Ape Language Research: A Review and Behavioral Perspective

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The ape language research of the Gardners, Fouts, Terrace, Rumbaugh, and Savage-Rumbaugh is reviewed. This research involved the raising of chimpanzees (and a bonobo) in human-like environments over extended time periods. The results indicate that apes are capable of learning small verbal repertoires in a fashion similar to that of human infants. The writings of the ape language researchers show an opposition to behavioral approaches to language. Although they characterize each other's work as behavioral, they oppose such explanations applied to their own work. A behavior-analytic approach to language has much empirical support, and behavioral treatments for people with language delays have produced substantial results. Despite the protestations of the ape language researchers, now is an appropriate time to apply the extensive knowledge base derived from a science of behavior to language acquisition in apes.

In studying language with another species, there are two hypothetical extremes that could be considered the ends of a continuum. At one end, the major focus would be in determining whether a species has the ability for language. Researchers of this orientation would devise tests, and the organisms' passing or failing of these tests would determine the conclusions one draws. At the other end, the main interest would be in determining whether an organism could be taught language. These experimenters would identify critical aspects of language and try to explicitly teach those aspects. The former approach could be called a "testing approach" and the latter a "teaching approach." The orientations of the ape language researchers described in this paper fit somewhere between these two extremes. The teaching approach is characterized by the experimental and applied research behavior analysts have carried out with language-impaired people. It will be argued that a greater emphasis on teaching may produce more significant results in ape language research.

This paper has four goals: First, I review the research of the Gardners, Fouts, Terrace, Rumbaugh, and Savage-Rumbaugh. It is fairly safe to say that these researchers have conducted the most well-known and respected research in this area. Each research project consisted of long-term exposure of chimpanzees (including the bonobo) to human-like environments. Similar projects have been conducted with other primates, such as the orangutan (Miles, 1983) and gorilla (Patterson, 1978, 1981). Premack (1976) was interested in chimpanzee intelligence. He developed a number of tests on what he considered to be the atomic constituents of language. The results of these tests were supposed to shed light on the intelligence of primates. Premack's research will not be discussed because the testing environment and the results are not directly related to human language acquisition. Second, I describe how these researchers oppose behavioral interpretations of their work, and discuss their views of language and reinforcement. Third, I describe the reinforcement practices of the ape language researchers. Also, behavioral interpretations of this work will be provided. This can be

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done only in cases for which there are enough details to make this possible, but some interpretation is demanded, especially in cases that are supposed to illustrate the inadequacy or implausibility of behavioral accounts. Fourth, I briefly discuss some of the evidence supporting a behavioral interpretation of language, with a focus on the role of reinforcement in language acquisition. Part of the evidence consists of the success applied behavior analysts have had in teaching language to language-impaired humans. These four areas lead to the conclusion that ape language research could benefit from a greater emphasis on teaching over testing, and on the application of empirically proven teaching methods.

NONHUMAN LANGUAGE PROJECTS

History

The extent to which human language depends on environmental experience could be tested by raising a normal human infant in a language-free environment, but this would be unethical. Another approach is to observe the language development of a nonhuman organism raised in a language-rich human environment. Of course, it should also be an organism that is neurologically as much like a human as possible; hence, chimpanzees have been studied in human-like environments. A well-known study of this sort is that of Kellog and Kellog (1933), who for 9 months raised a 7-month-old chimpanzee in their home with their 10-month-old son. Another more extensive study is that of Hayes and Hayes (1951), who raised a chimpanzee from infancy in their home for about 7 years.

In both cases the chimps developed a good deal of the behavior normally shown by human children of comparable ages, including language comprehension; but in both cases the chimps failed to develop any effective form of vocal language. More recently, the vocal apparatus of the chimpanzee has been shown to be unable to produce the large variety of sounds produced by humans. The primary difficulty is the ape's inability to produce consonant-vowel combinations (Savage-Rumbaugh et al., 1993). This important difference between human and ape vocal capabilities may well rule out the development of vocal language in apes. Further efforts to develop a complex, human-like language in a nonhuman have continued with animals that are more capable of producing human vocal sounds, for example the extensive work by Pepperberg with the parrot (e.g., Pepperberg, 1988). But a major breakthrough in ape language research came with the work of Gardner and Gardner.

The Gardners' Work with Washoe, Tatu, Dar, and Moja

From the work of the Kellogs and Hayeses, it became clear that, despite the best efforts of the trainers, chimpanzees could not produce the complexity of vocal sounds of the human vocal apparatus. The innovation of the Gardners was to use a gestural rather than a vocal language. In most other respects, the research was similar to that of the Kellogs and Hayeses.

Two projects were conducted. The first project began in the summer of 1966 with a 10-month-old female chimpanzee named Washoe (Gardner & Gardner, 1969). After 51 months, the project was terminated, and she was taken to a chimpanzee research center at the University of Oklahoma to work with Roger Fouts (see below), because Washoe had become too large and difficult to manage (Fouts & Mills, 1997). The second project began in 1972 with 4 chimpanzees who were brought in at staggered times and at much younger ages than Washoe (1 chimpanzee died early in the project and will not be discussed). The chimpanzees were only a few days old when they arrived, and staggering the ages of the chimpanzees was done to allow the younger chimpanzees to learn from the older ones. The chimpanzees lived in a trailer, and, later, in cabins. The living quarters contained the usual items and furniture found in human homes. From 7:00 a.m. to 8:00 p.m., the chimpanzees were in constant contact with human signers. The sign language used by the experimenters was American sign language (ASL). "Sign language only" was the rule of the house. When experimenters conversed with the chimpanzees or each other in front of the

chimpanzees, it had to be in ASL. The chimpanzees were involved in the daily routines of the house, and were treated as deaf human children would be treated by deaf parents. Gardner and Gardner (1989a) describe some of the nonverbal behaviors Washoe acquired in the first project, and, presumably the other chimpanzees acquired in the second project, this way:

> In the next few years she learned to drink from a cup and to eat at a table with forks and spoons. She also learned to set and clear the table and even to wash the dishes, in a childish way. She learned to dress and undress herself and she learned to use the toilet. ... She had the usual children's toys and was particularly fond of dolls, kissing them, feeding them, and even bathing them. She was attracted to picturebooks and magazines almost from the first day and she would look through them by herself or with a friend who would name and explain the pictures and tell stories about them. The objects and activities that most attracted her were those that most engaged the grownups. She was fascinated by household tools, eventually acquiring a creditable level of skill with hammers and screwdrivers. (p. 1)

Teaching Methods

The Gardners (1989a) describe their teaching method as follows:

> The procedures that we used to teach signs were modelled after the procedures commonly used in human homes with human children. Most of all, we signed to each other and to the cross-fosterlings throughout the day the way human parents model speech and sign for human children. We used a very simple and repetitious register of ASL. We made frequent comments on common objects and events in short, simple redundant sentences. We amplified and expanded on their fragmentary utterances. We asked known-answer questions. ... We attempted to comply with requests and praised correct, well-formed utterances. (p. 15)

In addition to this imitative method of teaching, the Gardners and colleagues used shaping and a technique they called "molding," in which the experimenter shaped the chimpanzee's hand into the correct sign. For example, Washoe's hand might be guided through the correct sign for a cat just after the experimenter signed WHAT THAT? while pointing at a cat. In applied behavior analysis terms, molding is equivalent to physical prompting. At least for the first 3 years of training, molding was used to teach most of the new signs to Washoe (Gardner & Gardner, 1971). It is not reported how much this method was used later with Washoe or with the other chimpanzees. Although molding has been used by mothers with deaf infants 6 months of age and younger (Maestas y Moores, 1980), another study of mothers' verbal interactions with deaf children between 1 and 2½ years of age made no mention of this technique in either the review of the literature or in the study itself (Kantor, 1994). Perhaps molding is not necessary with deaf human infants.

Results: Washoe, Tatu, Dar, and Moja

Daily records. The size of the chimpanzees' vocabularies was determined through the use of daily records of each chimp's signing. According to Gardner, Gardner, and Nichols (1989), "when three separate and independent observations of a new sign had been reported by three different observers, and all three had been judged to be well-formed, unprompted, and appropriate, then the new sign was placed on a special list of candidates for reliability" (p. 83). While a sign was on this list, each observation was recorded until at least one well-formed, spontaneous, and appropriate sign had been reported for 15 consecutive days. If any days were missed, the count was restarted. When the criterion was met, the sign was added to the list of reliable vocabulary items. Signs were judged to be well formed when they matched a sign made by human adults or was an immature variant similar to those seen among human children. Decisions were guided by judgments of fluent signers who were familiar with the signing of young children. A sign was unprompted when the experimenter had not immediately before modeled or guided the target sign. A sign was appropriate when it was evoked by the verbal and situational context and by the presence of a suitable addressee. Often, the appropriate context began with a question by one of the experimenters. By 51 months of age, Washoe had acquired 132 signs according to the above criteria. At 80 months of age, Moja met the criteria for 168 signs. At 65 months of age, Tatu met the criteria for 140 signs, and at 58 months of age, Dar met the criteria for 122 signs. These are remarkable results in comparison to those of previous projects. However, hearing children have a vocabulary of approximately 2,000 words by the time they are 5

years old (Moskowitz, 1978), and deaf children raised by deaf parents exhibit a similar rate of language acquisition (Meadow-Orlans, 1990, p. 290).

