JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1996, 65, 477–492 NUMBER 2 (MARCH)

TOWARD GRANTING LINGUISTIC COMPETENCE TO APES: A REVIEW OF SAVAGE-RUMBAUGH ET AL.'S LANGUAGE COMPREHENSION IN APE AND CHILD[1]

MARK L. SUNDBERG

BEHAVIOR ANALYSTS, INC.

Savage-Rumbaugh et al.'s (1993) monograph describes a study that compared the language comprehension of an 8-year-old ape (a bonobo named Kanzi) with that of a normal 2-year-old human (Alia). The primary purpose of the research was to see if Kanzi could comprehend novel and compound spoken English commands without imitative prompts, contrived reinforcement contingencies, or explicit training procedures. As it turned out, Kanzi acquired a complex comprehension repertoire in a pattern similar to the human child's and even performed better than the human child in many cases. Although this review describes these empirical results favorably, it questions the authors' claim that the subjects learned the repertoire on their own, without reinforcement or training. A close examination of the subjects' histories and of the procedures, transcripts, and videos suggested that the training and testing procedures involved a number of independent variables and processes that were not discussed by the authors, including conditioned reinforcement and punishment, verbal prompts, stimulus control, establishing operations, and extinction. Nonetheless, the methodological and empirical contributions to ape and human language research are substantial and deserve behavior analysts' attention and support. Behavior analysts could contribute to this kind of research by applying the analytic and conceptual tools of behavior analysis in general and the concepts from *Verbal Behavior* (Skinner, 1957) in particular.

Key words: apes, verbal comprehension, verbal behavior, novel behavior, nonhuman verbal behavior

People have always been fascinated with the possibility of "talking with the animals." Many have observed that their pets seem to understand language, and others claim that theirs can actually talk. However, the scientific community has been less willing to grant nonhumans the ability to comprehend and emit language (e.g., Chomsky, 1988; Pinker, 1994; Terrace, 1979a). The recently published monograph, *Language Comprehension in Ape and Child,* by Savage-Rumbaugh et al. (1993), presents a research project designed to provide further evidence to the scientific community that "apes have a heretofore unrecognized capacity for language" (p. 110).

The monograph contains 7 chapters and an Appendix consisting of transcripts of interactions between the 2 subjects and the experimenters. The monograph ends with a commentary by Elizabeth Bates and a reply by Savage-Rumbaugh. In chapter 1 the authors point out that the current study is part of an ongoing research project started in 1972 by Duane Rumbaugh. Rumbaugh's pioneering work in this area has been a cornerstone of ape language research. His success with the chimpanzee Lana (Rumbaugh, 1977; Rumbaugh, Gill, & von Glasersfeld, 1973) and the computerized lexical communication system (Rumbaugh, von Glasersfeld, et al., 1973) started a long and productive line of ape language research. Duane Rumbaugh, along with Sue Savage-Rumbaugh, continues to make important discoveries regarding ape language, as demonstrated by the current monograph.

The Rumbaughs' research has also led to a number of important human applications. For example, their work has been instrumental in the successful development of symbol and picture communication systems for nonverbal humans. Many aspects of their research, such as the lexical system, the specific training procedures, and the data collection systems, have benefited this human population (e.g., Sevcik, Romski, & Wilkenson, 1991). In addition, the Rumbaughs' lexical system provides perhaps the most refined ex-

[1] Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R. A., Brakke, K. E., Williams, S. L., & Rumbaugh, D. M. (1993). Language comprehension in ape and child. *Monographs for the Society for Research in Child Development, 58,* 1–256.

I thank Genae Hall, Jack Michael, David Palmer, James Partington, and Cindy Sundberg for their comments on an earlier version of this manuscript.

Correspondence and reprint requests should be addressed to the author, Behavior Analysts, Inc., 888 Podva Rd., Danville, California 94626.

ample of what Michael (1985) has identified as selection-based verbal behavior. This type of verbal behavior, and its distinction from topography-based verbal behavior, has several important implications for speech pathologists and for those attempting to teach verbal behavior to nonverbal humans (Shafer, 1993).

The Rumbaughs' primary interest with this research has been to demonstrate that humans' biological kinship to apes carries over to complex learning, specifically language. The Rumbaughs have long campaigned for granting linguistic competence to the ape. However, as the authors point out in the abstract of the monograph, this position is controversial and is often met with skepticism because "popular theories of human language acquisition suggest that the ability to process syntactic information is unique to humans and reflects a novel biological adaptation not seen in other animals" (p. v). Furthermore, "claims of cognitive contiguity between ape and human still evoke in many scientists a quick reaction of disgust, as if humankind in general is not yet comfortable with the image of itself being part ape" (p. 2).

Chapter 1 also contains an excellent historical review of the major developments in ape language research. The authors point out that this long line of research began some time ago with the work of Furness (1916). However, the first several attempts to teach language to apes failed because of the researchers' focus on developing vocal speech as the response form (Furness, 1916; Hayes & Hayes, 1951; Kellogg & Kellogg, 1933). It was the success of Gardner and Gardner (1969) in teaching sign language to Washoe that turned the focus of ape language research to the use of nonvocal response forms. This work initiated a productive line of research on nonhuman verbal behavior and led to the widespread use of sign language with nonverbal humans (e.g., Fristoe & Lloyd, 1977). Following the breakthrough by the Gardners, a number of other researchers reported success in teaching sign language to apes (e.g., Fouts, 1973; Patterson & Linden, 1981). In addition, other researchers successfully demonstrated that apes could acquire linguistic skills by using symbols on plastic chips (Premack, 1970) and lexigrams on computer keys (Rumbaugh, Gill, & von Glasersfeld, 1973).

These early studies were followed by a number of replications and extensions. Each new project advanced both the training procedures and the apes' ability to acquire more complex verbal behavior (e.g., Fouts, Fouts, & Schoenfeld, 1984; Gardner & Gardner, 1971; Premack, 1976; Rumbaugh, 1977; Savage-Rumbaugh, 1984). This line of research drew a substantial amount of attention, and, as one might expect, controversy as well. Traditional linguists such as Chomsky (1988) argued strongly against an ape's ability to acquire language. Cognitive psychologists questioned the results (e.g., Thompson & Church, 1980), as did others (Terrace, 1979a, 1979b; Terrace, Pettito, Sanders, & Bever, 1979; Terrace, Straub, Bever, & Seidenberg, 1977). These criticisms led to a number of additional research projects, including the one presented in the current monograph.

Chapters 2 through 4 clearly establish the authors' theoretical position as primarily cognitivist, with appeals to abstractly specified physiological mechanisms. In these chapters the authors present their views on a number of topics, including child language acquisition, comprehension versus production, and language as innate versus learned. Despite their initial emphasis on the environment (p. 1), the authors repeatedly attribute the causes of language acquisition to cognitive processors and neural networks; environmental variables are assigned only minor status and are always overshadowed by cognitive mediators (e.g., processing, planning, mapping, strategizing). These cognitive mediators are then used to explain the emergence of new behavior. It is also in these 3 chapters that the authors argue that learning occurs "without rewards" and "without the arrangement of specific training contingencies." These arguments are later used to support the authors' position that their subjects' behavior was due to cognitive and physiological variables rather than environmental variables.

