In the Beginning Was the "Name"

H. S. Terrace *Columbia University*

ABSTRACT: In emphasizing the ability to generate sentences as a uniquely human skill, psycholinguists have overlooked an equally important and perhaps more fundamental skill—the ability to refer with names. The same oversight can be attributed to the first generation of projects devoted to teaching an ape to use a language. In the absence of referential naming, it is doubtful that syntax would have developed in human languages. Accordingly, students of human language, as well as those researchers who seek to establish linguistic skills in nonhuman subjects, for example, Savage-Rumbaugh and her associates, should reap handsome dividends by continuing their efforts to examine critically the ontogeny of naming. At least as much as any other ability, the ability to name has provided a unique impetus to the evolution of human language.

Recent attempts to teach apes basic features of human languages and the reactions to such efforts constitute an unusual chapter in the history of psychology. Few, if any, research programs that have generated such widespread interest have had to endure a subsequent reaction that has bordered on benign neglect. The reasons for this abrupt succession of attitudes are numerous and complex. It is, however, not too much of an oversimplification to observe that a major factor was the emphasis that these studies placed on demonstrating grammatical competence in apes.

That emphasis, which reflected the strong focus of psycholinguists during the 1960s and 1970s on the grammatical competence of children, stimulated ape language projects to set goals for themselves that were unrealistically ambitious. Appraisals of these projects focused almost exclusively on the extent to which they succeeded in training an ape to acquire certain rudimentary grammatical rules. (See Mounin, 1976, and Terrace, 1979a, for exceptions.) As a result, some essential nongrammatical aspects of language use by apes were neglected, both by the researchers who conducted those projects and by their critics.

The current negative attitude toward research on an ape's linguistic ability is unfortunate if for no other reason than that attention may be diverted from important aspects of an ape's ability to communicate symbolically, however primitive that ability may be. Crucial to our understanding of human language is a clear specification of the differences (and similarities) that exist between human and nonhuman use of symbols. In a later section of this article, I will discuss some recent studies that pose more productive comparisons of human and pongid linguistic competence than those posed by earlier studies. Before turning to that work, I will try to make clear why and how earlier research on language learning by apes went awry. (See Ristau & Robbins, 1982, for a thorough summary of the literature on attempts to teach language to apes.)

Initial Goals and Findings of Studies of Ape Language

Though differing in details of methodology and in the explicitness of their initial goals, the independent projects started by the Gardners (1969, 1975a, 1975b) and by Premack (1970, 1971) shared a common point of departure. Both sought to reverse earlier failures to teach chimpanzees to communicate with spoken words by shifting from a vocal to a visual medium of communication. Given Lieberman's observation that the human and chimpanzee vocal apparatuses differ significantly (Lieberman, 1968, 1975), it seemed reasonable to appeal to a chimpanzee's inability to articulate human phones as an explanation of various failures to teach home-reared infant chimpanzees to speak English or Russian (Hayes, 1951; Hayes & Hayes, 1951; Kellogg & Kellogg, 1933/1967; Khouts, 1935).

The Gardners sought to reverse those failures by teaching a chimpanzee to use American Sign Language (ASL), a natural language used by thousands of deaf Americans. ASL was the main medium of communication between Washoe (an infant female chimpanzee) and her caretakers and between the caretakers themselves while in Washoe's presence. Premack, who started an independent project at roughly the same time the Gardners began theirs, taught the principal subject of his study (a juvenile female chimpanzee named Sarah) to use an artificial visual language consisting of plastic chips of different colors and shapes. Rather than waiting for language to emerge spontaneously, as one might with a child or with a home-reared chimpanzee, Premack devised specific training procedures for teaching Sarah various "atomic" components of language.

Researchers studying ape language accepted as a given the prevailing working assumption of psycholinguists that human language makes use of two levels

Copyright 1985 by the American Psychological Association, Inc. 0003-066X/85/$00.75
Vol. 40, No. 9, 1011-1028

of structure: the word and the sentence. In contrast to the fixed character of various forms of animal communication (e.g., bird songs that assert the presence of food or a readiness to mate or bee "dances" that specify the location of a food source with respect to the hive), the meaning of a word is arbitrary. One must keep in mind, however, that even though apes can learn substantial vocabularies of arbitrary symbols, there is no a priori reason to regard such accomplishments as evidence of human linguistic competence. After all, dogs, rats, horses, and other animals can learn to produce arbitrary "words" to obtain specific rewards.

A second level of structure, one that subsumes the word (Chomsky, 1965), is generally regarded as the essential feature of human language. Sentences characteristically express propositions through words and phrases, each bearing particular grammatical relations to one another (actor, agent, object, and so on). Psychologists, psycholinguists, and linguists are in general agreement that using a human language indicates knowledge of a grammar. How else can we account for a child's ultimate ability to create an indefinitely large number of meaningful sentences from a finite number of words?

In an early diary report, the Gardners noted that Washoe used her signs "in strings of two or more . . . in 29 different two-sign combinations and four different combinations of three signs" (quoted in Brown, 1970, p. 211). That report prompted Brown (1970) to comment, "It was rather as if a seismometer left on the moon had started to tap out 'S-O-S' " (p. 211). Indeed, Brown compared Washoe's sequences of signs to the early sentences of a child and noted similarities in the structural meanings of Washoe's and children's utterances (agent–action, agent–object, action–object, and so on).

Other projects reported similar combinations of two or more symbols. Sarah produced strings of plastic chips such as "Mary give Sarah apple" (Premack, 1976). Lana, a juvenile female chimpanzee, was trained to use an artificial visual language of "lexigrams." Each lexigram, which is a combination of a particular geometric configuration and a particular colored background, was presented on the keys of a computer console or on a large visual display. After learning to use individual lexigrams, Lana learned to produce sequences of lexigrams such as "Please machine give M & M" (Rumbaugh, Gill, & von Glasersfeld, 1973). Subsequently, two young gorillas (Koko and Michael) and a young male orangutan (Chantek) were trained to use signs of ASL by Patterson (1978, 1981) and Miles (1983), respectively. Both investigators reported that their subjects produced many combinations of two or more signs.

By the late 1970s, much evidence had accumulated purporting to show that apes were capable of creating sentences. Specifically, it was claimed that an ape could produce new meanings by combining words according to grammatical rules. The importance of demonstrating grammatical competence in an ape was underscored by the focus of psycholinguists at that time on formal descriptions of the syntax of human languages and on claims that the ability to master a grammar was uniquely human (cf. Chomsky, 1965, 1966).

The various investigators studying language use by apes were, of course, keenly aware that unequivocal evidence that an ape could create sentences would blur profoundly the distinction between human and animal intelligence. An especially intriguing possibility was the unprecedented opportunity one would have to study the emergence of culture in a group of linguistic apes. Failing that, it might be possible to learn, through direct linguistic communication between an ape and its human teacher, how another organism thinks and how it views the world (Terrace, 1979b). Given these and related questions of obvious interest, we can easily understand the unusual attention that was directed at efforts to establish grammatical competence in an ape.

Nonsyntactical Interpretations of an Ape's "Sentences"

The Imitative and Nonspontaneous Nature of an Ape's Signing

By 1980, it was apparent that "sentences" created by apes could be explained without reference to grammatical competence. My associates and I analyzed approximately 20,000 combinations of two or more signs made by Nim, a young male chimpanzee who, like Washoe, had been reared by his human surrogate parents in an environment in which ASL was the major medium of communication (Terrace, 1979b; Terrace, Pettito, Sanders, & Bever, 1979). Superficially, many of Nim's combinations appeared to be generated by simple finite-state grammatical rules (e.g., *More* + *x*; *transitive verb* + *me* or *Nim*). Taken by themselves, such combinations provided the strongest available evidence that an ape could create a sentence. Indeed, many of Nim's multisign utterances resembled a child's initial multiword utterances (cf. Braine,

I thank Lois Bloom, Patricia Greenfield, Roy Harris, Barbara Landau, John Marshall, Rodney Needham, Duane Rumbaugh, and Joel Wallman for helpful comments on earlier drafts of this article. Preparation of this manuscript was supported in part by grants from the National Science Foundation (BNS 82-02423) and from the National Institute of Child and Human Development (06016), a gift from the Mrs. Cheever Porter Foundation, and fellowships from All Souls College, Oxford, England, and from the Fulbright Commission.

Requests for reprints should be sent to H. S. Terrace, Department of Psychology, Schermerhorn Hall, Box 27, Columbia University, New York, NY 10027.

1976; Bretherton, McNew, Snyder, & Bates, 1983; Nelson, 1981). However, a frame-by-frame analysis of videotapes of Nim's signing revealed that Nim responded mainly to the urgings of his teacher that he sign and that much of what he signed was a full or partial imitation of his teacher's prior utterance(s).

Although young children clearly imitate many of their parents' utterances, the relative frequency of imitated utterances is substantially lower in children. Further, although the imitative phase in children is transitory, Nim never moved beyond that phase (Terrace et al., 1979). Thus, unlike a child's speech at the end of Stage I of language acquisition (cf. Bloom, Rocissano, & Hood , 1976; Brown, 1973), Nim's signing remained predominantly nonspontaneous and imitative. Analyses of the available films of other signing apes revealed similar patterns of nonspontaneous and imitative discourse (e.g., Washoe signing with the Gardners and her other teachers, and Koko signing with Patterson).

The conclusions of Project Nim were criticized on various methodological grounds by other investigators attempting to teach an ape to use sign language, for example, Gardner (1981) and Patterson (1981). However, these investigators have not revealed enough of the procedures followed on their own projects to allow one to evaluate the significance of their criticisms of Project Nim (Terrace, 1981, 1982a). Of greater interest is the fact that my conclusions have yet to be countered with positive evidence. With one exception, to be noted below, no transcripts of unedited videotapes or films have been presented that show that an ape's combinations are spontaneous and that they are not whole or partial imitations of the teacher's most recently signed utterance.

Miles (1983) performed a discourse analysis of videotapes of the orangutan Chantek signing with his teachers. She reported that 37% of Chantek's utterances were spontaneous. However, Miles also noted that "Chantek's multi-sign combinations have not yet been analyzed for any evidence of grammar or rule following behavior, so there is no evidence that these sequences are sentences" (Miles, 1983, p. 53). Another telling problem is that the only discernible function of Chantek's utterances is to transmit requests to his teachers via arbitrary signs. Such responses are qualitatively similar to arbitrary requests trained in other animals. Accordingly, it is not clear what Chantek's use of signs tells us about the acquisition of human language.