Vocabulary tests. To further rule out the possibility of cuing, the experimenters tested the chimpanzees' naming of screen-projected objects while observers were positioned so that they could see the signs made by the chimpanzees but not the slide projection (Gardner & Gardner, 1989b). To test if the signs referred to conceptual categories, all of the test trials presented slides never before seen, but the features of the test slides were based on the features of pretest slides that best evoked appropriate signs. Also, in making the slides, the experimenters paid careful attention to the apparent controlling stimuli for certain responses. For example, Tatu often signed THAT TREE when she saw bare trees during the winter. Slides with such characteristics were used during testing. This clearly limits the extent to which the researchers could claim that the chimpanzees had learned broad conceptual categories. The results showed that all 4 of the subjects performed much better than chance: 79% to 88% correct for all subjects except Moja (54%). The number of test slides was fairly small, however. Moja was tested on 35 slides, Tatu on 34, and Dar on 27. Statistical analysis showed that the majority of the errors were of two types. The first type of error can be explained by stimulus generalization. For example, DOG was a common error for cows. The second type of error occurred with slides that evoked similar response topographies. The signs CAT and APPLE, for example, which are both made on the cheek, were confused.

The chimpanzees were also tested on answers to wh- questions. The wh- questions were question frames consisting of an interrogative sign with one or more additional signs. The question frames were broken into categories, such as what-demonstrative (e.g., WHAT THAT?), who-subject (e.g., WHO ME CHASE?), and how many (e.g., HOW MANY COWS?). The field records were consulted in selecting question frames. Only those questions that reliably evoked a reply (regardless of correctness) were used in the sample. Answers were scored correct if the answer was in the correct category. For example, a correct answer to the question WHO THAT? would be a proper noun, even if the specific name given was wrong. The results were consistent with those found with human children. Both children and chimpanzees show a similar developmental order in the types of wh- questions answered correctly. For example, for human children and young chimpanzees, what-demonstrative questions are answered correctly before *how many?* questions. Also like children, the accuracy of the chimpanzee's replies improved over time.

Fouts

After the cross-fostering project with the Gardners, Washoe, and eventually Moja, Tatu, and Dar, were moved for further study under the supervision of Roger Fouts. Fouts had been a graduate student of Allen Gardner and an experimenter for Washoe under the first cross-fostering project. The intensity of sign language training decreased under Fouts, and many naive subjects acquired only a small number of signs. But Washoe and the other chimps continued to acquire new signs (Fouts & Mills, 1997).

In an early experiment, Fouts taught 4 naive chimpanzees a small number of signs using molding (Fouts, 1973). The training sessions were 30 min long and were conducted inside metal cages. The purpose of this early research was to show that chimpanzees other than Washoe could learn ASL. Of more interest is a study Fouts conducted with a home-raised male chimpanzee named Ally (Fouts, Chown, & Goodin, 1976). Ally was first taught to select an object, among an array of objects, in response to a vocal request by the experimenter (e.g., "Ally bring me the pillow"). After Ally learned to select 10 different objects, the experimenters taught Ally to make the sign for each object in response to hearing the name of the object. The objects were not present during this training. At the end of each training session, Ally was presented with an object and asked WHAT THAT? in ASL. This was used to determine if he could correctly sign the name of the object after having learned the sign given the vocal name. Ally had already learned to make the appropriate

sign for many other objects, but not for the 10 objects used in this study. All signs but one required repeated testing before Ally made the appropriate sign. Fouts et al. took this as evidence that Ally transferred a sign from a vocal name based on learning the sign in response to the name. But this conclusion may be unwarranted due to the experimental design. First, for seven of the 10 objects, transfer criteria were met on the test session following training of that sign in response to the vocal name. Hence, Ally had been repeatedly reinforced for making the transfer response in the prior test session; now, when shown the object in the transfer task and asked WHAT THAT?, it seems possible that the previously reinforced response would be the one most likely to occur. Second, it took Ally between 1 and 14 test sessions to meet the test criteria for transfer, and correct transfer responses were reinforced during testing. Therefore, it seems possible that correct transfer responses may have been shaped during testing. One could imagine Ally making a number of different responses during testing, and, when he finally makes the right response, the reinforcement resulting in the acquisition of the response. This is why in stimulus equivalence research, the transfer responses are never reinforced during testing.

Fouts' later research focused more on chimpanzee-chimpanzee communication and learning, rather than on human socialization of the chimpanzees (Fouts & Mills, 1997). In one well-known study (Fouts, Fouts, & Van Cantfort, 1989), It was demonstrated that an infant chimpanzee, Loulis, acquired signs from his mother, Washoe, and other signing chimps, in the absence of any human signing. The criteria for an acquired sign were less stringent than the Gardners' criteria; the 15-consecutive-day criterion was omitted, but the sign had to be well formed, appropriate for the context, and observed by three different observers. According to these criteria, by the time Loulis was 73 months of age, he had acquired a vocabulary of 51 signs. This number is considerably less than that acquired by the other chimpanzees in the Gardners' projects, but the acquisition of signs through exposure to the signing of other chimpanzees was an important demonstration that language could be acquired without direct human intervention. Fouts has also demonstrated that the cross-fostered chimps engage in considerable signing among themselves with no humans present (Fouts & Fouts, 1989).

The previous discussion of the Gardners' and Fouts' research focused on the more objective studies and findings, but the Gardners and Fouts also provide many "rich interpretations" of the chimps' behaviors. For example, Fouts credits Washoe with cursing when she called an aggressive monkey DIRTY MONKEY, and when Fouts told her she could not go out she responded DIRTY ROGER (Fouts & Mills, 1997). At first glance, these are compelling examples of metaphor on the part of Washoe. But what is needed is a functional analysis to identify the controlling variables for such behavior, and this was not done. The Gardners claimed that the daily records showed the chimpanzees' appropriate and spontaneous use of combinations of signs. For example, when Washoe saw a duck in a pond she signed WATER BIRD. From an English language view, it appears that water is an adjective that modifies the noun BIRD, and this is supposed to be an example of spontaneous naming according to the Gardners. A serious criticism of such interpretations came from another ape language researcher, Herbert Terrace (Terrace, 1979; Terrace, Petitto, Sanders, & Bever, 1979). Terrace pointed out that Washoe had been taught to name a large number of objects; perhaps she was naming the water and the bird separately. Terrace also analyzed videotapes of Washoe's signing and found that many of her utterances were prompted by the teacher or imitations of the teacher's responses. From a behavioral perspective, Terrace showed that it was unlikely that the chimpanzees had learned many verbal units consisting of multiple signs. In Terrace's language, the chimpanzees had not learned to make a sentence. Before Terrace came to this conclusion, however, he first attempted his own ape language project.

Terrace: Nim

Terrace considered the use of sign language to be a major advance in teaching

language to chimpanzees, but he was not confident that previous attempts had shown that apes' language had grammar. Terrace obtained a 2-week-old male chimpanzee named Nim in 1973, and he and coworkers worked with Nim over the next 4 years. Project Nim was similar to that of the Gardners, except Nim had many more teachers (over 60) and talking was allowed in Nim's presence, but he still was constantly signed to and encouraged to sign. The goal of the project was quite specific: to determine whether Nim could learn to make a sentence. Terrace (1979, p. 45) described the goals this way:

> I wanted to see what combinations of signs Nim would produce without special training, that is, with no more encouragement than the praise that a child receives from its parents. I especially wanted to find out whether these combinations would be similar to human sentences in the sense that they were generated by some grammatical rule.

As in previously described experiments, Nim lived in a house with the typical human furnishings, and he learned many of the same nonverbal behaviors Washoe did, such as using the toilet, washing dishes, and helping out around the house. Unlike the Gardners' projects, Nim spent 5 to 6 hours a day, 5 days a week, in a classroom learning sign language from a teacher.