The primary research project is presented in chapters 5 through 7. The study addresses several of the criticisms leveled against ape language research by other language researchers (e.g., Terrace et al., 1979). Specifically, the current project was designed to (a) demonstrate that an ape could comprehend

novel and compound spoken English commands (b) without visual or imitative prompts or (c) specific training procedures involving contingent reinforcement, and that (d) the ape's acquisition of these linguistic skills occurs in a manner similar to that of a typically developing human child. The project is presented in the standard form of method, results, and discussion, and will be briefly described below.

METHOD

An 8-year-old male bonobo named Kanzi and a typically developing 2-year-old female human named Alia served as subjects. The formal study took place in a laboratory where Kanzi was raised and in a double-wide mobile home 300 feet away where from 3 months of age onward Alia visited each weekday afternoon. The arrangement of the interior of the mobile home was similar to Kanzi's environment, and many of the same daily activities that were conducted with Kanzi were conducted with Alia (e.g., games, eating, watching videos, outings, cleaning). One of the experimenters was Alia's mother, who worked in the morning with Kanzi and in the afternoon with Alia. During both of these periods, Alia's mother (as well as the other experimenters) always used speech and the lexical system while interacting with the 2 subjects. Alia and Kanzi, however, did not interact with each other.

Prior to the current experiment, both subjects had extensive histories with the experimenters, spoken English, and the lexical system. Alia was exposed to the lexigrams beginning at 3 months of age, and Kanzi was exposed to human speech and the lexigrams beginning at 6 months of age. Kanzi accompanied his mother, Matata, while she was receiving training on the lexical system. Sessions were frequently conducted in the forest surrounding the area, as well as in other places around the compound. During Matata's training, caretakers typically talked to Kanzi in natural English and pointed to lexigrams as they spoke; however, no specific training was provided for Kanzi. Matata failed to acquire the symbols, but Kanzi excelled, and by 5 years of age he was producing multiple responses in correct English word order (Savage-Rumbaugh, 1990). Kanzi learned so fast that the authors state that "more than any previous ape, the nature and the scope of Kanzi's language acquisition has paralleled that of the human child" (Savage-Rumbaugh et al., 1993, p. 12).

Kanzi spent each day with one or more human caretakers (experimenters) who treated him much like a typical human child. As a result, Kanzi, like Alia, became "accustomed to cooperating with [the experimenters] on a daily basis, and the experimenters were accustomed to determining their moods and facilitating a cooperative attitude" (p. 49). The caretakers also took Kanzi and the lexigam board several places, including the forest, where

> Kanzi could find food at many predictable locations, just as he might in the wild. These locations were replenished daily. Kanzi's caretakers always attempted to do things that were of interest to him and talk to him in a natural manner. They also carried with them a large symbol board and pointed to symbols as they spoke to Kanzi. If the words that they were saying were not on the symbol board, they simply continued talking without pointing to any symbols. (Indoors, Kanzi's symbol board was attached to a speech synthesizer so that he could "talk" aloud by pressing the symbols.) Kanzi spent a great deal of time outdoors during the warm months of the year, traveling and playing in the woods. In the winter, he played with toys, painted, helped cook, watched television, visited people in the other indoor parts of the building, played with the other apes at the facility, and even traveled by car (to keep warm) through the woods. All of these activities were accompanied by language in a way that seemed natural to the caretakers. (p. 46)

Testing Procedures

The dependent variable in the formal study consisted of the subjects' response to 660 different verbal instructions. The instructions consisted of a series of novel, and often odd, spoken multiple commands (e.g., *Pour the water on the vacuum*). Prior to the presentation of the multiple commands, both subjects were tested to ensure that they could comprehend the individual words to be used in the sentences. There were 13 different types of verbal commands that generally increased in complexity as the experiment progressed (e.g., from *Turn the vacuum on* to *Go get some cereal and give it to Rose*).

There were two phases of the study: nonblind trials (Trials 1–180 for Alia and Trials 1–244 for Kanzi) and blind trials (Trials 181–660 for Alia and Trials 245–660 for Kanzi). During the nonblind trials the experimenter presented the subjects with an array of nonverbal stimuli and a verbal command such as *Put the pine needles in the backpack.* During the blind trials the experimenter presented similar stimuli and verbal commands but was positioned out of the subject's sight. During many of the blind trials, the human recipients of specific actions wore radio headphones, so they could not hear what Kanzi or Alia were told to do by the experimenter (e.g., *Give Liz a shot*), thus ensuring that humans were not inadvertently providing prompts to the subjects.

Correct responses were specifically not followed by the delivery of food for both blind and nonblind trials. Incorrect responses were followed by a correction procedure that consisted of repeating the command, varying specific words, and providing verbal praise and reprimands. Most of the trials were videotaped, and a scoring system was employed to record correct, partially correct, and incorrect responses. After the experiment was completed, a more complex scoring system was developed to score the responses from videotape. These scores, and the complete transcripts of the interactions between the experimenter and subjects, are presented in the Appendix.

RESULTS

The results showed that Kanzi not only acquired a complex comprehension repertoire but acquired it in a pattern similar to that of a typically developing human child, and in many cases outperformed the human child. Kanzi was correct on 72% of the total trials (nonblind and blind), and Alia was correct on 66% of the total trials. The transition to blind trials, during which the speaker was out of the subject's sight, initially resulted in poor responding and confusion for both subjects, but they quickly improved. Over the whole set of blind trials, Kanzi was correct on 74% of the trials, and Alia was correct on 65% of the trials.

DISCUSSION

The results clearly demonstrate that an ape and a child can correctly respond to a wide variety of novel and complex verbal instructions. In addition, the results of the blind condition show that these responses were not a function of imitative or visual prompts that were inadvertently emitted by the experimenters, as suggested by Terrace et al. (1979). However, the issue of how Kanzi and Alia acquired this linguistic behavior has not been answered by the data. The authors propose that these novel responses emerged, as in humans, not as a function of reinforcement or specific training but rather as a function of the ape's human-like cognitive and abstractly specified physiological characteristics. The authors conclude that "the lack of contingent reward, the novel nature of the requests, the absence of previous training to perform these specific requests, and the unique nature of each trial countermand simple explanations that depend on the conditioning of responses" (p. 98).

When faced with the question of how Kanzi came to understand the complexities and nuances of human speech, when apes generally do not, the authors state that "the answer is to be found in how the neural networks of a highly complex and relatively plastic brain . . . become organized . . . during infancy and early development" (p. 103), and that the subjects learned these comprehension skills because they observed "competent speaking models and began to decode the speech signal into its components as well as assign meaning to those components" (p. 102). As a result of these views, the authors conclude that although "psychologists historically have emphasized the role of reinforcement as regards learning, we suggest that observation and perceptual learning processes are far more important to the infant for the learning of complex systems such as language" (pp. 103–104).

The book includes a commentary by Elizabeth Bates, whose primary focus concerns the issue of comprehension and its relation to verbal production. Bates is largely supportive of the authors' work and concludes that she is convinced that "the bonobo . . . is capable of language comprehension that approximates . . . the abilities of a human 2-year-

old" (p. 223). Bates presents an interesting overview of the research on comprehension, and the current methods for assessing its development in human children. She frequently compares these findings with those of Savage-Rumbaugh et al. and suggests several possibilities for additional research with both humans and apes. Bates also points out the many ways in which comprehension differs from production and searches for a biological explanation of these differences. She concludes her commentary by pointing out the general difficulty of giving up the notion that apes and humans are similar and recommends that it is time to learn to live with these similarities.