Rote Sequences Versus Sentences

Different considerations lead to a rejection of the view that Sarah's and Lana's sequences were sentences. Thompson and Church (1980) analyzed a corpus of approximately 14,000 of Lana's combinations collected by a computer. They concluded that those combinations could be accounted for almost completely by two nongrammatical processes: conditional discrimination and paired-associate learning. First, Lana learned paired associates, each consisting of a particular lexigram and a particular incentive. Lana then learned conditional discrimination rules that determined which of six stock sequences she should produce. For example, if the incentive was in view within the machine, the stock sequence would be of the form, *Please machine give x* or *Please machine give piece of x.* (*X* refers to the symbolic member of the paired associate, e.g., the lexigrams *apple, music, banana,* and *chocolate.*) If there was no incentive in view, the appropriate sequence would be *Please put into machine x.* Typically, the paired-associate symbol was inserted in the last position of the stock sentence. Although Lana clearly understood the meanings of the paired-associate lexigrams (in the sense that she could use them contrastively to make specific requests), there is no evidence that she understood the meanings of the other lexigrams that composed the stock sequences she learned to produce (e.g., *Please, machine, give, put,* and *piece of*).

The validity of Thompson and Church's "stock sequence + paired-associate" hypothesis was questioned by Pate & Rumbaugh (1983) in their analysis of Lana's later productions. Pate and Rumbaugh concluded that, given the variety of the stock sentences and the paired associates that would be needed to account for Lana's well-formed sequences, they were generated by rules (unspecified) more complex than those offered by Thompson and Church. That conclusion seems premature. Of the 881 sentences that were analyzed, only 512 (58.1%) were well formed, leaving 369 (41.9%) unexplained. Furthermore, many of the well-formed sequences were quite similar but apparently unmotivated variations of the same theme (e.g., *Juice name this, Juice name this in cup,* or *Juice name this that's in cup in room*). Given the constant context, it is not clear how longer sequences added any additional information.

Further evidence of the nonsentential nature of Lana's (and Sarah's) sequences was provided by studies demonstrating that pigeons could learn arbitrary sequences of four colors—for example, red → green → blue → yellow (Straub, Seidenberg, Bever, & Terrace, 1979; Terrace, 1982b). The colors were presented simultaneously in configurations that changed from trial to trial. Because no differential feedback was provided as the pigeon moved from one color to the next, its performance on such "simultaneous chains" cannot be explained by traditional chaining theory. Mention of a pigeon's sequence-learning ability is not to imply that a pigeon could approach a chimpanzee's ability to learn various conditional discriminations that specify what arbitrary sequence is to be emitted in what context. Nor is it meant to imply that

a pigeon could master even a single arbitrary sequence as rapidly as a chimpanzee could. Indeed, there is strong evidence to the contrary (Pate & Rumbaugh, 1983). There is also no reason to assume that pigeons and chimpanzees use similar strategies in learning to produce a sequence.

These considerations should not, however, detract from the fact that, in each case, what was learned was a rote sequence. It would be just as erroneous to interpret the rote sequence of pecks, red → green → blue → yellow, as a sentence meaning, *Please machine give grain,* as it would be to interpret the arbitrary sequence of digits that a person produces while operating a cash machine as a sentence meaning, *Please machine give cash.* In sum, a rote sequence, however that sequence might be trained, is not necessarily a sentence.

Symbolic Problem-Solving Versus Language

Questions regarding the nature of symbol use by apes have changed the direction of both types of projects using artificial languages. Premack's (1983) most recent work has been concerned more with the study of cognitive processes in apes (e.g., conservation, syllogistic reasoning, and the role of symbol use in various kinds of problem solving) than with language per se. Yet Premack's attitude toward an ape's linguistic capacity seemed ambivalent. In an exchange with Chomsky, Premack observed that "as early as 1970 . . . [he] essentially quit concentrating on the attempt to operationally analyze some aspects of human language . . . because it was clear . . . that the accomplishments of which the ape was capable with regard to human-type language were very slight" (Premack, 1979, p. 7). Premack did not, however, state why he questioned an ape's capacity to learn any of the basic features of a human language. Indeed, in *Intelligence in Ape and Man,* Premack (1976) cited an ape's ability to acquire simple grammatical rules as evidence of an ape's linguistic competence.

Perhaps the most important lesson to be learned from Premack's provocative experiments is that training a highly intelligent creature to solve complex symbolic problems is not sufficient to establish linguistic communication (Terrace, 1979a). Once the sophisticated problem-solving abilities of Premack's chimpanzees are recognized as such, their ramifications (analogical reasoning, matching proportions of physically unlike exemplars, and so on) are not very surprising. If "language training" is viewed as training to use symbols in solving particular kinds of problems, one would expect positive transfer to occur between problems that can be solved through the use of similar strategies. Although the nature of those nonlinguistic strategies is by no means clear, they pose an important problem: How does an animal think without language? Answers to that question may help to place in perspective the role of language in human thought (Terrace, 1984).

What Do the Words of an Ape's Vocabulary Mean?

If the only question one raises about an ape's linguistic competence is whether it can create (or understand) sentences, progress on this issue will necessitate some means of discrediting nonsyntactical interpretations of an ape's utterances. There remain, however, other interesting and more basic issues. In a searching review of the literature on ape language, Savage-Rumbaugh, Rumbaugh, and Boysen (1980) not only were skeptical of the validity of evidence purporting to show that apes can produce and comprehend sentences, but they also doubted whether the apes studied by any project (Lana included) used the individual elements of their vocabularies as actual words.

By questioning the lexical status of an ape's use of signs of ASL, of plastic chips, or of lexigrams, Savage-Rumbaugh, Rumbaugh, and Boysen (1980) identified a basic problem of interpretation common to all the projects that sought to demonstrate that apes could master simple features of human language. Indeed, a strong case can be made for the hypothesis that the deceptively simple ability to communicate via words required a cognitive advance in the evolution of human intelligence that was at least as significant as the advance(s) that led to grammatical competence. In addressing this issue, we can comfortably skirt various unresolved psychological and philosophical issues that stand in the way of formulating a rigorous definition of the term *word* (cf. Miller & Johnson-Laird, 1976; Quine, 1980). As we compare human and nonhuman symbol use, it should become clear that the basic defining characteristics of words—names in particular—will prove relatively easy to establish.

The Development of a Child's Vocabulary—The Behaviorist View

Until recently, developmental psycholinguists have paid little attention to the process of lexical acquisition per se. It is, of course, true that ample information is available regarding the kinds of words children learn and at what rate they do so (e.g., Brown, 1956; Clark, 1973; Nelson, 1973). It was, however, widely assumed (at least implicitly) by most psychologists that some version of a behaviorist explanation of word learning would suffice to explain how children acquired their initial vocabulary.

At first glance, the behaviorist position may seem reasonable, because it is generally agreed that, unlike sentences, words are learned individually. Accordingly, why not invoke principles of associative learning to account for vocabulary acquisition? In this view, an infant learns to understand a particular word by as-

sociating the speech of a parent with primary reinforcers, such as physical contact, food, or the removal of distressful stimulation. Consequently, the parent's vocalizations become reinforcing.

The behaviorist account of vocabulary growth holds that an infant learns to produce a particular word because his or her vocalizations are reinforced directly, either by the parent providing a primary reinforcer, by the parent's attention, or by the parent's vocalization. Initially, virtually any instance of the infant's babbling is reinforced. As the infant becomes older, the parent shapes her or his vocabulary to approximate adult sounds. In addition, it is assumed that the infant's vocalizations that resemble the parent's speech are self-reinforcing. Gradually, the frequency of the infant's vocalizations that resemble sounds uttered by a parent increases, whereas the frequency of vocalizations that differ from the parent's sounds decreases (e.g., Mowrer, 1954; Winitz, 1969).

One influential expression of the view that a child's vocabulary is shaped according to principles of reinforcement distinguishes two kinds of verbal responses of young children: words that request various reinforcing agents and words that refer to objects. In his theoretical analysis of verbal behavior, Skinner (1957) defined these functional categories of words as "mands" and "tacts," respectively. Of necessity, the first verbal utterances of a child are mands. These are verbal responses that are reinforced by primary reinforcers.

Tacts, which appear after a child has learned to mand, are reinforced by generalized secondary reinforcers, for example, verbal expressions such as *thank you,* expressions of praise, and so on. Unlike mands, tacts are always under the control of discriminative stimuli. For example, the response of saying *tree* would be reinforced if, and only if, it occurred in the presence of an actual tree or a picture of a tree. Thus, from Skinner's point of view, the act of tacting is synonymous with stating the name of some discriminable feature of the environment.

If naming is nothing more than performing some arbitrary response in the presence of a specific discriminative stimulus (where the consequence of that response is a general secondary reinforcer provided by another organism), it follows that the vocabularies of the various apes taught to use either ASL or some artificial language consist predominantly of names. Various apes reliably used a sign, a piece of plastic, or a lexigram in the presence of a particular stimulus in order to earn the praise of their teachers (and/or some other reward).

Discriminative Responding by Apes, Pigeons, and Children

That the vocabularies learned by the apes in recent language projects did not consist of actual names is best seen by comparing the discriminative responding of apes, pigeons, and children that are purported to involve the use of symbols. At the very least, such comparisons will reveal how important questions of meaning are begged by gratuitous interpretations of animal behavior.

In the first systematic study of two-way symbolic communication between two chimpanzees, Savage-Rumbaugh, Rumbaugh, and Boysen, (1978a, 1978b) trained their subjects (Sherman and Austin) to request tools from one another by using lexigrams. The tools (a wrench, a stick, a sponge, a key, a straw, and "money") were used to open various food sites. First, Sherman and Austin were taught the function of each tool. They were then trained to ask their teacher for a particular tool by pressing the appropriate lexigram. Subsequently, they were trained to respond to lexigrams, illuminated on a display panel by their teacher, by giving *her* the tool she requested.

In the main part of the study, Sherman and Austin were housed in adjacent rooms separated by a window. Prior to each trial, one chimpanzee was designated as the requester (R), the other as the tool provider (P). At the start of a trial, the window between the two rooms was covered. In R's presence, the experimenter placed an item of food in a particular food site. Access to the food was possible only by applying one of the six tools. Once the food site was secured, the window was uncovered. In order to obtain the relevant tool, R had to request it from P by pressing the appropriate lexigram on his keyboard. Doing so illuminated that lexigram on a display in P's room. P's task was to select the tool that R requested and to then pass it to R through a hole in the wall separating the two rooms. If P provided the correct tool, R could retrieve the food and then share it with P. Though P and R could see and hear one another when the window separating their rooms was uncovered, their vocal and gestural communication was not sufficient to specify which tool R needed to open a particular food site.

During the course of an experimental session, the roles of Sherman and Austin were reversed every few trials. Their joint accuracy was 92% correct, even when the experimenter was absent. When Sherman's and Austin's keyboards were deactivated (that is, when they could not communicate with lexigrams), their joint accuracy fell to 10% correct, even though they could still see and hear one another.