Teaching Methods

The primary teaching methods were imitation and molding. Nim's teachers signed in his presence all the time "to get him to understand that signing was a way of communicating and that he would be left out of this kind of activity if he didn't sign" (Terrace, 1979, pp. 45-46). The quality of teacher signing was probably not as high as it was in the Gardners' projects because many of Nim's teachers had little prior knowledge of sign language. Nim was required to sign to receive an item or engage in some activity. For example, he had to sign TICKLE to be tickled. When Nim was 10 months old he began going to a special classroom designed for him at Columbia University for one-on-one teaching 5 days a week. For the next 6 months Nim's primary teacher was Carol Stewart, who had experience teaching sign language to children with mental retardation using behavior modification. Terrace resisted a number of Stewart's ideas (Terrace, 1979, pp. 77-79). For example, Terrace instructed Stewart to "use food and drink rewards only when teaching a sign related to those rewards." Stewart believed that Nim should be taught receptive language, followed by productive behavior (imitation of signs), followed by expressive language. In behavioral terms, she suggested control by verbal stimuli should precede echoic behavior, which should precede the acquisition of other verbal operants. There is a good deal of evidence that for most normal children, receptive language precedes comprehension (Savage-Rumbaugh et al., 1993, chap. 1) and echoic behavior of phonemes precedes word production (Kent & Miolo, 1995). It is surprising that Terrace resisted a behavioral approach to Nim's teaching, because he was a student of Skinner at Harvard. Nevertheless, Skinner's work did not seem to influence the goals or methods of Project Nim. Terrace made no use of Skinner's verbal operants, resisted a behavioral approach to teaching, and accepted some of Chomsky's criticisms of Skinner's approach to language (Terrace, 1979).

Although the goal of Project Nim was to teach Nim to make a sentence, Nim was never explicitly taught to do so. His teachers were instructed to not require him to make a multisign utterance to get something. For example, Nim could just sign TICKLE, rather than TICKLE ME, to be tickled. Terrace believed that multiword utterances are not specifically reinforced for human children; rather, children spontaneously begin using grammatical rules.

Results

Nim acquired 125 signs in 4 years. The criteria for determining if a sign was known was similar to the Gardners' criteria, except that the sign had to spontaneously occur for a 5-day period rather than a 15-day period. The primary goal of the experiment was to see whether Nim could learn to make a sentence. Nim did show regularities in his utterances; that is, particular signs tended to occur in a particular order (e.g., "more + x" was much more common than "x +

more"), but utterances greater than two signs showed a different pattern. When children's utterances increase, they expand on a topic, but Nim's utterances did not. Nim's utterances were highly redundant. For example, his most frequent four-sign utterance was EAT DRINK EAT DRINK followed by EAT NIM EAT NIM. Terrace reports that multiword utterances by a child do not show this high level of repetition. Between the age of 26 to 45 months, Nim's utterances showed no increase in utterance length, whereas deaf and hearing children's utterance length increases dramatically during this period. However, these results may not be surprising because Nim was not taught to emit multisign utterances, nor were his multisign utterances specifically reinforced. Terrace assumes that children are not taught to emit multisign or multiword utterances, but recent analyses of mother-child interactions indicate that mothers quite often expand on children's utterances, and, thus, serve as a model (Moerk, 1990, 1992). For example, Moerk (1992, p. 65), in a reanalysis of Brown's data (Brown, 1973), gives an example of an expansion involving the interaction between a mother and her daughter Eve:

> Eve: "Cathy spill grape juice on plate."
>
> Mother: "Cathy spilled grape juice on the plate."
>
> Eve: "Cathy spill grape juice on *the* plate."

Eve partially corrects her initial utterance in this case because of the mother's expansion. Eve's initial response is much more complex than any of Nim's statements, and Terrace probably would have considered his work a success if Nim had made such utterances, but the important point of the example and Moerk's analysis is that parents do use repetition, expansion, and correction to improve their child's language. Moerk's analysis also suggests that some of the parent's statements function to reinforce appropriate child responses. Other research has found that the features of parent-child interactions identified by Moerk have a beneficial effect on children's language acquisition (Hart & Risley, 1995).

Nim's ability to respond appropriately to verbal stimuli was also tested. Often the tests consisted of having various objects placed throughout a room and telling Nim YOU GIVE ME X. From these tests Terrace concluded that Nim could respond appropriately (i.e., point to or retrieve particular objects) to 200 signs. Interobserver agreement scores were not calculated, but Nim had to perform correctly with respect to an object with two different teachers before a sign was said to be "comprehended."

Terrace concluded that neither Nim nor any other chimpanzee has been shown to make a sentence. Terrace's conclusions and results made it difficult for ape language researchers to get their work published or funded (Savage-Rumbaugh & Lewin, 1994, p. 54). Nevertheless, Savage-Rumbaugh and colleagues at the language research center at Georgia State University continue to the present day in developing a variety of methods for studying language with apes.

Rumbaugh and Savage-Rumbaugh

Early research: Lana, Sherman, and Austin. In 1971 Duane Rumbaugh started the Language Analog (LANA) Project with a single chimpanzee named Lana. The goal of the project was to develop language-teaching procedures with chimpanzees that could then be applied to language-delayed humans (e.g., people with severe mental retardation). This is a significant difference from the other projects. Whereas the other projects focused on language acquisition in a more normal environment with less attention paid to explicit teaching, the LANA Project was aimed at developing teaching procedures. Unfortunately, developing explicit teaching procedures seems to have been emphasized less over time.

Lana learned a selection-based form of language[1] involving a large number of keys with arbitrary geometric figures on them. Pressing a key caused it to light up. The keyboard was connected to a computer that recorded Lana's responses and responded to her requests, which were typically for food. Lana eventually acquired what were called "stock sentences," such as *please machine give banana.* Although Lana learned to ask for a number of objects in this way, it was never

[1]For a discussion of selection-based versus topography-based verbal behavior, see Michael (1985).

clear if she actually emitted each member of the sequence under the same control as each word would be emitted in human verbal behavior. Also, although Lana appeared to emit responses under appropriate stimulus control, she could not react appropriately to verbal stimuli produced by another organism. For example, Lana did not respond accurately if asked by an experimenter using the geometric symbols to give the experimenter a banana. Savage-Rumbaugh's experiments with 2 new chimpanzees were conducted to address this "comprehension" problem.

Savage-Rumbaugh began working with 2 chimpanzees named Sherman and Austin in 1975. According to Savage-Rumbaugh and Lewin (1994, p. 59), the primary goal of the project was to "elucidate the processes of language acquisition in apes and compare them with the phenomenon of spontaneous language acquisition in human children." Sherman and Austin were taught a selection-based language similar to that used with Lana, except that single symbols were taught rather than stock sentences. Sherman and Austin learned mands and tacts for various objects (Savage-Rumbaugh, 1984). They also learned to respond appropriately to the symbols. These three repertoires could then be combined to allow various forms of interaction between Sherman and Austin. For example, Sherman would be shown a food item that would be made available to both chimpanzees if Austin manded for that same food. Initially, Sherman pressed the symbol as a mand for that food item because that had been the previous contingency, but the key-press response eventually became a mand that controlled Austin's pressing of that same symbol.[2] Austin had a screen that displayed the symbols pressed by Sherman. When Austin saw the symbol that was produced by Sherman, he would press the corresponding symbol on his keyboard. The chimpanzees also learned to switch roles. In this way, both chimpanzees could mand a particular response from the other chimpanzee. At first glance it appears to be a matching-to-sample task for the "listener" chimpanzee (i.e., the chimpanzee that sees the symbol produced by the other), but other evidence suggests that more had been learned. For example, when one of the chimpanzees saw the symbol associated with a highly preferred food, he would begin making food barks and grin – the same types of responses that were associated with the availability of that food. Also, after seeing the symbol, the listener chimpanzee was able to hand the experimenter a photograph of the food associated with that symbol. The chimpanzees also learned to emit mands for tools that could be used to open boxes baited with food.

Research with Sherman and Austin under these more rigorous environmental conditions began to demonstrate some of the complexities of human language. Initially, the mand, tact, and verbally controlled behavior had to be taught separately, but there is some evidence that these different repertoires began to become interchangeable. For example, after having learned to mand many different foods, teaching the subjects to tact these foods proved to be difficult at first, but after the subjects first learned to tact three foods at a high level of accuracy, they were able to accurately tact all of the other foods. Similar results have been reported for humans with severe mental impairments (Hall & Sundberg, 1987). Sherman and Austin were also taught to categorize items that they could tact into the categories *tools* and *food*. Initially, the subjects were taught to tact three foods with the food symbol and to tact three tools with the tool symbol (the symbols normally associated with each item were not available). After achieving 90% accuracy or better for two consecutive sessions, the subjects were tested with 10 food and tool items with which they had not been trained in categorization. Sherman correctly tacted the food and tools 9 of 10 times, and Austin did so 10 of 10 times.

As can be seen by the types of tests Savage-Rumbaugh devised, she was very interested in novel or spontaneous behavior. However, Sherman and Austin often

[2]Actually, Sherman's key pressing should be considered a selection-based tact because the specific key that evoked the selection response was controlled by a nonverbal stimulus, that is, the food item shown by the experimenters. This tact has mand-like characteristics, however, because Sherman's pressing behavior was controlled by a specific establishing operation related to getting Austin to press the correct key.

required explicit training to perform correctly. For example, it took explicit training in the initial phases to teach manding, tacting, and verbally controlled behavior. In contrast to the performances of Sherman and Austin, an infant chimpanzee named Kanzi was able to learn much easier and with much less explicit training. This was exciting to Savage-Rumbaugh and colleagues and altered their research significantly.