In the reply to Bates, Savage-Rumbaugh discusses some new techniques currently being developed with apes to assess comprehension. Savage-Rumbaugh suggests that these new techniques will "provide an increasingly sophisticated understanding of the behavioral and neurological relation between man and ape" (p. 244). Savage-Rumbaugh then goes on to discuss the discrepancy between Kanzi's comprehension and production repertoires. She takes issue with Bates's proposal that this dichotomy is related to differences in the brain's right and left hemispheres and proposes that "the productive-receptive discrepancy itself results from a more basic dichotomy, one that characterizes many activities in addition to language" (p. 244). The remainder of the reply primarily focuses on, like Bates's commentary, a search for biological explanations of the differences between comprehension and production.

A BEHAVIORAL INTERPRETATION OF THE DATA

The authors' primary objective for their study was to demonstrate that an ape could acquire language comprehension in a manner similar to that of a human child. That objective was accomplished; however, the authors' analysis of the variables responsible for this acquisition can be questioned. The authors take the position of traditional psychology and attribute the causes of the learning to cognitive and physiological variables while deemphasizing the role of the environment. However, there are a number of possible environmental variables that have not been identified and methodologically controlled by the authors. These variables will be identified here, and four major issues raised in the monograph will be addressed: (a) performing without rewards, (b) providing no specific training, (c) novel verbal stimuli evoking novel responses, and (d) the relation between verbal comprehension and verbal production.

Performing Without Rewards

A major theme emphasized throughout the monograph and in the recorded presentation of this work at the 1994 Association for Behavior Analysis (ABA) convention (Savage-Rumbaugh, 1994)[2] was that the subjects acquired the targeted behavior without contingent reinforcement. The authors wanted to eliminate reinforcement as a causal variable so they could argue that the ape's acquisition of language comprehension was more like that of an "untrained" human child rather than that of a "trained animal." (The prevailing psycholinguistic view, of course, is that human children acquire language comprehension without reinforcement.) In addition, by ruling out reinforcement, the authors argue that human-like cognitive and physiological variables are responsible for the ape's emerged behavior.

The authors' procedure to control for reinforcement consisted of not following correct responses with food. When acquisition still occurred, the authors concluded that reinforcement was not essential for acquisition and that their subjects learned the behavior "on their own." The authors then criticized other language researchers (Herman, 1987; Schusterman & Krieger, 1986) for using food reinforcement, implying that reinforcement produced a less significant type of learning. The following passage demonstrates the authors' position.

> Both Alia and Kanzi observed competent speaking models and began to decode the speech symbol into its components as well as assign meaning to these components on their own. By contrast, the dolphins and sea lions were taught to perform specific actions on

[2] Savage-Rumbaugh, E. S. (1994, May). *Language work with apes and the co-construction of meaning.* Paper presented at the meeting of the Association for Behavior Analysis, Atlanta, GA.

> specific objects and were rewarded with fish for doing so. The "sentences" to be comprehended were broken down into word units, and the dolphins were repeatedly rewarded for carrying out individual commands . . . until [they] could perform them without error. (p. 102)

Although it is perhaps true that the subjects in the Savage Rumbaugh et al. study acquired the behavior without contingent edible reinforcement, it is unlikely that reinforcement was irrelevant to the acquisition of the behavior. The problem lies in the authors' interpretation of Skinner's principle of reinforcement and its relation to other behavioral principles. In the monograph under discussion here, the authors restrict their definition of reinforcement to the programmed delivery of edible items following the targeted behavior. However, Skinner defined reinforcement as any thing or event that follows behavior and increases the frequency of the behavior. In addition, reinforcement can occur without the knowledge of the giver or receiver. That is, reinforcement is not always a programmed event, but is something that often occurs unplanned in the natural environment.

Many nonedible forms of reinforcement were apparent in both the transcripts in the Appendix and in the videos of Kanzi. For example, some of these other possible forms of reinforcement for the bonobo and the child could have included smiles, eye contact, praise, games, physical contact, verbal contact, manipulation of objects, and a fully attentive audience. Humans (i.e., the experimenters) may have also delivered reinforcement by unlocking doors, opening packages, starting cars, removing aversives, providing assistance, and so on. Adult humans not only implemented these important daily contingencies but were paired with them as well. Thus, certain humans, human vocal behavior, and even the symbols may have also become forms of generalized conditioned reinforcement (e.g., the appearance of Alia's mother at the door probably strengthened some behavior).

In addition to these other types of reinforcement, a close look at the subjects' history and their daily contact with humans reveals the possibility that other behavioral principles and operations were also relevant to the behavior that emerged. For example, humans extinguished behavior by not attending to it. Humans punished behavior by reprimanding, frowning, scowling, removing reinforcers, and preventing access to reinforcers. Also, the ape, like the child, was probably affected by a number of establishing operations (operations that potentiate reinforcers) occurring on a moment-to-moment basis throughout each day (Michael, 1982, 1993), and humans provided specific reinforcement (as most parents do) by both delivering reinforcers and removing aversives. As a result of the daily contact with these contingencies, it is also likely that specific humans, human vocal behavior, and the symbols acquired effective stimulus control over behavior and established a number of different types of functional equivalence relations (e.g., Dougher, 1994; Hall & Chase, 1991).

It is interesting to note that Moerk (1992) discovered similar omissions in Brown's (1973) well-known analysis of the variables responsible for human language acquisition. Moerk's reanalysis of Brown's transcripts on parent–child interactions revealed that a number of independent variables, such as modeling and corrective feedback, were not accounted for by Brown. Salzinger (1994), in his review of Moerk's work, pointed out that it was Brown's definition of reinforcement as an obvious event delivered contingently on completely correct responses that led him to conclude that reinforcement had little or no effect on language acquisition. However, although Savage-Rumbaugh's disregard of reinforcement effects is inconsistent with relevant facts, this need not undermine their assertions of similarity between language acquisition in apes and humans.

No Specific Training

It was also repeatedly stressed throughout the monograph and in Savage-Rumbaugh's ABA presentation that the subjects acquired the comprehension repertoires without specific training. For example, the authors state in the monograph that "More interesting than the specific lexical items, however, was the way in which the words were learned . . . ape subjects readily acquired the symbols without reward or training" (p. 40). The authors go on to say that "Kanzi learned to comprehend individual spoken words that were of interest to him and to associate these

words with the symbols on the board without any specific training" (p. 46). The authors wanted to eliminate specific training for the same reasons that they wanted to eliminate reinforcement; to argue that the ape's acquisition of language comprehension was a cognitive and physiological process and was more like that of a typical human child than that of a "trained animal."

The "no-training" procedure consisted of having the caretakers simply interact with the subjects in a manner that seemed typical of that of a mother and child interacting during the course of a day, except that they pointed to the symbols as they talked. Although it is true that the "no-training" conditions were very different from the formal training given to the dolphins and sea lions (and perhaps were a procedural improvement), it is unlikely that environmental contingencies were irrelevant to the emergence of the observed behavior. The daily interaction with the subjects in their natural environment, although not considered training by the authors, contained many of the previously identified behavioral contingencies that were probably relevant to acquisition.