An experiment performed by Epstein, Lanza, and Skinner (1980) purported to show that pigeons could communicate in a manner analogous to that observed between Sherman and Austin. The experiment involved two pigeons, Jack and Jill, who were placed in adjacent operant conditioning chambers, each separated by a clear lucite barrier. This arrangement allowed one pigeon to have a clear view of the

other's behavior. Ostensibly, Jill's pecks to English color names instructed Jack to peck a particular physical color. Appropriate "instruction" on Jill's part and correct color selection on Jack's part resulted in food reinforcement for each pigeon.

Jack began each trial by pecking a key on which appeared the English question, *What color?* In Jill's chamber, one of three randomly alternating colors was displayed in a recessed tube. Jack could not see any of those colors. After viewing a particular color, Jill was required to peck one of three response keys, which Jack could see. On each of these keys appeared the English color name of the colors that could be viewed in the recessed tube: red, green and blue, respectively. The key that Jill pecked remained illuminated until the end of the trial. Upon seeing a color-name illuminated, Jack's task was, first, to peck a key on which appeared the words, *thank you.* That peck produced food reinforcement for Jill. Jack was then required to peck one of three keys—one red, one blue, and one green. Which color was "hot" was determined by the color name selected by Jill. A correct choice by Jack resulted in food reinforcement.

An obvious variant of the Epstein et al. experiment would reveal the trivially superficial relationship that exists between the behaviors of Jack and Jill, on the one hand, and Sherman and Austin, on the other. Suppose that Jack and Jill are placed in separate chambers in which they cannot see each other. However, the discriminative stimuli each pigeon produces are displayed as previously. Thus, whenever Jill pecks a particular color name, that name lights up in Jack's chamber. Likewise, whenever Jack pecks the visual display, *thank you,* an identical display is illuminated in Jill's chamber. Under these circumstances, there is no reason to expect that Jack's and Jill's behavior would differ from that reported by Epstein et al.

Although the pecking behavior of Jack and Jill was clearly controlled by the discriminative stimuli each produced, there is no basis for saying that these pigeons were communicating intentionally with one another. Certainly Jill was not saying anything like "I just saw a red light." That would presuppose not only that Jill could discriminate each color from the others (which she clearly could) but that Jill also understood that (a) some arbitrary communicable symbol described $color_i$, (b) she sought to communicate to Jack that the color she saw was $color_i$, and (c) Jack would interpret Jill's message as Jill intended it. There is no evidence to support any of these suppositions.

There is also no evidence of communication at a more general level. For the moment, let us put aside the question of whether Jack and Jill learned that colors have communicable names. Even if they did not, it is still conceivable that Jack might somehow urge Jill to hurry up. For example, Jack might urge Jill to peck any key so that he could perform his response and thereby advance in the chain of responses that would lead to reinforcement. No such behavior was reported in Epstein et al. In contrast, it is interesting to note Savage-Rumbaugh et al.'s (1978a) observations of the behavior of the chimpanzees Sherman and Austin in their tool-requesting task. When R was not satisfied with P's progress, he guided P's selection of a tool by referential gestures—for example, by pointing at a particular tool—as well as by nonspecific gestures to hurry up. As Savage-Rumbaugh et al. noted, "[P] began to rush hurriedly to the window to observe the request of [R], who would look at him to see that his request had been noted. Often if [P] appeared inattentive, [R] would draw his attention to the request by repeating it or by pointing to the projectors where the requested tool was displayed" (p. 544).

The Epstein et al. experiment raises two basic questions regarding symbolic communication. One has to do with what qualifies as symbolic communication, and the other with what might be communicated. I have explored briefly the first question and have shown that there are no grounds for claiming that Jack and Jill communicated intentionally with one another. Before pursuing this issue further, I will focus briefly on the second question by considering whether Jill was actually naming the colors, albeit in a noncommunicative manner. The same question can be asked about apes who have been reported to respond symbolically to different colors. Superficially, Jill's response to each color (pecking its English name) appears to qualify as a tact. So does an ape's use of an arbitrary color name when shown a particular color (cf. Essock, Gill, & Rumbaugh, 1977; Gardner & Gardner, 1975b; Premack, 1976; Terrace, 1979b). However, a moment's thought regarding some examples of symbol use should reveal an inherent weakness in the notion that a tact is a category of "verbal" behavior that is synonymous with naming.

The purported evidence that both apes and pigeons tact the names of colors can be questioned on two grounds. A superficial objection is that the consequence of a tact is supposed to be a generalized secondary reinforcer, for example, *thank you,* which is administered by another organism. In both the Epstein et al. and the ape language studies, the organism who administered reward dispensed primary reinforcers. This should not, however, be regarded as a serious objection to the proposition that Jill and the apes were tacting. The literature on schedules of reinforcement provides ample evidence that, in the absence of primary reinforcement, discriminative responding can be maintained at high rates through the judicious application of generalized secondary reinforcers. However, to interpret an ape's or a pigeon's use of a symbol as a name, simply because symbol use is not always followed by a primary reinforcer, would be to miss the main function of such words in

the use of human language—the transmission of information from one individual to another for its own sake. It is this aspect of naming that is lacking in Jill's and an ape's use of symbols (at least in the ape's purported use of color names). It is also not specified either by the concept of a tact or by the definition of a generalized secondary reinforcer.

In children, the informative function of words is evident in their early vocabularies. Consider, for example, the following exchange between a 17-month-old child and her mother:[1]

Mother:	Child [Allison]:
(A[llison] putting calf on table) There.	there/
(A[llison] putting cow on table) More, right.	more cow/

(A[llison] goes to chair)	
(A[llison] picking up bull and putting it on table)	cow/ cow/ cow
(A[llison] walks back to chair; picking up pig and putting it on table) More?	more cow/

(Bloom, 1973, p. 176)

As I will discuss in some detail below, a child will utter a name of an object, person, color, and so on, simply to indicate that she or he knows that the object she or he is attending to has a name and also to communicate the fact that she or he has noticed that object (cf. Bates, 1976; Greenfield & Smith, 1976; Nelson, 1973).

In the above examples of symbol use by pigeon, ape, and child, we could, arbitrarily, restrict our focus to the response in question and to some of the obvious variables that influence that response. For some (e.g., Skinner, 1953, 1974), the resulting relationship between the relevant discriminative stimuli and the response would justify the conclusion that all of the following responses are equivalent: a pigeon's peck to the printed word *red* upon seeing a red patch of light, an ape's response of *red* following the teacher's question "What color flower?," and a child spontaneously saying "red" while pointing to a red flower. It should be obvious, however, that each of these responses exemplifies a different kind of behavior and that a failure to recognize how these responses differ is to deny the importance of the intent simply to inform another organism that some feature of the environment has been noticed.

Of course, it is true that even in simple conversations exchanges of information have consequences, as yet poorly understood, for both the speaker and the listener. Those consequences could be construed as reinforcers if one defines the sharing of information or some similar process as a reinforcing event. However, to do so is to engage in yet another unrewarding exercise of generating circular definitions of reinforcement. More to the point are the distractions that exercises of that nature create from our understanding of the psychological processes that enable the speaker and the listener to exchange information in the first place.

Naming Versus Paired-Associate Learning

At best, the behaviorist view of vocabulary acquisition is an explanation of paired-associate learning: learning to use an arbitrary symbol as a means toward the end of obtaining some reinforcer in the presence of a particular discriminative stimulus. Although it is clear that language, even utterances containing but a single word, entails something more than paired-associate learning, it is no simple matter to distinguish rigorously between a name and a paired associate.

What is missing from the behaviorist view is the speaker's intention in using a word. Saying something and meaning what you say are obviously different. In most human discourse, a speaker who utters a name expects the listener to interpret the speaker's utterance as a reference to a jointly perceived (or imagined) object (cf. Austin, 1962; Grice, 1975; Searle, 1983). It should therefore come as no surprise that an important function of a child's initial vocabulary of names is to inform another person, usually a parent, that the child has noticed something (Halliday, 1975; MacNamara, 1982; McShane, 1980). In many instances, the child refers to the object in question spontaneously and shows no interest in obtaining it. The child not only appears to enjoy sharing information with his or her parent but also appears to derive intrinsic pleasure from the sheer act of naming. As I will elaborate later, these aspects of uttering a name have not been observed in apes, and there is reason to doubt whether the most intensive training program imaginable could produce an ape that would approximate a child's natural ability to refer to objects as an end in itself.

Because my major concern in this article is to distinguish an ape's use of a symbol as a means of requesting an object from a child's use of a name as a device for referring to an object that attracts his or her attention, I will not elaborate other deficiencies of the behaviorist account of vocabulary growth. There is, for example, little evidence that the sounds an infant emits are truly imitative of the parent's sounds (cf. Winitz & Irwin, 1958). There are also numerous studies showing that a child's initial utterances often function as names rather than as requests (e.g., Greenfield & Smith, 1976; Nelson, 1973). Dis-

[1] Ongoing behavior or action is presented parenthetically on the same line as the utterance; immediately previous behavior or action is coded parenthetically on the line preceding the utterance.

cussions of these and other observations that cannot be accommodated by a behaviorist account of language development can be found in recent reviews of the growth of a child's vocabulary (e.g., Bloom & Lahey, 1978).

Language Acquisition in Children: From Pragmatics to Semantics to Syntax

The motivation for constructing formal models of grammar is to provide a means of generating the various kinds of elaborate and well-formed sentences that adult speakers can produce and comprehend (e.g., Chomsky, 1957). Even though such models do not attempt to account for the linguistic competence of young children, they have exerted a powerful influence on research on language development. Initially, the development of grammatical competence was considered apart from other aspects of a child's cognitive and social development (e.g., Braine, 1963; Brown & Bellugi, 1967; Miller & Ervin, 1964). Accordingly, a child's earliest multiword utterances were analyzed solely with respect to their formal syntax. Subsequently, attention was drawn to the fact that syntactic relations derived from a child's semantic interpretations of the environment (e.g., Bloom, 1970; Fillmore, 1968; Schlesinger, 1971). Slowly but surely, other investigators began to supplement formal analyses of a child's utterances with analyses of a child's semantic development (e.g., Brown, 1973).

Another important focus of research on language development was the influence of extralinguistic context on a child's single- and multiword utterances (e.g., Bloom, 1970, 1973; Greenfield & Smith, 1976). More recently, attention was directed to the function of a child's utterances as specified by speech act theory as well as to prelinguistic forms of communication that precede speech acts (e.g., Bates, 1976; Bruner, 1975, 1983; Dore, 1975; Stern, 1977). Indeed, in recent years, an extensive literature has developed whose main focus is the pragmatic and semantic interpretation of an infant's initial gestures and utterances (e.g., Bates, 1976; Bruner, 1983; Lock, 1978; McShane, 1980; Sugarman-Bell, 1978). A common theme of this literature is the assumption that it is not profitable to analyze the "grammar" of a child's communication system prior to the appearance of spoken words. Interest is therefore directed toward defining crucial antecedents of grammatical structures.