Kanzi. Up to now, all of the chimpanzees described have been of a particular species called common chimpanzees or *Pan troglodytes*. Another species of ape, termed bonobos, pygmy chimpanzees, or *Pan paniscus*, are slightly smaller than common chimpanzees and have longer legs, more vertically mounted skulls, and more expressive faces. They also behave differently: Bonobos can more easily walk bipedally, are more vocal, and are less aggressive. Bonobo society is more egalitarian than that of common chimpanzees, and both males and females assist in the care of the young. These descriptions of bonobo behavior and reports in Yerkes' book *Almost Human* (1925) about the significant differences in intellectual capacity between a common ape and a bonobo piqued Savage-Rumbaugh's interest in working with bonobos (Savage-Rumbaugh & Lewin, 1994). Some people claim the bonobo is the closest living relative to humans in terms of physical characteristics and behavior (Savage-Rumbaugh, 1993).

The first bonobo that Savage-Rumbaugh worked with was a female named Matata. Matata was conversed with using the symbol system, and she received particular items contingent upon the symbols she pressed. But, although Matata pointed to symbols, she did not learn to press particular symbols to mand particular items. Matata's lack of progress was discouraging to Savage-Rumbaugh. She believed Matata would easily learn language because "Matata seemed so intelligent that we assumed she would be able to tell the lexigrams apart and utilize them for communicative ends" (Savage-Rumbaugh & Lewin, 1994, p. 124). Matata's training was conducted in the presence of her adopted son Kanzi. Savage-Rumbaugh believed that work with a younger bonobo might be more successful, but systematic attempts to teach Kanzi were not conducted. However, he watched his mother perform, and, at times, he pressed the symbols on the keyboard and the experimenters treated his responses as requests. When Kanzi was 2½ years old, he was separated from Matata so she could breed with a bonobo at the Yerkes Regional Primate Research Center. According to Savage-Rumbaugh and Lewin (chap. 5), Kanzi immediately began using the keyboard correctly after his mother's departure. He apparently had learned to use the symbols that they were trying to teach his mother. This finding significantly changed the research agenda: "Given what Kanzi could already do, the only logical research strategy seemed to be to abandon any and all plans of teaching Kanzi and simply to offer him an environment that maximized the opportunity for him to learn as much as possible" (p. 137).

Learning environment. Kanzi was exposed to a language-rich environment in which experimenters talked to him with spoken English and the symbol keyboard. Because it appeared that Kanzi could respond appropriately to spoken English, the keyboard was connected to a voice synthesizer that produced spoken words appropriate to the symbols. Kanzi was encouraged to use the keyboard, but food was not made contingent on symbol acquisition (except for those explicitly related to food). Kanzi was exposed to a 55-acre outdoor environment that simulated some of the features of a bonobo's natural environment. Particular foods were placed at 17 different named locations. Kanzi was encouraged to indicate where he wanted to go using the keyboard, and the experimenters modeled this performance for him. Inside the Language Research Center, Kanzi was encouraged to help in a variety of daily activities such as changing the bed sheets, doing the laundry, and preparing food (Savage-Rumbaugh, McDonald, Sevcik, Hopkins, & Rubert, 1986). The teaching methods appear to be less structured than those used with Sherman and Austin and more like those of the previously discussed ape language projects. Savage-Rumbaugh identified the following differences in the training of Sherman and Austin and that of Kanzi:

1. Sherman and Austin were introduced to lexigrams in a training as opposed to an observational setting. Training without the opportunity to observe lasted 1 year. Beyond that time, they had many opportunities to observe and did acquire some symbols through observation.

2. Sherman and Austin's keyboard [unlike Kanzi's] was not equipped with a speech synthesizer, because tests revealed that they did not understand spoken English words. ...

3. Sherman and Austin did not use a keyboard outside the laboratory [whereas Kanzi took his throughout the day on trips in the woods.] (Savage-Rumbaugh et al., 1986, p. 215)

In spite of these differences, Savage-Rumbaugh and colleagues initially believed that the difference in performance was due to phylogenic factors: "The pygmy chimpanzee appears to possess a far greater propensity for the acquisition of symbols than other apes" (Savage-Rumbaugh et al., 1986, p. 231).

Results

Vocabulary acquisition criteria were different from those used in previous studies. Kanzi's utterances had to be spontaneous and had to show a concordance between his symbol choice and his next behavior. For example, if Kanzi pressed the "peaches" symbol, this would only be scored correct if he then chose peaches when presented with a number of foods. This concordance for a vocabulary item had to occur 9 of 10 times before it was added to his vocabulary list. Using this criterion, Kanzi had acquired approximately 50 words by the time he was 46 months old.

Savage-Rumbaugh and colleagues were very interested in Kanzi's comprehension of language. This aspect of language was probably emphasized during experimenter interactions with him. To compare Kanzi's performance to that of a human child, Alia, a 3-month-old human female, was exposed to an indoor environment very similar to Kanzi's, with a human caretaker (her mother) who both talked to her and pointed to symbols in their appropriate context. Alia was taken around the same outdoor area as Kanzi, and during these outings her caretakers talked to her and used the symbol board in the same way they did with Kanzi. Alia was exposed to the symbol board from 3 months of age, and, like Kanzi, she learned to point to the symbols. When Kanzi was 8 years old and Alia was 2, systematic comparisons of speech comprehension were conducted using 660 novel sentences. Testing for Kanzi occurred in the main laboratory where he was reared, and testing for Alia occurred in a mobile home where she had spent each weekday afternoon since she was 3 months old. The two environments were very similar, with multiple rooms containing household items. Pretests determined that subjects understood most of the individual words that would be used in the test sentences. During testing, the experimenter said a sentence such as "Kanzi, put the ball on the pine needles." There were many items in the room in addition to the pine needles and ball. The sentences presented to each subject were novel in that those specific sentences had never been said to the subject before. Also, contextual cues were eliminated by the novelty and unusualness of the sentences, and by the experimenter saying the sentence behind a one-way mirror during most of the trials. The requests were classified into 13 different types and subtypes. The following are some examples taken from Savage-Rumbaugh et al. (1993, chap. 5): Give Object X to Animate A (e.g., "Give the lighter to Rose"); do Action A on Object X (e.g., "Knife the sweet potato"); take Object X to Location Y (e.g., "Take the snake outdoors"); make pretend Animate A do Action A on Recipient Y (e.g., "Make the doggie bite the snake"). Both subjects had free access to food during the test trials. If the subject's performance was incorrect, then the experimenter helped the subject perform correctly.

The results showed that Kanzi's and Alia's performances were very similar. In many cases Kanzi outperformed Alia. Overall, Kanzi was correct on 72% of the sentences and Alia was correct on 66%. Kanzi's performance was poorer on one sentence type that is of interest from a behavioral perspective. This sentence type was of the form *Give Object X and Object Y to Animate A*. Alia performed very deliberately and accurately when given these types of sentences, but Kanzi either quickly gave both items or only one. According to Savage-Rumbaugh et al. (1986, p. 85), "Alia's behavior suggested that

she could tolerate fairly long delays before forgetting what she was to do ... whereas Kanzi could not." This is interesting because it points to the possibility that Alia may have been rehearsing the request, whereas Kanzi may have been unable to do likewise because he could not produce speech.

Savage-Rumbaugh has replicated the methods and results with other bonobos and with a female common chimpanzee. The common chimpanzee also learned language "spontaneously," but "she never fully matched the performance of the comparison bonobo" (Savage-Rumbaugh & Lewin, 1994, p. 177). But, overall, this study showed that Savage-Rumbaugh's suspicion of large differences in linguistic ability between bonobos and common chimpanzees was unjustified. She attributes the difference between the performance of Sherman and Austin and that of more recent apes to the much younger ages at which the more recent apes have been exposed to the language-rich environment. Sherman and Austin were 2½ and 1½ years old, respectively, whereas the more recent apes were exposed to human speech and the symbol system from infancy.

BEHAVIOR ANALYSIS AND APE LANGUAGE RESEARCH

After having discussed each project in some detail, the remainder of the paper will (a) discuss the opposition by the ape language researchers to a behavioral analysis of language and will point out their narrow view of what constitutes reinforcement, (b) discuss these researchers' views of language, (c) examine evidence supporting reinforcement in language acquisition, and (d) describe the methods and results of applied behavior analysts in teaching language to people with language impairments.