For example, in her ABA presentation, Savage-Rumbaugh (1994), although arguing that Kanzi's behavior was acquired without training or programmed reinforcement contingencies, showed a videotape of Kanzi and his caretakers making hamburgers over an open fire in the forest. In making the hamburgers Savage-Rumbaugh said to Kanzi "Put the hamburgers in the pan, no we're not going to eat it, put it in the pan. In the pan! In the pan! . . . No. No, it's not done yet." Then Savage-Rumbaugh (1994) said to the audience "That's how you learn 'in the pan.'" From a behavioral point of view, there is no question that training is occurring by using verbal prompts and conditioned punishers. The fact that training was not systematically programmed is irrelevant to whether processes of reinforcement, punishment, and extinction are involved in the language acquisition that resulted. The focus on these natural environmental contingencies for language training has long been the subject of research in the applied behavioral literature (e.g., Halle, 1987; Hart & Risley, 1975; Warren & Gadzag, 1990).

The formal study was begun after both subjects had long histories of daily contact with these types of natural environmental contingencies. They also had successful histories of following verbal instructions given to them by the experimenters, as would be expected with a typical 2-year-old child, and as demonstrated in pretests with each subject. Therefore, not only did the experimenters have stimulus control over the subjects' behavior, but the comprehension of the individual words was already strong in the subjects' repertoires (i.e., the subjects had already acquired an effective listener repertoire). In addition, many of the independent variables identified above were present during the 660 test trials of the formal experiment, as is revealed by an analysis of the errors and correction procedures presented in the Appendix. These independent variables can be clearly identified in the following description of a correction procedure: After Kanzi failed to correctly respond to Request 522 (*Give me Rose's cereal. Get Rose's cereal. Rose's cereal.*), the experimenter (E), who was out of sight, said to Kanzi

> *Rose's cereal, pick it up, get her cereal. Kanzi get Rose's cereal, Kanzi, Kanzi, go ahead, that's right, Kanzi see Rose's cereal.* (Kanzi seems hesitant to take the cereal that is in Rose's lap since, when he reaches for it, she gives no indication that he is permitted to take it. Finally, Kanzi picks up a box of cereal from the array.) E says, *Kanzi, Rose's cereal, No.* (Kanzi continues to hold the cereal from the array in his foot while eating a banana.) (pp. 179–180)

The interaction, still unsuccessful, continued with the experimenter saying

> *Kanzi get Rose's cereal.* (Kanzi hands Rose the box he has taken from the array.) E says, *Kanzi get Rose's cereal.* (Kanzi points to a box of cereal in Rose's lap.) Rose says *This thing?* [Rose is in the blind condition and does not know what Kanzi was after because she could not hear the verbal stimuli presented to Kanzi.] E says *Yes* speaking to Kanzi. Rose points to the box of cereal repeatedly and looks at Kanzi with a quizzical expression on her face. E says *Pick up. Give me Rose's cereal.* (Kanzi reaches for the milk in Rose's lap.) E says *Go ahead, not the milk, the cereal. Give me Rose's cereal. Rose's cereal. The cereal that Rose has.* (Kanzi picks up an item in the array and eats it.) E says *Put that down, Kanzi. Can you get Rose's cereal?*

The use of *That's right, Go ahead, Yes,* and *No, Put that down, Not the milk* strongly suggests

the presence of verbal prompts, praise, and reprimands in the shaping of successive approximations to receptive discriminations. Praise and reprimands were probably effective as conditioned reinforcers and conditioned punishers, because both the child and the bonobo had extensive histories of these verbal stimuli being paired with other effective consequences. The occurrence of these consequences following specific behavior would also then begin to establish several different forms of stimulus control and functional equivalence, while reducing the evocative strength of the relevant establishing operations (including reflexive conditioned establishing operations; see Michael, 1993). Although a good percentage of responses did occur in the absence of prompts and consequences, it does demonstrate how nonprogrammed prompts and differential reinforcement, punishment, and extinction were used to shape instruction-following behavior. One also wonders what role the banana and the stolen food item may have played in Kanzi's responding.

Novel Forms of Stimulus Control and Novel Responses

The formal testing conditions consisted of the presentation of novel combinations of the known verbal stimuli (e.g., *Take the doggie to the bathroom*). Savage-Rumbaugh et al. (1993) argue that Kanzi's ability to respond correctly to these novel and untrained verbal stimuli demonstrated that the observed responses were not due to operant conditioning but rather to the ape's cognitive and physiological characteristics that are similar to those of the human. That is, the ape is not just a trained animal that emits specifically shaped behavior, but rather is an organism with human-like cognitive processors and neural networks that organize novel stimuli and produce creative and novel behavior.

The authors state that novel and untrained behavior cannot be explained by behavioral concepts, and in fact, that novel behavior negates behavioral explanations. This view, which was repeatedly emphasized by Savage-Rumbaugh (1994) in her ABA presentation, reveals the common misconception that behavior analysis is predicated on specifically established stimulus–response relations and cannot account for variability or novelty of behavior. However, a fundamental aspect of behavior analysis is that operant behavior consists of functional correlations between classes of stimuli and responses rather than structural bundles of specific stimulus–response relations (e.g., Catania, 1973; Hineline & Wanchisen, 1989; Skinner, 1935). A functional stimulus class consists of stimuli that share a common stimulus function in that they exert the same functional control over a specific class of responses, even though there may be substantial differences among stimuli that comprise the class (Skinner, 1935).

This functional analysis of behavior readily accommodates variability and novelty and has been addressed by a number of behavioral researchers. For example, Gewirtz (1971), in response to Bandura's (1969) account of the variables responsible for behavior acquired through observation and vicarious reinforcement, argued that novel imitative behavior is an outcome of conventional learning procedures involving conditional discriminations, response classes, and extrinsic reinforcement. Thus, Savage-Rumbaugh et al.'s argument that the behavior was acquired through observational learning rather than reinforcement is challenged by Gewirtz's argument that observational learning is a by-product of reinforcement. Catania and Cerutti (1986) have also provided support for the view that novel behavior is a function of environmental variables by showing that pigeons emit novel behavior when the discriminative stimuli of two previously acquired repertoires are combined. Several other researchers have studied relations between open-ended sets of stimuli and open-ended sets of responses (e.g., Herrnstein & Loveland, 1972; Layng & Andronis, 1984; Page & Neuringer, 1985), and it seems clear that these enable the production of novel behavior patterns to be well accounted for within a behavioral framework.

Skinner frequently focused on the emergence of novel behavior, especially in relation to verbal behavior. For example, his early experimental work on the verbal summator (Skinner, 1936) demonstrated how unique behavior could be evoked by the combination of antecedent variables. This work was later followed by his extensive analysis of multiple control in *Verbal Behavior* (Skinner, 1957, chap. 9, 10, and 11). In addition, his analyses

of abstraction (Skinner, 1957, pp. 107–114), concept formation (Skinner, 1957, pp. 127–128), and manipulative autoclitic frames (Skinner, 1957, pp. 340–343) focus on how apparently untaught stimulus–response relations are acquired.