Numerous investigators of child language who are concerned with the ontogeny of words as such have differentiated two important aspects of the development of language that, typically, occur between 9 and 13 months. Bates (1976), for example, observed that "this brief period in human ontogeny reflects not one but two critical moments in the dawning of human communication through symbols: (a) the onset of communicative intentions and conventional signals and (b) the emergence of symbols and the discovery that things have names" (p. 33). A consensus has developed that during these phases, "the child is developing skills that are at least as essential to speaking and understanding language as the mastery of grammar is supposed to be" (Ryan, 1974, p. 186; see also Markova, 1978).

Prelexical stages of language development warrant careful scrutiny for a number of reasons. A delineation of immediate precursors of language could help to demystify the "miraculously" sudden appearance of language in human infants. It is also likely that a specification of differences between the cognitive development of an ape and of a child would clarify the difficulty apes have in mastering rudimentary linguistic skills.

The Contribution of Social and Cognitive Skills to Language Development

An obvious truism about language learning (at least with the wisdom of hindsight of various research programs begun during the 1970s) is that language draws upon certain kinds of nonlinguistic knowledge. For example, before learning to speak, an infant acquires a repertoire of instrumental behavior that allows her or him to manipulate and/or approach various objects. An infant also learns how to engage in various kinds of social interaction with her or his parents—for example, being able to look where the parent is looking or pointing. Eventually, the child learns to point to things that he or she would like the parent to notice. In short, the infant first masters a social and conceptual world onto which she or he can later map various kinds of linguistic expression.

Psycholinguists have yet to agree upon a theory that specifies which kinds of social and/or cognitive skills are necessary for the development of a particular linguistic skill. For example, it is not clear whether linguistic skill_n is a direct consequence of cognitive skill_n or whether both derive from a "shared base" of cognitive abilities (cf. Bates, 1976; Bates, Bretherton, Shore, & McNew, 1981). The major difficulty in determining which of these and related hypotheses best fit the data is the difficulty of inferring causality from correlational data, the best available data that bear on this problem (see Golinkoff, 1983; Harris, 1983, for extensive discussions of this issue).

Prelinguistic Devices for Directing an Infant's Attention

What is clear from the rapidly expanding literature on the prelinguistic development of the child is that, for whatever reason(s), the production and comprehension of words emerge from highly structured interactions between an infant and her or his parents. Referred to collectively by Bruner (1983) as the Language Acquisition Support System (LASS), such in-

teractions are noteworthy for two reasons, one having to do with children, the other with apes. In the case of children, direct analogies can be drawn between LASS and the subsequent appearance of vocabulary. In the case of apes, there is no compelling evidence of analogs of LASS in interactions between an infant ape and its natural or surrogate (human) parent.

Sustained eye contact is perhaps the earliest interaction between a mother and an infant that can be said to have analogs in subsequent language development. Such eye contact has been observed during the first month (Robson, 1967). By the second month, vocal accompaniments of eye-to-eye contact occur reliably (Stern, Beebe, & Bennett, 1975). At the age of roughly four months, a parent can direct an infant's attention to an object simply by looking at it (Bruner, 1983). Subsequently, the parent can accomplish the same end by pointing to an object. By the eighth month, there is a clear tendency for an infant to follow an adult's direction of gaze (Collis & Schaffer, 1975; Scaife & Bruner, 1975). Such infant–adult coordination of eye movements provides compelling evidence for joint attention to particular features of the environment. (See Collis, 1979, for a review of this literature.)

Intentional communication, by any definition, presupposes an ability to direct one's message to a particular audience. Unfortunately, operational definitions of intentional communication are difficult to come by. This lack is readily traceable to the formidable problems one must overcome in measuring intentionality. However, recent concern about the significance of intentionality in infant communication (indeed, in any kind of communication) holds out promise for definitional advances (e.g., Bruner, 1980; Greenfield, 1980). Exemplary of the current status of such efforts is Bates's (1976) definition of intentional communication: "signalling behavior in which the sender is aware a priori of the effect that a signal will have on his listener, and he persists in that behavior until the effect is obtained or failure clearly indicated" (p. 36). As behavioral criteria of intentional communication, Bates (1976) suggested

> alternations in eye contact between the goal and the intended listener . . . augmentations, additions, and substitutions of signals until the goal has been obtained, and . . . changes in the form of the signal toward abbreviated and/or exaggerated patterns that are appropriate only for achieving a communicative goal. (p. 36)

It should be recognized, however, that none of the behavioral criteria cited by Bates follow rigorously from her definition of intentional communication. Her definition also contains no provision for ruling out such nonintentional (and involuntary) acts of communication as the mating rituals of various species. At present, a critical examination of self-evident instances of intentional communication would appear to be the best means of establishing a rigorous definition of this important concept. Of particular interest is a clear account of how an infant communicates before and after speaking her or his first words and how such communication contrasts with purportedly similar instances of communication by apes.

Although highly effective, an infant's earliest cries are not intentional. They are inborn and involuntary reactions to particular internal states whose occurrence is not influenced by the presence or absence of an audience. An infant's motor responses are similarly reflexive. By the age of approximately nine months, a dramatic change occurs in the infant's communicative patterns. This can be illustrated by observing how he or she attempts to obtain a desired object. Suppose that an infant is looking at the object and is situated near a parent but cannot see the parent. Before an age of roughly nine months, the infant may reach in the direction of the object and cry and fuss (in an undirected manner) upon failing to obtain it. At some point, he or she may abandon the effort and turn to the parent for comfort. Significantly absent from the infant's behavior is any attempt to involve the adult while searching for the object (Piaget, 1952).

This pattern soon changes in a number of ways. The child alternates between looking at the object and the parent while crying. As Bates (1976) noted, "it is difficult to avoid the inference that the child sees some relationship among the goal, the adult and the signal" (p. 34). Another change involves the way the child tends to "augment, add or substitute signals contingent upon changes in adult behavior toward the goal" (Bates, 1976, p. 35). Such modulations of the child's communicative efforts suggest that they are aimed at the adult rather than at the object the child is seeking. Yet another new feature of the child's attempt to obtain a desired object can be characterized as a "conventionalization" of his or her communicative signals. Instead of reaching and grabbing, she or he might make a reduced gesture toward the adult. Similarly, the child's undifferentiated noises and sounds become shorter and more regular.

Bates (1976) has referred to a child's efforts to involve a parent in helping the child obtain some goal as a "proto-imperative." At a later stage of development, a child will learn to use a word instead of gestures and noises to request a particular object or event. A similar developmental process leads to the appearance of "proto-declaratives." Often a parent comments about an object while pointing to it or moving it toward the infant. When the parent stresses the spoken name of the object to which he or she seeks to direct the infant's attention, the infant comes to discover that a stressed vocalization is a signal that there is "something to look at." Likewise, highly ritualized games, in which an object is made to disappear and

later reappear (typically with distinctive vocal accompaniments), also facilitate a parent's control over an infant's attention (e.g., Greenfield, 1972; Ratner & Bruner, 1978).

As the infant grows older, his or her contribution to these interactions increases. At first the infant may simply try to grab the object that the parent is about to hide (approximately five months). Subsequently, the infant's attempts to reach or grab the object may be accompanied by undifferentiated vocalizations (approximately six months). At a later stage (approximately seven months), the infant may lose interest in grabbing and instead may react at appropriate moments by smiling and laughing. By virtue of the infant's ability to attend, alternatively, to the object and to the parent, she or he can often share smiles and laughter with the parent. Eventually, the infant learns to repeat the name of an object that the parent provides while both attend to it (see Bruner, 1983, for summaries of such studies).

During the course of a long series of object-oriented interactions with the parents, an infant not only learns to direct her or his attention to objects presented by a parent but also learns that her or his response to such objects, whether pointing, babbling, or saying the actual name of the object, is recognized by the parent as a sign that she or he has noticed the object. In short, the infant learns that her or his response to an object has much in common with the parent's response to the same object. In that sense, the child learns the conventions of reference, first at a nonverbal level and subsequently at a verbal level. As Smillie (1982) concluded in his review of Piaget's observations of child development, "Between 8 and 12 months human infants are able to combine an interest in objects and a communicative exchange with others and, thus, to understand and to produce acts that say something *about* the world *to* other people" (p. 292, italics in original).

Although there is compelling evidence for the existence of proto-imperatives and proto-declaratives in the developmental studies reported by Bates and others, these concepts pose a host of unanswered questions. Some involve the universality of the processes that have been cited as necessary for the establishment of proto-imperatives and proto-declaratives; others involve the rigor with which these concepts have been defined and their adequacy as explanations of the development of language.

Let us consider first the question of universality. Although it may seem reasonable to hypothesize that prelinguistic visual interactions between infants and their parents play a pivotal role in the development of proto-imperatives and proto-declaratives, ample anecdotal and empirical evidence indicates that such interactions are not necessary for language development. Blind children learn to speak without the benefit of mutual eye gaze, peekaboo games, and the various other kinds of visual exchanges that have been cited as crucial for language development in seeing children (cf. Landau & Gleitman, 1983; Mulford, 1985).

Even in seeing children, the importance of visual interactions between a parent and an infant can be questioned. In a description of language development of Kaluli children in New Guinea, Schieffelin and Ochs (1983) noted that "mothers and infants do not gaze into each other's eyes, an interactional pattern that is consistent with adult patterns of not gazing when vocalizing in interaction with one another" (p. 122). Schieffelin and Ochs also reported that dyadic exchanges between parent and infant, which are common in Western societies, are absent in the Kaluli culture. Accordingly, they concluded that "infants and caregivers do not interact with one another according to one particular 'biologically designed choreography' " (p. 127).

What is striking about these reports of language development in blind children and in children who experience virtually no visual interaction with a parent is that, despite such apparent obstacles, mutual attention does develop with respect to particular features of the environment. "Looking," for example, would be inappropriate as a description of how a blind child responds to particular objects. Nevertheless, blind children develop a sense of the focus of their parents' attention and readily learn to refer to the act of engaging someone else's attention with words such as "look" (Landau & Gleitman, 1983). Transcripts of Kaluli children talking with their parents provide similar evidence of joint reference. Taken together, these data indicate the importance of broadening the scope of LASS so as to delineate the underlying processes that enable a parent and an infant to attend mutually to particular features of their environment.