Ape Language Researchers Oppose Conditioning Models of Language Acquisition

The ape language researchers appear to be highly motivated to ensure that the behaviors the apes exhibit are not just "conditioned responses," but are, instead, evidence of "true" language or "symbolic" behavior. This may be because linguists have criticized this research as demonstrating nothing but conditioned responses rather than language (Fouts & Mills, 1997). Early in their research the Gardners acknowledged the importance of operant conditioning in the training of Washoe, as indicated by such statements as "The acquisition of individual signs is the aspect of this project that is most clearly related to the paradigm of S-R reinforcement theory. This paradigm had a strong influence on the tactics that we used for teaching individual signs" (Gardner & Gardner, 1971, p. 129). For example, the Gardners had difficulty in teaching the SWEET sign until they arranged the appropriate contingency. Here is the Gardners' description of the teaching procedure (Gardner & Gardner, 1971, p. 135):

> At the end of a meal ... we would make a sweet sign to her. If Washoe made a sweet sign in reply, then she received her dessert at once. ... Gradually, some acceptable version of sweet was made by Washoe at the end of meals without any prompting at all.

During shaping of the TICKLE sign with Washoe, the reinforcement for making the sign was being tickled by the experimenter. According to the Gardners (1969, p. 669), "tickling is the most effective reward that we have used with Washoe." Food reinforcers were also used. But in later writings they say that "Operant conditioning was impractical as a method of teaching signs" (Gardner & Gardner, 1989a, p. 19). The chimpanzees "learned and used the signs of ASL in an environment modelled after the living and learning conditions of a human household" (p. 23). These two statements taken together suggest that operant conditioning does not occur in human households. A likely reason for the Gardners' beliefs is that they appear to have a narrow view of what constitutes reinforcement. The Gardners claim that chimpanzees must have an inborn desire to communicate because "to the modern mind, the existence of many such inborn motives seems rather more compatible with Darwinism than the elaborate process of conditioning based on hunger and thirst that was formerly posited" (Gardner & Gardner, 1989a, p. 20). This statement betrays an underestimation of the types of unconditioned and conditioned establishing operations and conditioned reinforcement. The Gardners

also seem to believe that reinforcement is equivalent to the delivery of an edible contingent upon some behavior. For example, during the testing of the vocabulary items they claim that rewards were no longer delivered, but they later say, "Whether [the observers] ... were aware of it or not, they often revealed their approval or disapproval of a cross-fosterling's performance by smiling and frowning and by nodding or shaking their heads as well as signing such things [as] GOOD GIRL or SMART BOY" (Gardner & Gardner, 1989b, p. 188). Whether the Gardners are aware of it or not, such verbal stimuli can come to function as reinforcers or punishers even if the chimpanzees could not eat or drink the words. It seems likely the Gardners overlooked many critical independent variables.

Fouts and Mills (1997, p. 83) state, "Nobody was teaching, much less conditioning, Washoe. She was learning. There is a very big difference." Fouts claims that it is impossible to teach through reward and punishment and that, if you did, learning would be retarded. This is surprising because one of his earliest studies demonstrated that the rate of sign acquisition was related to the effectiveness of the reinforcement (Fouts, 1973). Reinforcement is alleged to negatively affect creativity as well (Fouts & Mills, 1997, p. 84): "Creativity and learning are examples of innate behavior that can only be hindered, not helped, by rewards." Another reason that behavioral theory is opposed by Fouts is that it purportedly cannot account for human language acquisition. According to Fouts and Mills (1997, p. 93), "Chomsky discredited B. F. Skinner's theory that children learn language through parental reinforcement by pointing out that children can construct completely new sentences (sentences they've never heard before) without any reinforcement at all." This particular issue will be addressed later in the paper. Fouts reported using praise and tickle play in his research for correct responses (Fouts et al., 1976), so it is difficult to understand his statements unless one assumes he, like the Gardners, equates reinforcement with the delivery of food and water.

Savage-Rumbaugh (1986, p. 121) claims that the performance of Sherman and Austin could not be accounted for in terms of conditioning processes: "It became clear to us that they were not simply organisms who learned which behaviors resulted in reinforcement and which did not." Their behavior was supposed to demonstrate "symbolic representation." For example, when they saw the symbol associated with the availability of a highly preferred food, they got excited and began emitting food barks. To Savage-Rumbaugh this meant the sight of the symbol functioned as a symbolic representation of that food. But whenever a stimulus is paired with another stimulus that has a particular behavioral function, the first stimulus often acquires that same function. In this case, the sight of preferred foods elicited food barks, and the pairing of this food with the symbol would be expected to result in the symbol's eliciting these same responses. The symbol may even elicit various conditioned perceptual responses; that is, the symbol might cause the chimpanzee to "see" and "smell" the food covertly (see Skinner, 1953, p. 266; Staats, 1996, pp. 65-66).

Sherman and Austin's behavior was also supposed to demonstrate "intentionality." When Sherman produced a symbol for Austin to see, Sherman often engaged in behaviors that would get Austin's attention. This fact is supposed to be indicative of intentionality on the part of Sherman. But it is not especially exciting or surprising that such behavior was shaped. Both subjects had to respond correctly to get the food. The fact that the chimps learned to engage in behaviors that facilitated the correct response by the other is interesting, but does not require the construct of intentionality to explain it, unless intentionality is considered as nothing more than the effects of reinforcement (e.g., Skinner, 1971, pp. 61-63). The results do show that the behavior of one chimpanzee can come under the control of the stimulus properties of another chimpanzee's behavior.

The categorical naming tasks devised by Savage-Rumbaugh, in which Sherman and Austin named items as foods or tools, were conducted to explicitly rule out cuing, conditioning, and imitation as explanations for their behavior. Explaining the categorical naming behavior of Sherman and Austin

from a behavioral perspective is somewhat complex. In cases of concept formation, the behavior of subjects, such as pigeons, is under the control of an abstract property of a stimulus, such as redness. But in the present case, what is the property controlling the behavior of Sherman and Austin? It is not difficult for Savage-Rumbaugh to explain this behavior because, for her, language is representational or symbolic. To Savage-Rumbaugh, Sherman and Austin had a representation of food and tools in their minds that aided them in choosing the correct symbol. One problem with such an explanation is that the explanatory principle (representation) was not derived from an independent experimental analysis. Rather, the explanation is circular because the only evidence for the representation is the behavior that the representation is supposed to explain. Another possibility is that the subjects selected symbols based on the behavior evoked by the presented item. For example, seeing food evokes salivation and eating behaviors. The tools evoked other sorts of behaviors, such as grasping the tool and carrying it toward a baited box. If the sight of the objects had a tendency to evoke certain behaviors, perhaps even covert ones, then these could serve as discriminative stimuli to control the selection of the appropriate category symbol. There is some evidence that this may have been the case. Before Sherman and Austin had learned the category names, they were taught to sort the items into piles of tools and food. Sherman and Austin had difficulty learning to do this. Learning was facilitated when they were prompted to engage in item-related behavior before sorting the item. When prompted to sort a food item, they were encouraged to take a small bite of food, and before sorting a tool they demonstrated the use of that tool. According to Savage-Rumbaugh (1984, p. 252), "Their sorting abilities quickly improved with this procedural change, and we were then able to drop out the bites of food and the demonstration of tool use." Although the present interpretation in terms of response mediation is speculative, it is constrained by principles that have been identified through prior experimental analyses. In this sense, the explanation is more parsimonious than one that invokes unspecified principles such as mental representations. Constraining explanatory mechanisms to those identified through prior experimental analyses is a characteristic of behavior-analytic interpretation (Donahoe & Palmer, 1994).

It is also interesting to note that the ape language researchers strongly criticize each other's research as demonstrating nothing but "conditioned responses." Terrace (1979) concluded of the Hayes' work in getting Vicki to say a few words: "What the Hayeses showed was that a chimpanzee could learn some unnatural tricks in order to obtain a reward" (p. 13). Terrace was skeptical of the evidence from the other ape language researchers that "implied that a chimpanzee could create sentences or that their motivation to use language was sufficient to allow them to engage in conversations about things other than their basic needs" (p. 32). Terrace said of Rumbaugh's work with Lana (p. 28), the findings "suggested that through rote repetition chimpanzees, like many animals studied in conditioning experiments, were capable of learning a chain of responses," and of Savage-Rumbaugh's work with Kanzi, "All the evidence suggests that the animals are using sophisticated ways to request things" (Terrace, 1990, p. 68). As discussed earlier, Terrace et al. (1979) concluded that Washoe's behavior was largely imitative and the product of extensive drills. For example, the Gardners used Washoe's utterance NAOMI GOOD as an example of attribution, but according to Terrace et al. (1979, p. 899), this interpretation "would be appropriate only in the absence of the kinds of prompting and reward shown in the films of Washoe signing."