Skinner's (1957) analysis of abstraction is of particular relevance to the research by Savage-Rumbaugh et al. (Hall, 1995).[3] In abstract stimulus control, "any property of a stimulus present when a verbal response is reinforced acquires some degree of control over that response, and this control continues to be exerted when the property occurs in other combinations" (Skinner, 1957, p. 107). Although Skinner's treatment of abstraction in this section is in relation to tacting, it can occur in all verbal operants and in receptive responding as well. For example, in the Savage-Rumbaugh et al. study, the novel command *Put the oil in the backpack* contains previously reinforced elements that occur in new combinations. Recall that the pretest demonstrated that the individual words (*put, oil, in,* and *backpack*) were already strong in Kanzi's repertoire; what was novel was the unique combination of these words. Thus, it is possible that the emergence of novel behavior by Kanzi may be a function of abstract stimulus control (Hall, 1995; Hall & Chase, 1991). Abstract stimulus control has been examined by a number of other researchers, although it is often not called abstraction. For example, Alessi (1987) provides an excellent summary of this work and how it relates to Skinner's analysis of verbal behavior. A notable example of abstraction has been the work of Englemann and Carnine (1982) with their efforts to establish more efficient teaching routines for children. Also, Becker's (1986) work on general case analysis demonstrates how new responses are acquired without teaching each stimulus–response relation.

It is also possible that the emerged responses were a function of training procedures that resulted from the formation of functional equivalence relations. Functional equivalence, according to Dougher (1994), occurs "when a variable applied to one member of a functional stimulus class affects the other members in the absence of direct training" (p. 73). A number of researchers have demonstrated the transfer of function across stimulus classes (e.g., Catania, Horne, & Lowe, 1989; de Rose, McIlvane, Dube, & Stoddard, 1988; Sidman, Wynne, Maguire, & Barnes, 1989), and it appears that some of Kanzi's behavior could have been related to this type of equivalence formation (Hall, 1995; Hall & Chase, 1991). However, functional equivalence, like abstraction, was not considered in Savage-Rumbaugh et al.'s monograph.

Unfortunately, the research methodology employed in the study, although effective for showing that the subjects could comprehend novel verbal stimuli without human imitative or visual prompts, was insufficient for identifying the critical independent variables responsible for the emergence of the observed behavior that constituted comprehension. It is inadequate to simply say that Kanzi and Alia's "activities were accompanied by language in a way that seemed natural to the caretakers" (p. 46), and as a result, the subjects "began to decode the speech symbol into its components as well as assign meaning to these components on their own" (p. 102). The authors were not clear on the specific identification and experimental control of what "seemed natural." Therefore, it would be difficult to replicate this experiment given this limited information, and even taken at face value, the observation does not justify their assertion.

Furthermore, no data were reported (or apparently taken) on variables such as levels and frequencies of prompts, schedules of reinforcement and punishment (which surely were intermittent), the relative strength of establishing operations, or the frequency of daily trials (other than the targeted trials). In addition, there was no experimental manipulation to separate reinforcement from nonreinforcement, punishment from nonpunishment, extinction from nonextinction, pairing from nonpairing, and so on. It seems quite possible that the true absence of any of these variables would indeed affect acquisition. For example, when Kanzi attempted to take an item from Rose's lap, but when he reached for it Rose gave "no indication that he [was] permitted to take it" (p. 179), it appears that

[3] Hall, G. A. (1995, May). *Early language acquisition in ape and child: A behavioral analysis of emergent listener relations.* Paper presented at the meeting of the Association for Behavior Analysis, Washington, D.C.

extinction was used to weaken incorrect responses. In order to clearly identify the role of this behavioral principle in the acquisition of the comprehension repertoires, conditions involving extinction and no extinction would have to be compared.

In order to determine more precisely how Kanzi and Alia acquired their comprehension repertoires, these potential independent variables would have to be further identified and partitioned using standard behavioral methodology (e.g., Sidman, 1960). The law of scientific parsimony suggests that it would not be prudent for the authors to attribute the causes of their subjects' behavior to autonomous cognitive processors and neural networks until all these easily specifiable environmental sources are experimentally controlled. The research presented in the current monograph made no such attempt to account for any of these potentially potent independent variables.

Comprehension and Production

The final topic to be addressed is the authors' position on verbal comprehension and its relation to verbal production. The authors' view of comprehension is that "comprehension precedes production in the language development of normal children, and it may indeed guide production" (p. v). In addition, "the fact that comprehension did *not* require reinforcement supports the view that comprehension is the driving force underlying all of language acquisition" (p. 19). Behavior analysts, of course, argue that comprehension does indeed require reinforcement as well as the other behavioral principles and procedures, and that it is these environmental variables that are the primary basis for language acquisition. Behavior analysts also assert that comprehension does not cause production; rather, it is a functionally independent repertoire (e.g., Lee, 1981), because mands, tacts, and intraverbals are functionally independent repertoires at the time of acquisition (e.g., Hall & Sundberg, 1987; Lamarre & Holland, 1985; Sundberg, San Juan, Dawdy, & Arguelles, 1990).

The authors' focus on comprehension alone seems to be a function of a number of variables. In addition to their view that comprehension caused production, the authors suggest that other ape language research suffered because "no systematic, controlled measures of receptive capacities were taken by the Gardners or by Terrace and his colleagues" (p. 9). Perhaps the most significant reason, however, was that "popular theories of human language acquisition suggest that the ability to process syntactic information is unique to humans and reflects a novel biological adaptation not seen in other animals" (p. v). By demonstrating that comprehension could be acquired by apes in a manner similar to humans, the authors could argue that the ape possesses cognitive and biological equipment similar to that of humans. In addition, they could then argue that the emergence of expressive behavior in apes is due to the same variables that are responsible for its emergence in humans.

However, there are no data in the monograph that show the transfer to production. Thus, it is not clear, despite the authors' assertions, how this research supports the view that comprehension causes production. Also, in the video of Kanzi, the majority of his responses were receptive responses, and there is a striking absence of expressive behavior (i.e., mands, tacts, and intraverbals). Although it is clear that Kanzi had acquired expressive behavior (Savage-Rumbaugh, 1990) and that the authors are well aware of the different types of expressive behavior (Savage-Rumbaugh, 1984), there does not appear to be much of this behavior occurring in the videos. This seems odd because one would expect a wider variety of verbal responses (like Alia often emitted), given the size and strength of his comprehension repertoire, if indeed comprehension caused production.

In summary, the authors' claim that the subjects learned the behavior without reinforcement or training does not hold up to a behavioral analysis of the subjects' history or to an analysis of the procedures, transcripts, and videos. Their view that the subjects' acquisition of comprehension was not due to "simple explanations that depend on conditioning of responses" (p. 98) is true, not because behavioral explanations are simple, but because simple explanations are inadequate to analyze the emergence of behavior as complex as language comprehension. In fact, the behavioral analysis of comprehension is quite complex (e.g., Parrott, 1984; Schoneberger, 1990; Skinner, 1957, 1989; Stemmer, 1992),

involving much more than one principle of behavior and one formal training procedure. Finally, in order to scientifically determine how the subjects acquired a comprehension repertoire, a more rigorous research methodology that controls for the many potential independent variables should be employed.

THE VALUE OF THE AUTHORS' POSITION: ADVANCES AND APPLICATIONS

It should be pointed out, however, that a cognitive view with appeals to abstract physiological mechanisms is especially important to the authors because it reflects the current views of mainstream psychology and child language development. This compatibility with the prevailing views is critical for their cause of demonstrating that apes learn complex behavior in a manner similar to humans. At this time, a strong behavioral position would probably hurt the Rumbaughs' cause of demonstrating the similarities between apes and humans, because explanations in behavioral terms such as reinforcement, prompting, and shaping often evoke pejorative comments by critics such as "rote responding" or "just a trained animal." The authors' ability to show that simple behavioral explanations, such as imitation and reinforcement, are not responsible for learning may be attractive to many members of the scientific community because it supports their views of cognitive and biological control (individuals who may become more willing to attend to ape language research and support the authors' cause of granting linguistic competence to apes). These authors cannot be faulted for the fact that a behavioral analysis is generally not understood or accepted in linguistics or psychology.