However proto-imperatives and proto-declaratives are established, a particular instance of behavior may pose a problem of interpretation when one seeks to assign it to either of these categories. This problem is, of course, no different from that encountered in determining whether a particular utterance is an imperative or a declarative statement. For example, when a child exclaims "pony!" the child may be communicating both the fact that he or she has noticed a pony and that he or she would like to ride it. In the absence of intonation contours (and other information that a complete transcript would provide), it may be difficult to distinguish between alternative interpretations of a child's utterance. It is nevertheless a fairly straightforward matter to identify unequivocally those utterances in which a child is clearly demanding an object and those utterances in which he or she is clearly referring to one (cf. Greenfield & Smith, 1976). At issue is whether both categories apply to the symbols used by apes.

Similarities and Differences in Vocabulary Acquisition by a Child and an Ape

There is little question that apes overlap with human beings more than any other species with respect to their ability to learn arbitrary rules regarding the use of symbols. However, the degree to which such overlap bears on their linguistic ability remains controversial. Both species learn to make requests by using arbitrary symbols, and both species are able to use symbols to communicate intentionally (cf. communication between Sherman and Austin in the tool exchange paradigm described earlier). Much evidence exists that an infant ape's development through the proto-imperative stage (and from that stage to the use of symbolic demands) is similar to that of a human infant (Gardner & Gardner, 1973; Terrace, 1979b). Indeed, recent analyses of demands, as expressed by lexigrams, have revealed an interesting similarity of the role of "perceived variability" between the discourse of an ape and that of a human child. Greenfield (1978, 1982), who reported that a child is more likely to comment about change or novelty in the environment, observed a similar tendency in Sherman's and Austin's mutual requests for foods and tools (Greenfield & Savage-Rumbaugh, 1984). Greenfield and Savage-Rumbaugh have reported not only that Sherman and Austin used lexigrams to make requests more frequently during novel opportunities than they did during familiar opportunities but also that the number of lexigrams they used in their requests varied directly with the number of dimensions of variability a particular opportunity provided.

Comparisons of the acquisition of symbols by human children and young apes reveal important differences in the circumstances under which they expand their vocabularies. Consider, for example, studies of the acquisition of common (but unfamiliar) nouns by children as young as two years in which the experimenter (E) varied the frequency of presentation of exemplars of each noun; how often the noun was stated by the teacher; whether it was stated before, during, or after the presentation of the exemplar; and so on (e.g., Nelson & Bonvillian, 1973; Whitehurst, Kedesdy, & White, 1982; also see Carey, 1978, for a comparable study of four-year-olds). Such studies have shown rapid noun acquisition with a minimal number of exemplar presentations and repetitions of the exemplar's name. The only reinforcement was occasional mild praise from the teacher.

We have seen earlier that, in order for an ape to learn a new symbol, the symbol had to be paired repeatedly with the relevant exemplar and that a potent primary reinforcer had to be furnished for the correct selection of the symbol. Although it might be objected that the children who served as subjects in the Carey, Nelson and Bonvillian, and Whitehurst et al. studies had appreciable vocabularies at the time they were asked to learn new words, the same can be said of Austin, Lana, Koko, Nim, Sarah, Sherman, and Washoe—the apes who have been the beneficiaries of the most extensive and thoroughly documented language projects to date. However, unlike children, who are able readily to add new items to their vocabularies in response to casual instruction (or without any instruction at all), apes are able to do so only in narrowly structured situations and with extensive drill. What appears to be lacking in the case of the apes is an understanding of the fact that one can refer to an object by its name.

Can Referring Be Taught?

In a provocative discussion of how children learn to name objects, (MacNamara, 1982) concluded that referring to an object (the act of communicating that one's attention is directed to a particular object) is not learned. Instead, he regarded referring as a "primitive of cognitive psychology" (MacNamara, 1982, p. 190). What is learned is reference: the conventions of using symbols and words that do the work of referring.

Despite MacNamara's painstaking marshaling of empirical evidence and logical arguments, verification of his view of learning of names awaits much further research. It is of interest, however, to consider the extent to which learning theory can account for a child's ability, first, to understand that the parent is referring to a particular object and, subsequently, to master preverbal techniques for directing the parent's attention to a particular object. As commonplace as such skills may seem, it is not obvious how one can teach them. To argue that referential behavior is shaped begs the question of what rudimentary forms of referential behavior can be used as a point of departure for shaping. To acknowledge that such a rudimentary form exists is to agree with MacNamara that the act of referring is a given. At best, principles of learning might be invoked to characterize the acquisition of the conventions of reference and how a parent adds to the variety and complexity of situations in which referring occurs.

It is of interest to consider the analogous case of recognizing particular entities as objects as opposed to combinations of attributes. Here again, learning theory cannot specify any procedures for training this basic act of perception. The available evidence (reviewed earlier) suggests that infants are able to recognize objects as such and, without the benefit of any explicit training to do so, to perceive that another person's attention may be directed at an object. Infants are also able to communicate nonverbally that their attention is directed toward a particular object. It is these psychological givens, both untaught, that provide the foundations for learning the conventions of reference.

The Function of Symbols for Chimpanzees and Children

The hypothesis that the act of referring is a given and that it is also a necessary precursor of naming provides an important basis for comparing symbol use by children and chimpanzees. Like children, chimpanzees appear to show evidence of object recognition soon after birth. It is also quite easy to direct a chimpanzee's attention to a particular object by looking at it, by pointing to it or by moving it into the chimpanzee's line of sight. Though chimpanzees' reactions to objects have not been subjected to systematic study, informal observations suggest that their main reaction is acquisitive (Terrace, 1979b).

Noticeably absent from an infant ape's reaction to an object is the sheer delight a human infant expresses in contemplating the object and sharing it perceptually with the parent. The ape's more rapid motor development (and concomitant reaching and grasping reactions), compared with that of humans, may preclude the kinds of docile and contemplative reactions that human infants display when looking at an object. When confronted with an object, familiar or otherwise, an infant ape simply makes soft reflexive hooting noises and either reaches for the object or tries to approach it. When obtained, the object is typically explored orally and manually. There is no evidence that suggests that the infant ape seeks to communicate, either to another ape or to its human surrogate parent, the fact that it has simply noticed an object. To be sure, chimpanzees will communicate with one another about food locations (cf. Menzel, 1979) or about objects of prey (cf. Telecki, 1973). It is, however, important to recognize that such communication is in the service of some concrete end and is not intended simply to inform a companion that some feature of the environment has been noticed.

Though rare, some fortuitous observations of symbol use that seem to be motivated to some extent by a desire to transmit information have appeared in the literature on ape language. One of the more compelling examples was reported by Savage-Rumbaugh (1984). Austin approached his teacher in a state of anxiety (as evidenced by piloerection), pressed the lexigram *scare* on a nearby console, and then gestured toward a window. Through the window, Austin and his teacher could see an anesthetized chimpanzee being carried by two laboratory attendants. *Scare* had been taught as a request to play a game in which the teacher dressed up in a costume and pretended to scare the chimpanzees. Savage-Rumbaugh (1984) reported that as

> I looked out the window, Austin looked rapidly back and forth between the anesthetized chimpanzee and me. When I made a threat bark, Austin pounded vigorously on the window toward the white-coated attendants and seemed to want me to look out the window so that he could determine what behavior was appropriate for the situation. (p. 242)

Although it is clear that Austin used *scare* to seek his teacher's comfort and support, it is of interest that, in this anecdote, Austin used *scare* in a novel situation.

The absence of natural referential skills that are not tied to concrete ends makes all the more remarkable the kinds of symbol use that an ape can master. For example, one recent study (Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980) has shown that chimpanzees are capable of learning symbolic concepts such as generic terms that apply to symbols for particular foods and tools. It remains to be seen, however, to what extent such concepts reveal previously unsuspected cognitive skills in apes, as opposed to linguistic skills per se. On the other hand, another study (Savage-Rumbaugh, Pate, Lawson, Smith, & Rosenbaum, 1983) showed some rudimentary intentional communication in highly structured play situations. In order to pinpoint just where a human child and a chimpanzee diverge in the growth of their symbolic skills, in the next section, I will summarize the basic findings of these studies.

Recent Studies of Symbol Use by Chimpanzees

Symbolic Categorization of Symbols

An experiment performed by Savage-Rumbaugh, Rumbaugh, Smith, and Lawson (1980) demonstrated that apes can learn the symbolic status of a symbol. The experiment was conducted in four phases: sorting objects by category, labeling objects by category, labeling photographs by category, and labeling lexigrams by category.

During the first phase, the chimps were required to sort, into one of two bins, three physically different foods (an orange, beancake, and bread) and three physically different tools (a key, money, and a stick). During the second phase, the chimps were required to select one of two lexigrams (*food* or *tool*) after they sorted each food or tool. Subsequently, they were asked to choose the lexigram food or tool each time the experimenter presented new exemplars of foods and tools. Sherman and Austin showed virtually complete generalization to 10 new foods and tools.

During the third phase of training, photographs were taped to the original three foods and tools. Subsequently, Sherman and Austin were required to apply the lexigram food or tool to the photographs themselves. After mastering this test, both chimpanzees responded correctly to nine novel photographs of foods and tools. During the final phase, each photograph of the original three foods and tools was presented along with the specific lexigram that corresponded to the item shown in the photograph. The chimpanzees were then required to apply the lexigram

food or tool to these lexigrams when presented *without* the photographs of their referents. Finally, they were required to identify 17 test lexigrams by selecting one or the other of the lexigrams, food or tool. Both Sherman's and Austin's identification of the test lexigrams as foods or tools was nearly perfect.

In interpreting Sherman's and Austin's performance, it is important to keep in mind that none of the test lexigrams was ever paired with the lexigram food or tool. Indeed, neither Sherman nor Austin had ever been required to categorize the actual food and tool items to which the test lexigrams referred. At the very least, this study shows that chimpanzees can respond to a particular lexigram with some representation of its referent and decide whether the representation is a food or a tool. However, given the design of this study, it is not possible to conclude that Sherman and Austin had formed generic representations of *both* foods and tools. They could just as well have determined that "X is a food or a nonfood" or "X is a tool or a nontool." Quite clearly, what needs to be done is to replicate this study with additional categories of lexigrams, for example, *location* and *drinks.* A step in that direction was taken recently by Savage-Rumbaugh (1981). In an extension of her original study of the symbolic status of particular lexigrams, she reported that Sherman had no difficulty in tests that were based on photographs or on actual exemplars of the new categories, *location* and *drink.* However, Sherman's ability to assign these lexigrams to specific lexigrams that are instances of these categories awaits vocabulary expansion (Savage-Rumbaugh, 1981, p. 57).