Somewhat surprisingly, the Gardners and colleagues made the same types of criticisms of Terrace's work as Terrace made of theirs (Gardner & Gardner, 1989a). The Gardners criticized the work of Terrace as simply involving operant conditioning (as contrasted with their own work): "Eventually, a prominent student of B. F. Skinner [Herbert Terrace] fielded a rigorously operant version of Project Washoe, with the chimpanzee Nim" (p. 21). Although Terrace concluded that Nim's signing was not like human language, the Gardners contended that their

chimpanzees did exhibit human-like language. But, the Gardners agreed with Terrace that Nim's signing was not language, and they blamed this on Terrace's operant methods: "The relentless application of extrinsic incentives evoked the extrinsic responses that stifled communication" (p. 22). The Gardners said of the Rumbaughs' work,

> The lack of spontaneity and communication and the difficulties that the Rumbaughs had in transferring Lana, Sherman, and Austin from step to step in their program of "language-learning" are typical of the successes and failures of other rigorous applications of operant behaviorism. Where they relaxed operant rigor as in the case of the pygmy chimpanzee, Kanzi, the Rumbaughs themselves obtained dramatically more advanced results. (Gardner & Gardner, 1989a, p. 23)

At one brief moment in her career, Savage-Rumbaugh described her work using a behavioral framework – specifically, she analyzed her results with Sherman and Austin using the verbal operants as outlined by Skinner in *Verbal Behavior* (1957) (Savage-Rumbaugh, 1984). It appears that Savage-Rumbaugh used behavioral principles and explicit teaching techniques only when less intensive procedures did not work. Savage-Rumbaugh, Romski, Hopkins, and Sevcik (1989, p. 272), in characterizing their work with Sherman and Austin, state, "Individual training tasks are utilized as needed to promote vocabulary acquisition when modeling proves insufficient." Even though she used behavioral principles to some extent with Sherman and Austin, she did not view their behavior as conditioned responses. This is evident in the title of her 1986 book *Ape Language: From Conditioned Response to Symbol*. In this book she discusses the limitations of a behavioral analysis, and characterizes the approach of the Gardners as a reinforcement model (pp. 83-84). Savage-Rumbaugh and Lewin described how Washoe was taught this way:

> The Gardners and their helpers taught Washoe a limited ASL by molding her hands into the appropriate sign in the presence of an object. She was often rewarded for success with a tidbit of food. It was a laborious business, requiring repeated presentation of the object and repeated molding of the hands. (1994, p. 38)

Before starting her work with Sherman and Austin, Savage-Rumbaugh worked under Roger Fouts' supervision with Washoe. This was after the Gardners' work with Washoe. Savage-Rumbaugh was skeptical that Washoe actually comprehended language. She was also skeptical of the explicit training methods, for she notes (Savage-Rumbaugh & Lewin, 1994), "I didn't have to drill object-sign associations with my son, Shane. Words just popped into his vocabulary" (p. 46). Once Savage-Rumbaugh discovered that less explicit procedures were effective with infant apes, she dropped the explicit training. Like the Gardners, Savage-Rumbaugh repeatedly points out that Kanzi's behaviors were not explicitly taught and are more than conditioned responses. The following quotes from Savage-Rumbaugh and Lewin will illustrate:

> This ape, a bonobo named Kanzi, began to learn language on his own, without drills or lessons. (p. x)
>
> I vigorously objected to the idea that Kanzi had been trained to do anything. (p. 27)
>
> [In describing her results with Sherman and Austin] I knew that linguists would dismiss it all as unimportant because syntax was not required and that some sort of conditioning explanation would be evoked by behaviorists. (p. 69)
>
> One issue that undoubtedly had provoked the behaviorists' attack was my conclusion that Sherman and Austin were exhibiting conscious intentionality during their communication – a clear red flag to those who believe behavior should simply be viewed as responses to external stimuli. (p. 83)
>
> Once apes could make statements about their intentions, and then carry out such statements appropriately, their behavior could no longer be explained by condition-response chains. (p. 127)
>
> [The lesson] we learned from the project with Kanzi, Mulika, Panbanisha, and Panzee ... was that chimpanzees can acquire language spontaneously, through social exposure to a language-rich environment, as human children do. (p. 177)

From Savage-Rumbaugh et al. (1993):

> 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 independently of semantic and syntactic comprehension. (p. 98)

And from Savage-Rumbaugh (1987, p. 288):

> The goal of the Language Research Center has been to develop programs which go beyond the limitations of instrumentally conditioned response patterns, to communications that are representational. Because receptive language ac-

> quisition of the spoken word occurred spontaneously, it cannot be even partially explained by an instrumental account. (p. 289)

Savage-Rumbaugh and colleagues believed that Kanzi's language acquisition was spontaneous. Like the Gardners, one of the reasons for this belief may be their narrow view of the nature of reinforcement. M. Sundberg (1996) clearly documents the role of reinforcement and training (e.g., prompting and fading) in Savage-Rumbaugh et al.'s (1993) work with Kanzi. In addition, he points out that for Savage-Rumbaugh and colleagues, reinforcement consists of "the programmed delivery of edible items following the targeted behavior" (p. 482). Because the role of reinforcement and training with Kanzi is clearly described by Sundberg, this issue will only briefly be covered here. The following is a transcript from a videotape of Kanzi (Savage-Rumbaugh, 1993):

> Savage-Rumbaugh: "Can you get a wipey out?"
>
> Kanzi picks up a different object.
>
> Savage-Rumbaugh: "Kanzi stop playing with things you want to play with." She grabs the item away from Kanzi. "Just stop. Just stop. Stop."

Such interactions clearly demonstrate the role of conditioned punishment (verbal reprimands) and unconditioned punishment (the removal of a desired object). The verbal reprimands would become conditioned punishers because of the pairing with other punishers (e.g., the removal of the desired object). In other scenes, Kanzi appears to get gum for participation, or he gets to take a break. Kanzi received verbal praise for every correct answer. It seems likely that similar events took place with the apes in the other research projects discussed in this paper.

In summary, reinforcement and training are likely to have been important independent variables despite the researchers' lack of description or recognition of these phenomena. For example, much of Sherman and Austin's behavior can be accounted for by behavioral principles, and an analysis of videotapes of Kanzi's performance indicates that reinforcement and punishment were involved in his training. The Gardners downplay the role of reinforcement in later writings, but their earlier writings suggest that reinforcement was important. The Gardners, Fouts, and Savage-Rumbaugh have a narrow view of reinforcement consisting of the delivery of edible items. The Gardners praised the subjects for correct responses, and the delivery of items was contingent on the chimpanzee's signing. Fouts used praise and tickling in his research. Terrace did consciously use some behavioral principles, but the limited frequency of Nim's multiword utterances can easily be attributed to a lack of contingencies supporting correct multisign utterances. Reasons for deemphasizing and avoiding a behavioral approach to language can be found in the ape language researchers' views of language.

How the Ape Language Researchers View Language

Terrace is highly critical of behavioral explanations of children's language acquisition (Terrace, 1985). He believes that the main reason for the emission of language is the transmission of information, and that, if we conceptualized the transmission of information as reinforcement, "to do so is to engage in yet another unrewarding exercise of generating circular definitions of reinforcement" (p. 1017). It is unclear whether Terrace is aware of Skinner's analysis of this issue (Skinner, 1957, pp. 151-152). Although Terrace concluded that neither Nim nor any other ape has demonstrated the motivation to transmit information for its own sake, the Gardners believe that "Chimpanzees are among the many species that behave as if they were born with a powerful motive to communicate," and that humans also have this desire: "Normal human children learn to speak as if they were born with a powerful motive to communicate; no other incentive seems to be necessary" (1989a, p. 20). Similarly, Fouts and Mills (1997, p. 85) believe many species of infants are "born with a powerful drive to learn whatever system of communication ... [they] will need to socialize, mate, and breed." Savage-Rumbaugh et al. (1993) do not believe that the motivation for language production is innate, but that the motivation for language comprehension is, and that this naturally leads to production. The following

statement illustrates this point when describing some research with humans:

> The fact that comprehension did *not* require reinforcement supports the view that comprehension is the driving force underlying all language acquisition and that the motivation for comprehension lies in the listener's desire to predict what the speaker is going to do as a consequence of having produced a particular utterance. (p. 19)[3]

Terrace further believes that an essential component of "true" language is a grammar (although this emphasis has been tempered, see Terrace, 1985). Terrace (1979, p. 10) states, "In humans the capacity to learn words is secondary to the ability to combine and recombine them to create new meanings." There is some suggestion that he believes that there is an innate ability related to learning grammar (p. 11): "Most people learn to talk correctly without any awareness of the grammar needed to generate the sentences they produce. The important thing is to recognize that our ability to create and comprehend sentences presupposes an ability to conform to a grammar." Indeed, Terrace's training of Nim supports the notion that he believed the rules of grammar or the ability to learn grammar is innate because he explicitly did not want Nim's teachers to teach him to talk in sentences.