This monograph, despite its conceptual shortcomings, does advance ape and human language research in many important ways. In addition to showing that an ape can acquire language comprehension in a manner similar to a human child and that an ape can emit those skills in the absence of visual prompts, the research contains several procedural advances that have implications for both ape and human language research. For example, the authors' effective use of natural contingencies to develop Kanzi's basic comprehension and verbal repertoires could serve as a model for those attempting to develop verbal behavior in human subjects. The frequent outings to the forest and other places with Kanzi and the lexigram board made use of many naturally occurring stimuli, establishing operations, consequences, and so on, that helped to establish not only differential verbal stimulus control but also Kanzi's verbal response forms of pointing to the lexigrams. The use of these natural contingencies to teach verbal behavior to nonverbal humans has been shown to be a very important tool for language training (e.g., Halle, 1987). Language research with nonhumans offers several experimental advantages over research with humans, and it may be possible to examine more carefully a number of the parameters and variables involved in designing a natural environment to teach verbal repertoires in cases in which explicit teaching techniques are needed.

The authors' hierarchy of increasingly complex verbal stimuli could also provide clinicians with a method to assess a nonverbal person's comprehension skills. In addition, Kanzi's and Alia's performances on these different tasks could give the clinician some guidelines as to which types of comprehension to teach first. For example, the finding that it was more difficult for both subjects to go to a location and get an object than it was to select an item and take it to a location has interesting implications for language training. More research on the relative difficulty of these different types of comprehension tasks could improve the current methods of language instruction.

The scoring system used in the study, especially the modified system used to score the videotapes, should also be of interest to researchers attempting to score and classify ongoing verbal interactions. This system was very useful in identifying potential antecedents and consequences that were relevant to the observed behavior. Applied behavior analysts could benefit from using such a system for recording the emission of verbal behavior by early language learners. Also, the authors' flexible approach to experimentation was similar to many aspects of the exploratory research strategies suggested by Skinner (1956). This approach to experimentation was termed *radical methodology* by Willard Day

and his students, and it has led to several interesting behavioral findings (e.g., Dougher, 1989; Moore, 1991). The most significant aspect of radical methodology is that the experimenters allow their behavior to be controlled by the subjects' behavior. The experimenters then analyze their behavior as a dependent variable that changes as a function of the subjects' behavior as an independent variable. The authors of the monograph under discussion made several changes in the procedures as a function of their subjects' behavior, resulting in an interesting research project that produced important findings. This approach can be seen throughout the study. For example,

> the present study was not designed to determine whether the subjects could process sentences that utilized a recursive structure. Rather, our tests of this capacity evolved when it became apparent that the subjects were having difficulty with an ambiguous linear structure—only then was the recursive structure introduced to resolve this ambiguity. (p. 100)

Finally, the Rumbaughs' continued development of their computerized lexical system has significant implications for the development of symbol communication systems for nonverbal humans. Their study demonstrated advances by the development and use of portable boards, the use of a voice synthesizer for auditory output, and procedures involving constant exposure to the system. Research on these features may improve the methods currently being used for teaching language to nonverbal persons.

BEHAVIOR ANALYSIS AND NONHUMAN VERBAL BEHAVIOR RESEARCH

The field of behavior analysis has much to offer to research on nonhuman verbal behavior. Behavior analysts are not only experts in the use of the behavioral principles and methods for shaping new repertoires, but they also have long histories of working with various nonhuman species. In addition, and perhaps most significant, behavior analysts have a functionally based conceptual framework for systematizing the development of verbal repertoires. These conceptual and methodological resources, which are readily applicable to both human and nonhuman behavior, could enable substantial improvements in the methods of language assessment and intervention for the millions of humans who fail to acquire effective language skills. The involvement of behavior analysts in this exciting line of research could also advance the cause of granting linguistic competence to apes and other nonhumans.

There are two general lines of research that could be pursued by behavior analysts. The first involves the systematic identification and control of the relevant independent variables that are responsible for the emergence of linguistic repertoires in nonhuman subjects. A number of potential independent variables were identified above, but the precise roles of these variables can only be revealed by a thematic line of experimental research that carefully partitions these variables from one another. It is unreasonable to expect that a nonbehaviorist could accomplish this level of behavioral experimentation (Knapp, 1990), especially because many of the behavioral explanations suggested above involve complicated concepts such as stimulus control, functional equivalence, conditioned reinforcement, and establishing operations. Determining, for example, the role of abstraction or functional equivalence in the emergence of novel behavior would require a number of sophisticated research projects with both basic and applied components.

The second general line of research suggested for behavior analysts involves the specific use of Skinner's (1957) analysis of verbal behavior as a conceptual framework for establishing verbal repertoires in nonhuman organisms. Most of the current language research with nonhumans (as well as humans) adheres to the traditional linguistic framework of receptive (comprehension) and expressive (production) language. As a result, language researchers often focus on establishing these two repertoires and studying the cognitive or physiological connection between them. Perhaps the most significant contribution of Skinner's analysis of verbal behavior is the distinction he makes between receptive language and the several different types of expressive behavior. Skinner distinguishes among echoic, mand, tact, intraverbal, textual, transcriptive, and autoclitic repertoires as the basic components of expressive verbal behavior (note that Skin-

ner's use of *verbal* includes all types of response forms such as speaking, signing, and pointing). Interestingly, many of the disagreements over the years among researchers of nonhuman language is related to the fact that each one taught specific types of verbal behavior and none taught all the verbal operants under all the necessary and sufficient conditions. An exception was suggested by Savage-Rumbaugh's (1984) behavior-analytic reinterpretation of Sherman and Austin's data that showed that the subjects did learn mands, tacts, and intraverbals. Unfortunately, this application of Skinner's analysis of verbal behavior has not been followed by other researchers, including Savage-Rumbaugh herself.

Apes have been considered to have great potential for acquiring verbal repertoires. Savage-Rumbaugh et al. (1993) suggest that the bonobo in particular represents the subspecies that is likely to acquire the most advanced forms of verbal behavior. However, it has also been demonstrated that language can be acquired by several other species as well. Deciding which nonhuman species to work with is often determined by funding and the availability of the necessary facilities. Although there are undoubtedly going to be varying degrees of acquisition by different species, there are still a number of basic verbal behavior research projects that could be conducted with almost any species. Large species such as apes (e.g., Fouts, 1973; Gardner & Gardner, 1969; Patterson & Linden, 1981), sea lions (e.g., Schusterman & Krieger, 1986), and dolphins (e.g., Herman, 1987) require special (and often expensive) facilities that may prohibit the widespread use of the species. Birds such as the African gray parrot (e.g., Pepperberg, 1981) and the mynah (Hake & Mabry, 1979) may be easiest to house and work with and because of their vocal capabilities may lead to some very fruitful results. Pigeons, although unable to emit words, can acquire various types of nonvocal verbal behavior and are very practical for large-scale research (e.g., Epstein, Lanza, & Skinner, 1980; Lubinski & MacCorquodale, 1984; Lubinski & Thompson, 1987; Michael, Whitley, & Hesse, 1983; Sundberg, 1985).