The uncertainty regarding the nature of the representation(s) that an ape uses in assigning the lexigrams *food* and *tool* to lexigrams in identifying specific food and tool lexigrams should not detract from an important fact that Savage-Rumbaugh et al. have demonstrated about an ape's symbolic ability. An ape can represent a particular lexigram, for example, *banana,* as an instance of a concept (as defined by a superordinate lexigram e.g., *food*) in the absence of the physical referents of any of the lexigrams. That sophisticated cognitive skill is of obvious importance in forming semantic categories.

Specificity and Intentionality of Demands

However sophisticated an ape may be in forming semantic categories, that knowledge would be of no use to another ape unless it could be readily shared. In principle, models of paired-associate learning can account for the learning of particular lexigrams or of generic lexigrams that define certain categories of lexigrams (e.g., Anderson & Bower, 1973; Osgood, 1953). However, such models cannot account for intentional communication: transmission of arbitrarily coded information about jointly perceived objects or events from a speaker to a listener. Thus, when evaluating Sherman's and Austin's impressive abilities to grasp the relationship between generic and specific lexigrams, one should not lose sight of the fact that neither type of lexigram was used to communicate information about the referents of the lexigrams.

As mentioned earlier, one of the erroneous assumptions of the various recent projects that sought to train apes to use basic features of a human language was that the symbols the apes learned to use functioned as names of objects, individuals, events, or relationships. Once the projections of human meanings were stripped away from the interpretations assigned to those symbols, it became clear that the ape's use of symbols amounted to a means of expressing demands for various incentives. That the form of some demands reflected requests for a specific incentive (given a choice of other incentives) and that the form of other demands was determined by the presence of a particular discriminative stimulus (e.g., a color, a shape, or a type of relationship), should not detract from the fact that the ape used a symbol simply as a means of obtaining a particular incentive.

Even at the level of a demand, an ape's use of a particular symbol does not typically share many features of a child's demand as expressed by a particular word. In some studies, the range of possible demands was varied minimally; for example, Premack's procedures in most instances provided the ape with a choice of only two symbols. Signing apes tend to produce a variety of signs until they obtain whatever incentive their trainer holds up for them to see. Thus, a banana could evoke the signs, *eat, Nim, me,* or *banana,* along with many irrelevant signs. Furthermore, signed requests are usually not spontaneous but have to be evoked by the trainer, who first has to show the ape that a particular incentive is available. In general, signs are emitted following unsuccessful attempts on the part of the ape to reach or to grab the incentive in view. Even in the tool-exchange paradigm, in which Sherman and Austin communicated intentionally their requests to each other for particular tools, the requests were triggered by the sight of the experimenter hiding food.

In contrast to an ape's use of a symbol as a demand, there is ample evidence that by the time a human child is 18 months old, his or her demand, as expressed by a particular word, is specific to what is being requested, is but one of a large number of words the child can express accurately, requires no prompting from the parent, and occurs reliably in the absence of the referent (Greenfield & Smith, 1976).

Indicating Objects

Experiment I of Savage-Rumbaugh et al. (1983) provides the first clear evidence that a chimpanzee can

request a food it cannot see and that the request is specific to a particular food. During each trial, the chimpanzee (Sherman or Austin) was allowed to look at a table containing a selection of five to seven foods. Each chimpanzee was then required to walk around a corner to a keyboard and request whichever food he wanted. The foods on the table (which were changed after each trial) could not be seen from the keyboard. After making his choice, the chimpanzee could then return to the table, where he was allowed to pick up an item of food and show it to the experimenter. The experimenter could see which food the chimpanzee had requested by looking at a display above the table. The experimenter allowed the chimpanzee to eat the food he chose at the table only if it corresponded to the previously selected lexigram. On 25 trials, Sherman and Austin made, respectively, two and three errors.

Evidence that a chimpanzee could indicate an object it desired was provided by another study in which Sherman and Austin again served as subjects. That study was stimulated by informal observations that one chimpanzee would announce, without any requirement to do so, which of a group of incentives he would select before actually obtaining that incentive. In one situation Sherman and Austin participated in the following cooperative game. Each chimpanzee took turns selecting a food that they would share, by pushing a particular lexigram on their computer console. The other chimpanzee would then fetch that item of food and share it with his partner. At one point, Sherman appeared to become impatient with Austin's slowness in requesting a food. Accordingly, Sherman usurped both roles: that of the requester and that of the provider. Under these circumstances, Sherman declared in advance which food he would select.

In another situation, both Sherman and Austin indicated their preference for a particular object without being required to do so when one of the chimpanzee's teachers appeared in their room with a collection of playthings. Instead of waiting for the teacher to decide which game to play or to require that one of the chimpanzees request a particular object, Sherman or Austin would point to the object of their choice and then confirm their choice by pressing the corresponding lexigram on their computer console. After pressing a particular lexigram, Sherman and Austin would often point to the object again.

In a more formal study of Sherman's and Austin's ability to indicate what incentive they would choose before actually making a choice, the procedure of the previous experiment was varied as follows (Savage-Rumbaugh et al., 1983): Five nonedible objects were placed on a tray outside one of two adjacent but visually isolated rooms. The items were selected randomly from a set of 20 photographs of food and 10 tools (actual tools or photographs). The task of the chimpanzee was to (a) look at the five objects outside room 1; (b) walk to room 2 and indicate, by pressing the appropriate lexigram, which object the chimpanzee intended to select in room 1; (c) return to room 1 to pick up the item requested; and (d) give the object to the experimenter in room 1 and receive praise and confirmation (or dismay and surprise). The experimenter learned which object the chimpanzee chose by looking at a display panel. Out of 53 trials, Sherman and Austin indicated correctly the objects they subsequently gave to the experimenter on 50 and 46 trials, respectively.

In both studies, Sherman and Austin were able to indicate a choice of a particular object (from a set of alternatives) without being able to see it. In the first study, they were allowed to ingest the object they indicated; in the second they were merely praised by their teachers for handing over the object they indicated (at least initially; see below). Taken together, these results are important demonstrations of a chimpanzee's ability to use a symbol to indicate its choice of incentive.

Can an Ape Refer?

The experiments by Savage-Rumbaugh and her colleagues (Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980; Savage-Rumbaugh et al., 1983) have revealed more clearly and critically than the first generation of ape-language studies an ape's ability to master a variety of symbolic skills at the level of an individual symbol. Chimpanzees can use a symbol to identify a concept, to demand a particular food or drink from a set of incentives that is out of sight, and also to indicate which object of a set of nonedible objects (also out of sight) they have chosen to present to their teacher. Given such a facility with symbols, it seems reasonable to ask, can apes be expected to take the seemingly small step that would allow them to use symbols as names?

Any answer to that question must take into account the fact that, as far as is known, an ape does not naturally refer to an object to which it attends solely for the purpose of noting that object to a conspecific. As mentioned earlier, whatever referential skills an ape displays naturally seem to be in the service of some concrete end.

The obvious time to attempt to instill referential skills in an ape is during infancy. In order to succeed, one would somehow have to train ape mothers to engage in certain commonplace practices followed by human mothers in rearing their infants. Unlike human mothers, ape mothers do not appear to try to involve their offspring in games whose purpose is to establish joint attention (Bard & Vauclair, 1984). Although infant apes play with objects in their natural environments (cf. McGrew, 1977), such play is solitary. Instead of drawing its mother's attention to ob-

jects, an infant chimpanzee seems more inclined to solicit bouts of tickling, usually by biting the mother's body (Plooij, 1979).

Reports of how a young chimpanzee learns to hunt termites provide good examples of the mother's indifference to her infant's failures to master a skill. In the case of termite hunting, it is necessary to poke into a termite mound with just the right touch. It is only by observational learning and by trial-and-error practice that the infant eventually masters the technique of using a stick as an aid in capturing a termite from its underground nest (cf. Lawick-Goodall, 1968, 1970; McGrew, 1977).

Studies such as those described in this section provide the major hope for leading an ape across the crucial threshold of symbol use that would enable it to refer to features of its environment. It is not unreasonable to anticipate that some sort of spontaneous indicating may emerge from highly structured games, either between two chimpanzees or between a chimpanzee and its teacher. What needs to be done is to expand the variety of such games and their contexts in ways that build upon the kinds of activities chimpanzees naturally prefer, for example, exploring a complicated outdoor area. Another promising line of research would attempt to exploit the natural pointing that has been observed during the mating behavior of *Pan paniscus,* the so-called pygmy chimpanzee (Savage-Rumbaugh, Wilkerson, & Bakeman, 1977). Natural pointing has not been observed in *Pan troglodytes,* the species that has been the subject of all of the chimpanzee language projects performed to date.

Dramatic evidence of the linguistic potential of *Pan paniscus* was presented in a recent report of the spontaneous acquisition of lexigrams by Kanzi, an infant male (Savage-Rumbaugh, Sevcik, Rumbaugh, & Rubert, 1985). When Kanzi was two and a half years old, he was separated from his mother so that she could be returned to a breeding colony. As Savage-Rumbaugh et al. reported, "Kanzi's use of the [lexigram] keyboard became prominent immediately following his mother's absence and his symbol usage was completely spontaneous, that is, no [formal] training was given" (p. 181). Within six months of his separation from his mother, Kanzi had mastered the correct use of more than 30 lexigrams, solely on the basis of observational learning. If, for example, his teacher pointed to an apple and pressed the lexigram *apple,* Kanzi readily demonstrated that he had formed the association between that symbol and the item it designated. Subsequently, Kanzi demonstrated his comprehension of lexigrams by selecting, from a set of photographs, the one photograph that corresponded to the lexigram the teacher presented to him.

Kanzi's acquisition of symbol use differed markedly from that of Sherman and Austin and, for that matter, from that of any other ape who had been taught to use arbitrary symbols. From the very start, it appeared as if Kanzi was the first ape to have learned to use a corpus of arbitrary symbols without the benefit of the tedious step-by-step drills that, heretofore, have been the only means available for teaching symbol use to apes. Given the ease with which Kanzi has been learning lexigrams, it seems reasonable to anticipate that his use of arbitrary symbols will, in other ways as well, surpass that of other apes who have been subjected to language training regimens.

Whatever kind of subjects one works with in attempting to establish naming in apes, it is important to minimize or, if possible, eliminate the role of specific reinforcers for any behavior one wants to claim as referential. If that cannot be done, there is no basis for arguing that the motivation for a purported instance of referential behavior is simply the transmission of information from a speaker to a listener.

The issue at hand is well illustrated by the experiment in which Sherman and Austin indicated symbolically which object they would subsequently present to their teacher. As far as I know, this is the first well-documented demonstration of a chimpanzee spontaneously directing another individual's attention to a particular object in a situation that did not provide an immediate concrete reward. It is, however, important to note the experimenter's description of Sherman's and Austin's behavior after indicating the object they were about to give to their teacher. They "would again point, now deliberately and with a more expressive gesture, at the object they just named . . . [they] clearly expected some sort of reward (either food, tickling, or praise) for having named and pointed to an object" (Savage-Rumbaugh et al., 1983, p. 479; second parenthetical phrase in original). Now that Savage-Rumbaugh et al. have established that chimpanzees can indicate objects symbolically, it is important that they try to go one step further and attempt to create the circumstances in which their chimpanzees' referential behavior would provide sufficient intrinsic reinforcement so as not to require any concrete reward from their teacher.