Savage-Rumbaugh and colleagues believe that language is symbolic or representational. In explaining symbolic behavior, Savage-Rumbaugh, Rumbaugh, and Boysen (1980, p. 51) quote Pylyshyn (1977). In part the quote read,

> To name an object implies that the object has been conceptually singled out or wrenched from its context and is available for arbitrary cognitive activity. Thus, for a child to acquire even something as apparently simple as the name of an object is already a highly cognitive activity.

Later Savage-Rumbaugh et al. (1980, p. 59) state,

> We see true symbolization as the use of arbitrary symbols to refer to objects and events that are removed in time and space. This implies "a view of the outside world as separable into things which maintain their identity and which can be manipulated in the mind, so that even actions and properties are reified into words" (Bronowski & Bellugi, 1970).[4]

In later writings Savage-Rumbaugh et al. (1993) have downplayed this internal symbolic approach to language. For example they state, "if one focuses on the kinds of things that apes have learned to accomplish with symbols and; shor combinations of symbols, rather than assessing the nature of their internalized `referents,' one then has a direct basis for measuring linguistic competence" (p. 15). This representational view of language often leads such people to overlook the different functional components of verbal behavior (e.g., tacts, mands, etc.) and behavior controlled by verbal stimuli. For example, many programs used to teach language to language-delayed people focus on receptive language and assume that appropriate training will teach them the symbolic meaning of words that they should then be able to use productively. In the opposite direction, Terrace and the Gardners focused on teaching some mands and tacts without teaching the other verbal operants and bringing the subject's behavior under the control of verbal stimuli. But Savage-Rumbaugh has, to some extent, recognized the difference and interdependence among these repertoires (Savage-Rumbaugh, 1984, 1986).

Because the ape language researchers have ignored or downplayed the role of training and reinforcement, it is difficult to determine the role of behavioral principles in the ape's language acquisition. The usefulness of the research also comes into question, especially for those interested in teaching language to people with language deficits. How does it help us to better understand language acquisition when the independent variable is described as a "speech-rich environment"? This sentiment was carefully stated by M. Sundberg (1996, p. 485):

[3]Alternatively, one might say that the speaker's reaction to the listener's behavior is an important source of reinforcement for the listener's behavior. This sort of explanation does not require an innate motive. The quote is another example that illustrates the narrow view the ape language researchers have of reinforcement.

[4]This quote and the preceding one, although unsatisfactory descriptions of language from a behavioral view, do point out an important feature of verbal behavior – that it can be relatively free from environmental and temporal restrictions. For example, we can talk about events occurring together that could never occur together in the nonverbal environment. See Skinner (1957, chap. 19) for a discussion of these aspects of verbal behavior.

> Unfortunately, the research methodology employed in the study [Savage-Rumbaugh et al., 1993], 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).
>
> 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. ... 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 reasonable that the true absence of any of these variables would indeed affect acquisition.

The ape language researchers' emphasis on cognitive strategies and motivational states that are the product of a certain biology as the key ingredients to language acquisition results in reduced attention to the details of the environment. Unfortunately, the ape language researchers may be ignoring certain findings that result from a careful analysis of the verbal environment.

The Role of Reinforcement in Language Acquisition

There is a fair amount of evidence supporting the role of reinforcement in language acquisition with normal human children. For example, Moerk (1990), in a reanalysis of Brown's data (Brown, 1973) on mother-child verbal interchanges, found many instances of modeling and reinforcement by the parent and imitation by the child. Whitehurst and Valdez-Menchaca (1988) demonstrated that 2- to 3-year-old children learning a second language acquired the names for toys only when the reinforcement consisting of the receipt of the toy was contingent on the child's naming of the toy. A control group that did not receive such reinforcement but equal exposure to the name of the toy did not learn its name. Although such explicit reinforcement procedures are probably not necessary in all cases, this study suggests the important role reinforcement can play in language acquisition. Infant vocal responses are subject to operant contingencies as well. Routh (1969) divided 30 2- to 7-month-old infants into three groups. One group received reinforcement for consonant vocalizations, another for vowel vocalizations, and the last for any type of vocalization. The reinforcement consisted of a smile, three "tsk" sounds, and light stroking of the infant's abdomen. The target response increased for each group relative to baseline. These studies also show that the range of reinforcers exceeds the food and water reinforcers considered by the ape language researchers. Furthermore, an infant's nonnutritive sucking can be reinforced by the contingent delivery of speech sounds (Trehub & Chang, 1977). It has even been demonstrated that the mother's voice functions as a stronger reinforcer for infant behavior than another female voice (DeCasper & Fifer, 1980). What role might these human voice reinforcers serve in infant language acquisition? One possibility is that these sounds could serve as conditioned automatic reinforcement for the vocalizations of the infant. When the infant, through its random babbling, produces a sound that approximates the sounds of the parents, then this response should be reinforced by hearing the sound. Presumably, the parents' voices are paired with many other reinforcers, such as warmth, food, play, touch, toys, removal of discomforts, and so on. This should establish the sounds of the parents' voices as conditioned reinforcement, as strongly suggested by the previously discussed research. M. Sundberg, Michael, Partington, and Sundberg (1996) demonstrated such a phenomenon with 5 children between the ages of 2 and 4 years who had severe to moderate language delays. The experimenter made a sound and paired it with tickling the child. After this pairing, the children's utterances of these sounds, but not other sounds, increased relative to baseline. This phenomenon was replicated with 2 normally developing female infants (aged 11 and 14 months) and was extended by demonstrating conditioned automatic punishment (Smith, Michael, & Sundberg, 1996). In this study, sounds were

either paired or not paired with an effective form of reinforcement (e.g., bubbles or tickles) or conditioned punishment (the experimenter saying "bad girl"). Overall, the pairings produced the predicted effects. Conditioned automatic reinforcement could possibly play an important role in vocabulary acquisition. If imitating the actions or speech of caretakers is automatically reinforced, then this lessens the need for extrinsic reinforcement delivery by the caregivers. The concept of conditioned automatic reinforcement is completely ignored or not understood by the ape language researchers. This fact, in addition to their lack of knowledge of unconditioned establishing operations, conditioned establishing operations, conditioned reinforcers, conditioned punishers, and basic behavioral repertoires (Staats, 1996), may explain a large part of why they see behavioral explanations as so implausible.

Fouts cites the fact that children construct novel sentences as evidence that reinforcement is not involved in language acquisition. Skinner (1957, p. 336) explained this type of behavior with an example of a boy making a novel verbal response:

> If he has acquired a series of responses such as the boy's gun, the boy's shoe, and the boy's hat, we may suppose that the partial frame the boy's _____ is available for recombination with other responses. The first time the boy acquires a bicycle, the speaker can compose a new unit the boy's bicycle. This is not simply the emission of two responses separately acquired. The process resembles the multiple causation of chapter 9. The relational aspects of the situation strengthen a frame, and specific features of the situation strengthen the responses fitted into it.

Of course research is needed to confirm Skinner's analysis, but in the absence of such data, the interpretation is logically consistent with known behavioral principles.

A Behavioral Approach to Language Training

To their credit, Rumbaugh and Savage-Rumbaugh have used their findings with apes to develop training programs for people with speech deficits (Savage-Rumbaugh & Lewin, 1994, chap. 7). They have used symbol boards, similar to those used with the apes, to teach people with little or no prior language to point at the symbols on the board as a form of language. Their work has further contributed to the use of pointing systems with nonverbal humans. Similarly, Fulwiler and Fouts (1976) taught sign language to a noncommunicative child with autism. This research has encouraged behavior analysts to teach sign language to people with developmental disabilities (e.g., Faw, Reid, Schepis, Fitzgerald, & Welty, 1981; Lovaas et al., 1981, chap. 24). Behavior analysts have even conducted experiments comparing pointing systems with sign language (e.g., C. Sundberg & Sundberg, 1990; M. Sundberg, 1993).

Although behavior analysts have taken advantage of some of the findings from ape language research, the ape language researchers seem to be unaware of the highly effective teaching methods that have been developed for teaching language to adults and children with developmental disabilities and language delays. In particular, the intensive behavioral treatment of young autistic children has important implications for traditional theories of language and the treatment of language-delayed children. This research also has important implications for ape language research because it clearly demonstrates the effectiveness and importance of behavioral principles in language acquisition. There is a growing body of evidence for the effectiveness of intensive behavioral interventions for young autistic children (Anderson, Avery, DiPietro, Edwards, & Christian, 1987; Birnbrauer & Leach, 1993; Harris, Handleman, Gordon, Kristoff, & Fuentes, 1991; Lovaas, 1987; Lovaas, Koegel, Simmons, & Long, 1973; McEachin, Smith, & Lovaas, 1993; Sheinkopf & Siegel, in press). Lovaas (1987) found that 47% of young autistic children achieved normal intellectual and educational functioning after approximately 2 years of 40 hours per week of intensive behavioral treatment. These children also performed successfully in the first grade. In the control group, only 2% of the children achieved normal educational and intellectual functioning. It should be noted that the speech of children in both groups was absent, abnormal, or abnormally low at the start of treatment. Similarly, Sheinkopf and Siegel (as cited in Maurice, Green, & Luce, 1996) found that of two groups of children with

autism initially matched in intellectual functioning, the group who received just under 20 hours of intensive behavioral treatment per week had significantly higher mental ages and IQ estimates after treatment than matched children in the control group. The effectiveness of the behavioral programs for autism are not limited to this disorder. Similar methods have been successfully used with children with mental retardation, Down syndrome, and language delays (Bijou, 1983; Drash, 1982; Drash & Tudor, 1990).

