87, 337–350.