Verbal Versus Nonverbal Reference

Recent studies of symbol use by chimpanzees and of the emergence of naming skills in children pose the following question: At what stage do the intellectual developments of these species diverge? In attempting to answer that question, researchers concerned with an ape's ability to name should bear in mind the distinction between nonlinguistic and linguistic reference. It is conceivable that both pongid and human infants can direct someone else's attention to a particular object by pointing but that only human infants are able to do so with an arbitrary name. It is the latter type of reference that provides a springboard for the growth of human language.

Naming as a Precursor of Syntax

It is beyond the scope of this article to speculate when in the evolution of human intelligence infants were able to relax their acquisitive reactions to objects and simply indicate to a parent that they had noticed an object. Whatever the origin of that kind of reaction, it must have influenced profoundly the evolution of language. Foremost, it provided a psychological basis for interactions between infants and their parents that capitalized on their joint perception of an object.

If children did not develop the ability to use names to register what they noticed, and if the sole function of their speech was to demand things, it is hard to see why they would combine words according to a grammatical rule. Although children might use multiword utterances to demand various things, there is no reason to expect that the symbols contained by those utterances would be arranged syntactically. Clearly, the same argument applies to apes and indicates why it was premature to have expected that an ape might master even the most primitive grammatical rules. As Greenfield and Savage-Rumbaugh (1984) have commented about the multilexigram symbols of Sherman and Austin, "no evidence was found that combinations are, in any way, related to syntactic rules" (p. 206). Miles's (1983) similar assessment of the orangutan Chantek's combinations was cited earlier.

In theory, one could argue that a highly structured system of demands might require syntactic rules, for example, a request for the red plum from the far tree (as opposed to the green apple under the near bush). Such a state of affairs is implausible for a variety of reasons. To the extent that such specific desires occur in the natural world, they could be dealt with by unordered demands, eye-gaze, pointing, facial expression, or some combination thereof or by the successive elimination of alternative incentives. Thus, it is not clear what natural function a hypothetical demand system that obeyed grammatical rules might serve. I should also note that any attempt to teach such skills in a laboratory environment would seem to overtax the ability of any nonhuman primate.

A different state of affairs obtains when there is a desire simply to communicate information about a relationship between one object or action and another, about some attribute of an object, or about past or future events. In these instances, ungrammatical strings of words would not suffice—hence the functional value of syntax.

Naming and Consciousness

The ability to name is also relevant to a basic aspect of human consciousness. As part of our socialization, we learn to refer to various inner states: our feelings, emotions, thoughts, and so on (cf. Skinner, 1945). If one applies to internal events the same distinction one makes between perceiving an external event and naming that event, one is left with an interesting difference between animal and human consciousness. Human beings are able to name their inner states; animals are not. This nonsyntactic difference between animal and human consciousness deserves careful consideration by those concerned with defining the nature of animal consciousness (e.g., Gallup, 1977; Griffin, 1976, 1984).

REFERENCES

Anderson, J. R., & Bower, G. H. (1973). *Human associative memory.* Washington, DC: Winston.

Austin, J. L. (1962). *How to do things with words.* Cambridge, England: Oxford University Press.

Bard, K. A., & Vauclair, J. (1984). The communicative context of object manipulation in ape and human adult–infant pairs. *Journal of Human Evolution, 13,* 181–190.

Bates, E. (1976). *The emergence of symbols.* New York: Academic Press.

Bates, E., Bretherton, I., Shore, D., & McNew, S. (1981). Names, gestures, and objects: The role of context in the emergence of symbols. In K. E. Nelson (Ed.), *Children's language* (Vol. 3). New York: Gardner Press.

Bloom, L. M. (1970). *Language development: Form and function in emerging grammars.* Cambridge, MA: MIT Press.

Bloom, L. M. (1973). *One word at a time: The use of single word utterances before syntax.* The Hague: Mouton.

Bloom, L. M., & Lahey, M. (1978). *Language development and language disorders.* New York: Wiley.

Bloom, L. M., Rocissano, L., & Hood, L. (1976). Adult–child discourse: Developmental interaction between information processing and linguistic knowledge. *Cognitive Psychology, 8,* 521–552.

Braine, M. D. S. (1963). On learning the grammatical order of words. *Psychological Review, 70,* 323–348.

Braine, M. D. S. (1976). Children's first word combinations. *Monographs of the Society for Research in Child Development, 41*(164), 1–96.

Bretherton, I., McNew, S., Snyder, L., & Bates, E. (1983). Individual differences at 20 months: Analytic and holistic strategies in language acquisition. *Journal of Child Language, 10,* 293–320.

Brown, R. (1956). The original word game. In Bruner, J. S., Goodnow, J. J., & Austin, G. A. (Eds.), *A study of thinking* (pp. 247–312). New York: Wiley.

Brown, R. (1970). *Psycholinguistics: Selected papers by Roger Brown.* New York: Free Press.

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

Brown, R., & Bellugi, U. (1967). Three processes in the child's acquisition of syntax. *Harvard Education Review, 34,* 133–151.

Bruner, J. S. (1975). The ontogenesis of speech acts. *Journal of Child Language, 2,* 1–19.

Bruner, J. S. (1980). Intellectual autobiography. In G. Lindzey (Ed.), *History of psychology in autobiography* (pp. 75–150). San Francisco: Freeman.

Bruner, J. S. (1983). *Child's talk.* New York: Norton.

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. A. Miller (Eds.), *Linguistic theory and psychological reality* (pp. 37–48). Cambridge, MA: MIT Press.

Chomsky, N. (1957). *Syntactic structures.* The Hague: Mouton.

Chomsky, N. (1965). *Aspects of the theory of syntax.* Cambridge, MA: MIT Press.

Chomsky, N. (1966). *Cartesian linguistics: A chapter in the history of rationalist thought.* New York: Harper & Row.

Clark, E. (1973). Non-linguistic strategies and the acquisition of word meanings. *Cognition, 12,* 161–182.
Collis, G. M. (1979). Describing the structure of social interaction in infancy. In M. Bullowa (Ed.), *Before speech: The beginning of interpersonal communication* (pp. 111–130). Cambridge, England: Cambridge University Press.
Collis, G. M., & Schaffer, H. R. (1975). Synchronization of visual attention in mother–infant pairs. *Journal of Child Psychology and Psychiatry, 16,* 315–20.
Dore, J. (1975). Holophrases, speech acts and language universals. *Journal of Child Language, 2,* 21–40.
Epstein, R., Lanza, R. P., & Skinner, B. F. (1980). Symbolic communication between two pigeons (*Columba livia domestica*). *Science, 207,* 543–545.
Essock, S., Gill, T. V., & Rumbaugh, D. M. (1977). Language relevant object- and color-naming tasks. In D. M. Rumbaugh (Ed.), *Language learning by a chimpanzee: The Lana project* (pp. 193–206). New York: Academic Press.
Fillmore, C. (1968). The case for case. In E. Bach & R. T. Harmes (Eds.), *Universals in linguistic theory* (pp. 1–88). New York: Holt, Rinehart & Winston.
Gallup, G. G. (1977). Self-recognition in primates. *American Psychologist, 32,* 329–338.
Gardner, B. T. (1981). Project Nim: Who taught whom? *Contemporary Psychology, 26,* 425–426.
Gardner, B. T., & Gardner, R. A. (1969). Teaching sign language to a chimpanzee. *Science, 162,* 664–672.
Gardner, B. T., & Gardner, R. A. (1973). *Teaching sign language to the chimpanzee: Washoe* [Film]. University Park, PA: Psychological Cinema Register.
Gardner, B. T., & Gardner, R. A. (1975a). Early signs of language in child and chimpanzee. *Science, 187,* 752–753.
Gardner, B. T., & Gardner, R. A. (1975b). Evidence for sentence constituents in the early utterances of child chimpanzees. *Journal of Experimental Psychology, 104,* 244–267.
Golinkoff, R. M. (1983). *The transition from prelinguistic to linguistic communication.* Hillsdale, NJ: Erlbaum.
Greenfield, P. M. (1972). Playing peekaboo with a four-month-old: A study of the role of speech and nonspeech sounds in the formation of a visual schema. *The Journal of Psychology, 82,* 287–298.
Greenfield, P. M. (1978). Informativeness, presupposition, and semantic choice in single-word utterances. In N. Waterson & C. Snow (Eds.), *Development of communication: Social and pragmatic factors in language acquisition* (pp. 443–452). London: Wiley.
Greenfield, P. M. (1980). Toward an operational and logical analysis of intentionality: The use of discourse in early child language. In D. Olson (Ed.), *The social foundation of language and thought* (pp. 254–279). New York: Norton.
Greenfield, P. M. (1982). The role of perceived variability in the transition to language. *Journal of Child Language, 9,* 1–12.
Greenfield, P. M., & Savage-Rumbaugh, E. S. (1984). Perceived variability and symbol use: A common language–cognition interface in children and chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 98,* 201–218.
Greenfield, P. M., & Smith, J. H. (1976). *The structure of communication in early language development.* New York: Academic Press.
Grice, P. (1975). Logic and conversation. In P. Cole & J. Morgan (Eds.), *Syntax and semantics: Vol. 3. Speech acts* (pp. 113–127). New York: Academic Press.
Griffin, D. R. (1976). *The question of animal awareness: Evolutionary continuity of mental experience.* New York: Rockefeller University Press.
Griffin, D. R. (1984). *Animal thinking.* Cambridge, MA: Harvard University Press.
Halliday, M. A. K. (1975). *Learning how to mean—Explorations in the development of language.* London: Arnold.
Harris, P. L. (1983). Infant cognition. In M. M. Haith, J. J. Campos, & P. Mussen (Eds.), *Handbook of child psychology* (pp. 689–782). New York: Wiley.
Hayes, C. (1951). *The ape in our house.* New York: Harper.
Hayes, C., & Hayes, K. (1951). The intellectual development of a home-raised chimpanzee. *Proceedings of the American Philosophical Society, 95,* 105–109.
Kellogg, L. A., & Kellogg, W. N. (1967). *The ape and the child: A study of environmental influence and its behavior.* New York: Haffner. (Original work published 1933)
Khouts, N. (1935). *Infant ape and human child.* Moscow: Museum Darwianum.
Landau, B., & Gleitman, L. R. (1983). *The language of perception in blind children.* Unpublished manuscript, University of Pennsylvania.
Lawick-Goodall, J. V. (1968). The behavior of free-living chimpanzees in the Gombe Stream reserve. *Animal Behavior Monographs, I,* 161–311.
Lawick-Goodall, J. V. (1970). Tool-using in primates and other vertebrates. *Advances in the Study of Behavior, 3,* 195–249.
Lieberman, P. (1968). Primate vocalizations and human linguistic ability. *Journal of the Acoustical Society of America, 44,* 1574–1584.
Lieberman, P. (1975). The evolution of speech and language. In J. F. Kavanagh & J. E. Cutting (Eds.), *The role of speech in language* (pp. 83–106). Cambridge, MA: MIT Press.
Lock, A. (1978). *Action, gesture and symbol: The emergence of language.* London: Academic Press.
MacNamara, J. (1982). *Names for things.* Cambridge, MA: Bradford Books.
Markova, I. (1978). *The social context of language.* Chichester, England: Wiley.
McGrew, W. C. (1977). Socialization and object manipulation of wild chimpanzees. In S. Chevalier-Skolnikoff & F. E. Poirier (Eds.), *Primate biosocial development* (pp. 261–288). New York: Garland.
McShane, J. (1980). *Learning to talk.* Cambridge, England: Cambridge University Press.
Menzel, E. W. (1979). Communication of object-locations in a group of young chimpanzees. In D. A. Hamburg & E. R. McGowan (Eds.), *The great apes* (pp. 359–371). Menlo Park, CA: Benjamin Cummings.
Miles, H. L. (1983). Apes and language: The search for communicative competence. In J. de Luce & H. T. Wilder (Eds.), *Language in primates: Perspectives and implications* (pp. 43–61). New York: Springer.
Miller, G. A., & Johnson-Laird, P. N. (1976). *Language and perception.* Cambridge, MA: Harvard University Press.
Miller, W., & Ervin, S. (1964). The development of grammar in child language. In U. Bellugi & R. Brown (Eds.), *The acquisition of language, monographs of the society for research in child development* (pp. 9–34). Chicago: University of Chicago Press.
Mounin, G. (1976). Language communication and chimpanzees. *Current Anthropology, 1,* 1–21.
Mowrer, O. M. (1954). The psychologist looks at language. *American Psychologist, 9,* 660–694.
Mulford, R. (1985). First words of the blind child. In M. D. Smith & J. L. Locke (Eds.), *The emergent lexicon: The child's development of a linguistic vocabulary.* New York: Academic Press.
Nelson, K. E. (1973). Structure and strategy in learning to talk. *Monographs of the Society for Research in Child Development, 38*(149), 1–135.
Nelson, K. E. (1981). Individual differences in language development: Implications for development and language. *Developmental Psychology, 17,* 170–187.
Nelson, K. E., & Bonvillian, J. D. (1973). Concepts and words in the two-year-old: Acquisition of concept names under controlled conditions. *Cognition, 2,* 435–450.
Osgood, C. E. (1953). *Method and theory in experimental psychology.* New York: Oxford University Press.
Pate, J. L., & Rumbaugh, D. M. (1983). The language-like behavior