The teaching methods utilized in the behavioral treatmeent of autism have been described in a number of treatment manuals (Lovaas, 1977; Lovaas et al., 1981; Maurice et al., 1996). Interestingly, the techniques contain a number of features the Gardners and Fouts explicitly argue against. In general, the treatment involves using behavioral techniques to teach all of the behaviors children usually learn in their natural environment, but, for whatever reason, are not learned by children with autism. The treatment is broken up into trials in which stimuli are presented, responses are shaped and prompted (if necessary), and reinforcement is delivered contingent on correct responding. The Gardners and Fouts claim that repeated trials and reinforcers are harmful for language acquisition. In behavioral treatment, on the other hand, repeated trials and reinforcers are an essential component of teaching. In describing the use of extrinsic reinforcers with the chimpanzees, the Gardners (1989a, p. 20) say that "the extrinsic rewards usually had to be discontinued because their main effect was to interfere with the intrinsically motivated task at hand." They also said that treats distracted the subjects and had to be discontinued (Gardner & Gardner, 1989b). This can also happen with children with autism. Initially, the presence of some reinforcer may evoke grabbing or crying for it, but these responses can easily be extinguished by only delivering the reinforcer contingent on the target behavior. Although the Gardners were highly critical of Skinner's personal letter to them, the Gardners' ineffectiveness in proper use of reinforcers suggests that Skinner was right when he wrote to them,

> I recently saw your Nova program and want to congratulate you. I have done enough of that sort of thing myself to know how difficult it is ... [however] I was quite unhappy about your new recruits – the young people working with the new chimps. They were not arranging effective contingencies of reinforcement. Indeed, they were treating the subjects very much like spoiled children. A first course in behavior modification might save a good deal of time and lead more directly to results. (personal communication, May 24, 1974) (from Gardner & Gardner, 1989a, p. 21)

In fact, both of the Gardners' projects were terminated because the chimpanzees had become too difficult to handle. Chimpanzees may be biologically disposed to behave in aggressive and difficult-to-manage ways, but the behaviors could at least partly be explained by the ineffective arrangement of contingencies by the Gardners.

Findings from applied and basic behavior analytic research can be used to make a number of recommendations for future ape language research. First, ape language research would benefit from a greater utililization of behavioral principles and the identification of relevant environmental variables in terms of behavioral principles. The importance of behavioral principles is evident in the research reviewed on the role of reinforcement in language acquisition and in the effectiveness of behavioral programs to teach language. Not only may the utilization of behavioral principles lead to even greater results, but the identification of environmental variables in terms of behavioral principles may provide greater detail of functional variables in the environment that are important to language acquisition. Important findings could then be more easily extended to work with people with language delays.

Second, the appreciation and direct teaching of different verbal repertoires should become a part of ape language research. This point has been realized to an extent by Savage-Rumbaugh but not by the other ape language researchers. The broadest distinction can be made between listener and speaker behavior, but speaker behavior can be further broken down – for example, into Skinner's verbal operants (Skinner, 1957). Hall and Sundberg (1987) demonstrated the independence of the mand and the tact by showing that the teaching of tacts to mentally retarded subjects did not necessarily

lead to their ability to mand for those same objects. The independence of tacts and intraverbals has also been demonstrated (Partington & Bailey, 1993). The establishment of certain repertoires can also play an important role in further language development. For example, after acquiring an echoic repertoire (or, in the case of ape language, an imitative repertoire), the acquisition of other verbal repertoires (e.g., tact, mand, intraverbal, and codic) can occur by taking advantage of this repertoire in teaching (e.g., see Lovaas, 1977). Horne and Lowe (1996) also point to the importance of prior repertoires in language acquisition. Specifically, they identified a new unit of verbal behavior that they call *naming* or the *name relation*. The name relation is composed of or derived from the interaction of listener, echoic, and tact repertoires. According to Horne and Lowe, once the child has acquired the three repertoires and they occur in combination, the acquisition of new tacts and listener behavior can proceed more rapidly. For example, if the child does not have the tact for shoe, the caregiver merely saying *shoe* in the presence of the shoe will be sufficient for the child to acquire the tact, *shoe*. This is because the child has learned to echo what the parent has said while orienting towards the object the parent is looking at. Horne and Lowe hypothesize that the establishment of the name relation is responsible for the naming explosion often seen with children:

> According to the present account, it may not be possible for many new names to be acquired until a critical number of echoic relations, with differing phonetic characteristics, have been learned. As the number of these echoic relations in the repertoire increases, the combinatorial possibilities for producing more name utterances rises exponentially. (p. 202)

Naming may also facilitate the development of new listener behavior. For example, if the child has learned listener behavior with respect to chairs, such as sitting on them, when the child is told that an unusual piece of furniture is a chair, appropriate listener behavior can be evoked. In other words, acquiring the tact of an object may evoke correct listener behavior to that object, if listener behavior has previously been established with respect to objects with that name. Not only can previously established repertoires facilitate the development of new repertoires, they can also hinder them. Noncompliant and disruptive behaviors can impede the development of appropriate language behavior (Drash & Tudor, 1993). These types of behaviors may have played a negative role in ape language research. Staats (1968, 1996) explores in detail the relationship between prior repertoires and further learning.

Third, if a response has been acquired and the controlling variables for that response are unknown, conduct a functional analysis to identify the controlling variables. Throughout much of the ape language research there are anecdotal reports of complex language behavior on the part of the apes, such as cursing, metaphoric extension, and humor. For example, when Washoe signed WATER BIRD upon seeing a duck, the Gardners interpreted this as a functional tact unit, but Terrace pointed out that Washoe could have been tacting the water and the bird. The controlling variables for such responses need to be more closely identified. Only through systematically manipulating the apparent controlling stimulus under different contexts could we be sure that WATER BIRD, in this case, is a functional unit.

CONCLUSION

Why have the ape language researchers been so resistant to a behavioral approach to language? First, their views on language are in conflict with a behavioral approach. In essence, they believe language is due to the cognitive or motivational aspects of the subject, which is the product of genetics. The only thing the environment has to provide is a language-rich experience. In some respects, this view is similar to Chomsky's (1988), even though Chomsky's views are strongly criticized by some of these researchers (e.g., Fouts & Mills, 1997; Savage-Rumbaugh & Lewin, 1994; Savage-Rumbaugh et al., 1993). The difference seems to be in the degree of exposure each believes is necessary. Chomsky believes less exposure is sufficient, whereas both the ape language researchers and Chomsky stress the importance of biology and cognitive capacity. Biology undoubtedly plays a critical role in an organism's acquisition of language, but an emphasis on biology may lead to a neglect

of the environment. Second, because most language scholars believe that language is due to much more than a conditioning history, critics of the ape language research will readily point out whether such conditioning has occurred, and, therefore, claim the research has no importance to human language. This type of criticism is clearly seen in the criticisms by Terrace of the work of the other ape language researchers.

If apes are so similar to humans, then it should not be surprising if they, like human children, respond positively to behavioral treatment. It is interesting to note that research on effective learning principles with normal children supports taking an approach similar to that taken with children with autism and other language disabilities. Becker (1992, p. 92) comments on the similarity of findings between research on effective instruction and behavior theory: "This body of research [on effective instruction] is quite consistent with what we know about effective learning conditions from behavior theory – get attention, present instruction, get lots of student responding, monitor the responding, reinforce and correct, etc." I think it would be prudent for the ape language researchers to consider such methods in their teaching.

In conclusion, ape language research has demonstrated that apes can acquire a relatively small verbal repertoire, and their behavior can come under the control of verbal stimuli under conditions similar to those that establish such behavior in human children. Ape research can (and has to a limited extent) play an important role in understanding human language. However, the ape language researchers have not identified the critical variables that are responsible for language acquisition. This is disappointing because a careful exploration of the environmental variables that are responsible for language, which would be difficult to conduct with human children, might be conducted with apes. It is hoped that future ape language researchers will more systematically identify the functional variables in the environment that establish language and will adopt teaching principles that have proven to be so effective with humans.

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