There are a number of specific research topics that could be pursued by behavior analysts interested in nonhuman verbal behavior and Skinner's analysis of verbal behavior (e.g., Fushimi, 1994; Michael et al., 1983; Oah & Dickinson, 1989; Sundberg, 1991). In addition to research on the basic verbal operants, there are many important topics currently being examined in behavior analysis that could perhaps benefit from research on nonhuman verbal behavior. For example, topics such as equivalence, rule-governed behavior, social interaction, and the distinctions between topography-based and stimulus selection-based verbal behavior could possibly be more carefully examined in a laboratory setting with nonhuman verbal subjects.

SUMMARY AND CONCLUSIONS

The research presented in the monograph by Savage-Rumbaugh et al. (1993) clearly demonstrates that an ape can acquire language comprehension in a manner similar to that of a human child and that an ape can emit those comprehension skills in the absence of visual prompts. The research also contains several procedural advances that have implications for both ape and human language research. These findings should contribute to the authors' long-term effort to convince the scientific community to grant linguistic competency to apes.

However, the authors' claim that the subjects learned such behavior on their own, without reinforcement or training, does not hold up to a closer examination of the subjects' history or to an analysis of the procedures, transcripts, and videos. The training and testing procedures appeared to involve a number of possible independent variables that were not examined, including conditioned reinforcement and punishment, verbal prompts, stimulus control, establishing operations, and extinction. In addition, other behavioral phenomena, such as abstraction and functional equivalence, were not considered but may have been relevant to the emergence of the observed behavior.

Behavior analysts are in a unique position to make substantial contributions to this line of research; their concepts and methods might well have a major impact on the current state of research on nonhuman verbal behavior. Such research could also have significant implications for applied work with language-delayed humans. In addition, verbal

behavior research with nonhumans provides behavior analysts with a valuable opportunity to bring together the conceptual, experimental, and applied aspects of behavior analysis in a single line of research (Hineline & Wacker, 1993; Mace, 1994).

Approximately 20 years ago Jack Michael took a small group of students to Hope College in Holland, Michigan, to see Duane Rumbaugh present his work on Lana. We were all fascinated by the movies of Lana and her rapid performance on the computerized keyboard, but we cringed when Rumbaugh presented his analysis of how Lana acquired her verbal behavior. After a few rounds of questions, Jack encouraged us to focus on what Rumbaugh was able to teach Lana and the specifics of his teaching procedures rather than on his cognitive analysis of how Lana learned the complex sets of behavior. The behaviorist reader of the current monograph will benefit from a similar approach. The Rumbaughs may have a different explanation of the repertoires acquired, but they have been successful in generating a number of complex receptive and verbal skills in apes. Behavior analysts should support this work and advance it by contributing the tools of behavior analysis in general and the concepts from *Verbal Behavior* in particular. It was pointed out by Knapp (1990) that behavior analysts should not expect others to make accurate use of our complex analyses until we have done so ourselves.

REFERENCES

Alessi, G. (1987). Generative strategies and teaching for generalization. *The Analysis of Verbal Behavior, 5,* 15–27.

Bandura, A. (1969). *Principles of behavior modification.* New York: Holt, Rinehart & Winston.

Becker, W. C. (1986). *Applied psychology for teachers: A cognitive behavioral approach.* Chicago: Science Research Associates.

Brown, R. (1973). *A first language: The early stages.* Cambridge, MA: Harvard University Press.

Catania, A. C. (1973). The concept of operant in the analysis of behavior. *Behaviorism, 8,* 175–186.

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

Catania, A. C., Horne, P., & Lowe, C. F. (1989). Transfer of function across members of an equivalence class. *The Analysis of Verbal Behavior, 8,* 99–110.

Chomsky, N. (1988). *Language and the problems of knowledge: The Managua.* Cambridge, MA: MIT Press.

de Rose, J. C., McIlvane, W. J., Dube, W. V., & Stoddard, L. T. (1988). Stimulus class formation and functional equivalence in moderately retarded individuals' conditional discriminations. *Behavioural Processes, 17,* 167–175.

Dougher, M. J. (1989). A functional analysis of a behavior analyst's functional analysis. *The Analysis of Verbal Behavior, 7,* 19–23.

Dougher, M. J. (1994). Stimulus equivalence, functional equivalence, and the transfer of function. In S. C. Hayes, L. J. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 71–90). Reno, NV: Context Press.

Englemann, S., & Carnine, D. (1982). *Theory of direct instruction: Principles and applications.* New York: Irvington.

Epstein, R., Lanza, R. P., & Skinner, B. F. (1980). Symbolic communication between two pigeons (*Columba livia domestica*). *Science, 207,* 543–545.

Fouts, R. S. (1973). Acquisition and testing of gestural signs in four young chimpanzees. *Science, 180,* 978–990.

Fouts, R. S., Fouts, D. H., & Schoenfeld, D. (1984). Sign language conversational interaction between chimpanzees. *Sign Language Studies, 42,* 1–12.

Fristoe, M., & Lloyd, L. L. (1977). Manual communication for the retarded and others with severe communication impairments: A resource list. *Mental Retardation, 15,* 18–21.

Furness, W. (1916). Observations on the mentality of chimpanzees and orangutans. *Proceedings of the American Philosophical Society, 45,* 281–290.

Fushimi, T. (1994). Acquisition of demand and reject behaviors in a chimpanzee. In S. C. Hayes, L. J. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 123–144). Reno, NV: Context Press.

Gardner, B. T., & Gardner, R. A. (1969). Teaching sign language to a chimpanzee. *Science, 165,* 664–672.

Gardner, B. T., & Gardner, R. A. (1971). Two way communication with an infant chimpanzee. In A. M. Schrier & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 4, pp. 117–184). New York: Academic Press.

Gewirtz, J. L. (1971). Conditional responding as a paradigm for observational, imitative learning and vicarious-reinforcement. In J. L. Gewirtz (Ed.) *Advances in child development and behavior* (Vol. 6, pp. 273–304). New York: Academic Press.

Hake, D. F., & Mabry, J. (1979). Operant and nonoperant vocal responding in the mynah: Complex schedule control and deprivation-induce responding. *Journal of the Experimental Analysis of Behavior, 32,* 305–321.

Hall, G. A., & Chase, P. N. (1991). The relationship between stimulus equivalence and verbal behavior. *The Analysis of Verbal Behavior, 9,* 107–119.

Hall, G. A., & Sundberg, M. L. (1987). Teaching mands by manipulating conditioned establishing operations. *The Analysis of Verbal Behavior, 5,* 41–53.

Halle, J. (1987). Teaching language in the natural environment: An analysis of spontaneity. *Journal of the Association for Persons with Severe Handicaps, 12,* 28–37.

Hart, B., & Risley, T. R. (1975). Incidental teaching of language in the preschool. *Journal of Applied Behavior Analysis, 8,* 411–420.

Hayes, K. J., & Hayes, C. (1951). The intellectual devel-

opment of a home-raised chimpanzee. *Proceedings of the American Philosophical Society, 95,* 105–109.

Herman, L. (1987). Receptive competencies of language-trained animals. In J. S. Rosenblatt, C. Beer, M. C. Busnel, & P. J. B. Slater (Eds.), *Advances in the study of behavior* (Vol. 17, pp. 1–60). New York: Academic Press.