of Lana: Is it merely discrimination and paired-associate learning? *Animal Learning and Behavior, 11,* 134–138.
Patterson, F. G. (1978). The gestures of a gorilla: Language acquisition by another pongid. *Brain and Language, 12,* 72–97.
Patterson, F. G. (1981). Ape language. *Science, 211,* 86–87.
Piaget, J. (1952). *Origins of intelligence in children.* New York: International University Press.
Plooij, F. X. (1980). How wild chimpanzee babies trigger the onset of mother–infant play—And what the mother makes of it. In M. B. Bullowa (Ed.), *Before speech* (pp. 223–243). Cambridge, MA: Cambridge University Press.
Premack, D. (1970). A functional analysis of language. *Journal of the Experimental Analysis of Behavior, 4,* 107–125.
Premack, D. (1971). On the assessment of language competence in the chimpanzee. In A. M. Schrier & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 4, pp. 186–228). New York: Academic Press.
Premack, D. (1976). *Intelligence in ape and man.* Hillsdale, NJ: Erlbaum.
Premack, D. (1979). Species of intelligence: Debate between Premack and Chomsky. *The Sciences, 19,* 6–23.
Premack, D. (1983). The codes of man and beast. *The Behavioral and Brain Sciences, 6,* 125–167.
Quine, W. V. (1980). What is it all about? *American Scholar, 50,* 43–54.
Ratner, N., & Bruner, J. S. (1978). Social exchange and the acquisition of language. *Journal of Child Language, 5,* 391–401.
Ristau, C. A., & Robbins, D. (1982). Language in the great apes: A critical review. *Advances in the Study of Behavior, 12,* 141–255.
Robson, K. S. (1967). The role of eye-to-eye contact in maternal-infant attachment. *Journal of Child Psychology and Psychiatry, 8,* 13–25.
Rumbaugh, D. M., Gill, T. V., & von Glasersfeld, E. C. (1973). Reading and sentence completion by a chimpanzee. *Science, 182,* 731–733.
Ryan, J. (1974). Early language development. Towards a communicational analysis. In M. P. M. Richards (Ed.), *The integration of a child into a social world* (pp. 185–213). Cambridge, England: Cambridge University Press.
Savage-Rumbaugh, E. S. (1981). Can apes use symbols to represent their world? *Annals of the New York Academy of Sciences, 364,* 35–59.
Savage-Rumbaugh, E. S. (1984). Verbal behavior at a procedural level in the chimpanzee. *Journal of the Experimental Analysis of Behavior, 41,* 223–250.
Savage-Rumbaugh, E. S., Pate, J. L., Lawson, J., Smith, S. T., & Rosenbaum, S. (1983). Can a chimpanzee make a statement? *Journal of Experimental Psychology: General, 112,* 457–487.
Savage-Rumbaugh, E. S., Rumbaugh, D. M., & Boysen, S. (1978a). Linguistically mediated tool use and exchange by chimpanzees (*Pan troglodytes*). *The Behavioral and Brain Sciences, 1*(4), 539–629.
Savage-Rumbaugh, E. S., Rumbaugh, D. M., & Boysen, S. (1978b). Symbolic communication between two chimpanzees (*Pan troglodytes*). *Science, 201,* 641–644.
Savage-Rumbaugh, E. S., Rumbaugh, D. M., & Boysen, S. (1980). Do apes use language? *American Scientist, 68,* 49–61.
Savage-Rumbaugh, E. S., Rumbaugh, D. M., Smith, S. T., & Lawson, J. (1980). Reference: The linguistic essential. *Science, 210,* 922–924.
Savage-Rumbaugh, E. S., Sevcik, R. A., Rumbaugh, D. M., & Rubert, E. (1985). The capacity of animals to acquire language: do species differences have anything to say to us? *Philosophical Transactions.* Royal Society of London, *B308,* 177–185.
Savage-Rumbaugh, E. S., Wilkerson, B. J., & Bakeman, R. (1977). Spontaneous gestural communication among conspecifics in the pygmy chimpanzee (*Pan paniscus*). In G. H. Bourne (Ed.), *Progress in ape research* (pp. 97–116). New York: Academic Press.
Scaife, M., & Bruner, J. (1975). The capacity for joint visual attention in the infant. *Nature, 253,* 265–256.
Schieffelin, B., & Ochs, E. (1983). A cultural perspective on the transition from prelinguistic to linguistic communication. In R. M. Golinkoff (Ed.), *The transition from prelinguistic to linguistic communication* (pp. 115–128). Hillsdale, NJ: Erlbaum.
Schlesinger, I. N. (1971). Production of utterances and language acquisition. In D. I. Slobin (Ed.), *Ontogenesis of grammar* (pp. 63–101). New York: Academic Press.
Searle, J. R. (1983). *Intentionality.* Cambridge, England: Cambridge University Press.
Skinner, B. F. (1945). The operational analysis of psychological terms. *Psychological Review, 52,* 270–277.
Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.
Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton–Century–Crofts.
Skinner, B. F. (1974). About behaviorism. New York: Knopf.
Smillie, D. (1982). Rethinking Piaget's theory of infancy. *Human Development, 25,* 282–294.
Stern, D. (1977). *The first relationship: Infant and mother.* Cambridge, MA: Harvard University Press.
Stern, D., Beebe, B., & Bennett, S. (1975). Vocalizing in unison and in alternation: Two modes of communication within the mother–infant dyad. In D. Aronson & R. Rieber (Eds.), *Developmental psycholinguistics and communication disorders* (pp. 89–100). New York: New York Academy of Sciences.
Straub, R. O., Seidenberg, M. S., Bever, T. G., & Terrace, H. S. (1979). Serial learning in the pigeon. *Journal of the Experimental Analysis of Behavior, 32,* 137–148.
Sugarman-Bell, S. (1978). Some organizational aspects of pre-verbal communication. In I. Markova (Ed.), *The social context of language* (pp. 49–66). New York: Wiley.
Telecki, G. (1973). *The predatory behavior of wild chimpanzees.* Lewisburg, PA: Bucknell University Press.
Terrace, H. S. (1979a). Is problem solving language? A review of Premack's "Intelligence in apes and man." *Journal of the Experimental Analysis of Behavior, 31,* 161–175.
Terrace, H. S. (1979b). *Nim.* New York: Knopf.
Terrace, H. S. (1981). Reply to Bindra and Patterson. *Science, 211,* 87–88.
Terrace, H. S. (1982a). Evidence for sign language in apes: What the ape signed or how well was the ape loved? *Contemporary Psychology, 27,* 67–68.
Terrace, H. S. (1982b). Simultaneous chaining: The problem it poses for traditional chaining theory. In M. L. Commons, A. R. Wagner, & R. J. Herrnstein (Eds.), *Quantitative studies in operant behavior: Discrimination processes* (pp. 115–137). New York: Ballinger.
Terrace, H. S. (1984). Animal cognition. In H. L. Roitblat, T. G. Bever, & H. S. Terrace (Eds.), *Animal Cognition* (pp. 7–28). Hillsdale, NJ: Earlbaum.
Terrace, H. S., Petitto, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science, 206,* 891–902.
Thompson, C. R., & Church, R. M. (1980). An explanation of the language of a chimpanzee. *Science, 208,* 313–314.
Whitehurst, G. J., Kedesdy, J., & White, T. G. (1982). A functional analysis of meaning. In S. A. Kuczaj, II (Ed.), *Language development: Syntax and semantics* (pp. 397–425). Hillsdale, NJ: Erlbaum.
Winitz, H. (1969). *Articulatory acquisition and behavior.* New York: Appleton–Century–Crofts.
Winitz, H., & Irwin, O. C. (1958). Syllabic and phonetic structure of an infant's early words. *Journal of Speech Hearing Research, 1,* 256–260.