Herrnstein, R. J., & Loveland, D. H. (1972). Food-avoidance in hungry pigeons, and other perplexities. *Journal of the Experimental Analysis of Behavior, 18,* 369–383.

Hineline, P. N., & Wacker, D. P. (1993). *JEAB* November '92: What's in it for the *JABA* reader? *Journal of Applied Behavior Analysis, 26,* 269–274.

Hineline, P. N., & Wanchisen, B. A. (1989). Correlated hypothesizing and the distinction between contingency-shaped and rule-governed behavior. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 221–268). New York: Plenum.

Kellogg, W. N., & Kellogg, L. A. (1933). *The ape and the child.* New York: McGraw-Hill.

Knapp, T. J. (1990). *Verbal Behavior* and the history of linguistics. *The Analysis of Verbal Behavior, 8,* 151–153.

Lamarre, J., & Holland, J. G. (1985). The functional independence of mands and tacts. *Journal of the Experimental Analysis of Behavior, 43,* 3–14.

Layng, T. V. J., & Andronis, P. T. (1984). Toward a functional analysis of delusional speech and hallucinatory behavior. *The Behavior Analyst, 7,* 139–156.

Lee, V. L. (1981). Prepositional phrases spoken and heard. *Journal of the Experimental Analysis of Behavior, 35,* 227–242.

Lubinski, D., & MacCorquodale, K. (1984). "Symbolic communication" between two pigeons (*Columba livia*) without unconditioned reinforcement. *Journal of Comparative Psychology, 98,* 372–380.

Lubinski, D., & Thompson, T. (1987). An animal model of the interpersonal communication of interoceptive (private) states. *Journal of the Experimental Analysis of Behavior, 48,* 1–15.

Mace, F. C. (1994). Basic research needed for stimulating the development of behavioral technologies. *Journal of the Experimental Analysis of Behavior, 61,* 529–550.

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

Michael, J. (1985). Two kinds of verbal behavior plus a possible third. *The Analysis of Verbal Behavior, 3,* 1–4.

Michael, J. (1993). Establishing operations. *The Behavior Analyst, 16,* 191–206.

Michael, J., Whitley, P., & Hesse, B. E. (1983). The pigeon parlance project. *The Analysis of Verbal Behavior, 2,* 6–9.

Moerk, E. L. (1992). *First language: Taught and learned.* Baltimore: Paul H. Brookes.

Moore, J. (1991). A retrospective appreciation of Willard Day's contribution to radical behaviorism and the analysis of verbal behavior. *The Analysis of Verbal Behavior, 9,* 97–104.

Oah, S., & Dickinson, A. M. (1989). A review of empirical studies of verbal behavior. *The Analysis of Verbal Behavior, 7,* 53–68.

Page, S., & Neuringer, A. (1985). Variability is an operant. *Journal of Experimental Psychology: General, 115,* 62–75.

Parrott, L. J. (1984). Listening and understanding. *The Behavior Analyst, 7,* 29–39.

Patterson, P., & Linden, E. (1981). *The education of Koko.* New York: Holt, Rinehart, & Winston.

Pepperberg, I. M. (1981). Functional vocalizations by an African gray parrot (*Psittacus erithacus*). *Zeitschrift für Tierpsychologie, 55,* 139–160.

Pinker, S. (1994). *The language instinct: How the mind creates language.* New York: William Morrow.

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

Premack, D. (1976). *Intelligence in ape and man.* Hillsdale, NJ: Erlbaum.

Rumbaugh, D. M. (1977). *Language learning by a chimpanzee.* New York: Academic Press.

Rumbaugh, D. M., Gill, T. V., & von Glasersfeld, E. C. (1973). Reading and sentence completion by a chimpanzee (*Pan*). *Science, 182,* 731–733.

Rumbaugh, D. M., von Glasersfeld, E. C., Warner, H., Pisani, P. P., Gill, T. V., & Bell, C. L. (1973). A computer controlled language training system for investigating the language skills of young apes. *Behavioral Research Methods and Instrumentation, 5,* 385–392.

Salzinger, K. (1994). The LAD was a lady, or the mother of all language learning: A review of Moerk's *First Language: Taught and Learned. Journal of the Experimental Analysis of Behavior, 62,* 323–329.

Savage-Rumbaugh, E. S. (1984). Verbal behavior at the procedural level in the chimpanzee. *Journal of the Experimental Analysis of Behavior, 41,* 223–250.

Savage-Rumbaugh, E. S. (1990). Language acquisition in a nonhuman species: Implications for the innateness debate. *Developmental Psychobiology, 23,* 599–620.

Schoneberger, T. (1990). Understanding and the listener: Conflicting views. *The Analysis of Verbal Behavior, 9,* 141–150.

Schusterman, R. L., & Krieger, K. (1986). Artificial language comprehension and size transposition by a California sea lion (*Zalpohus californianus*). *Journal of Comparative Psychology, 100,* 348–355.

Sevcik, R. A., Romski, M. A., & Wilkenson, K. (1991). Roles of graphic symbols in the language acquisition process for persons with severe cognitive disabilities. *Journal of Augmentative and Alternative Communication, 7,* 161–170.

Shafer, E. (1993). Teaching topography-based and stimulus selection-based verbal behavior to developmentally disabled individuals: Some considerations. *The Analysis of Verbal Behavior, 11,* 117–133.

Sidman, M. (1960). *Tactics of scientific research.* Boston: Authors Cooperative.

Sidman, M., Wynne, C. K., Maguire, R. W., & Barnes, T. (1989). Functional classes and equivalence relations. *Journal of the Experimental Analysis of Behavior, 52,* 261–274.

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

Skinner, B. F. (1936). The verbal summator and a method for the study of latent speech. *Journal of Psychology, 2,* 71–107.

Skinner, B. F. (1956). A case history in scientific method. *American Psychologist, 11,* 221–223.

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

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

Stemmer, N. (1992). The behavior of the listener, generic extensions, and the communicative adequacy of verbal behavior. *The Analysis of Verbal Behavior, 10,* 69–80.

Sundberg, M. L. (1985). Teaching verbal behavior to pigeons. *The Analysis of Verbal Behavior, 3,* 11–17.

Sundberg, M. L. (1991). 301 research topics from Skinner's book *Verbal Behavior. The Analysis of Verbal Behavior, 9,* 81–96.

Sundberg, M. L., San Juan, B., Dawdy, M., & Arguelles, M. (1990). The acquisition of tacts, mands, and intraverbals by individuals with traumatic brain injury. *The Analysis of Verbal Behavior, 8,* 83–99.

Terrace, H. S. (1979a). Is problem solving language? [A review of Premack's book *Intelligence in Ape and Man.*] *Journal of the Experimental Analysis of Behavior, 31,* 161–175.

Terrace, H. S. (1979b). *Nim.* New York: Knopf.

Terrace, H. S., Pettito, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science, 206,* 891–900.

Terrace, H. S., Straub, R. O., Bever, T. G., & Seidenberg, M. S. (1977). Representation of a sequence by a pigeon. *Bulletin of the Psychometric Society, 10,* 269.

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

Warren, S. F., & Gadzag, G. (1990). Facilitating early language development with milieu intervention procedures. *Journal of Early Intervention, 14,* 62–86.

Received May 12, 1995
Final acceptance November 1, 1995