Conditioning Communicative Responses in Animals

Kurt Salzinger

Polytechnic Institute of Brooklyn
and
Biometrics Research, New York State Department of Mental Hygiene

The purpose of this paper is to discuss the current place of animal communication in the study of psycholinguistics, to describe the contribution which behavior theory can make to this area, and finally, to review some experiments in the conditioning of sound production in different animals.

For many years, psychologists' major interest in verbal behavior took the form of nonsense syllable experiments. In their avid pursuit of a single methodology they appeared to remove themselves ever further from explanation of the variables which control the emission of verbal behavior in communication and even in problem solving. More recently, however, there has taken place a resurgence of interest stimulated by Miller's (1962) translation of Chomsky's (1957) generative model of grammar. New journals devoted to the study of language and many books have appeared in response to the new linkage between psychology and linguistics, eventually resulting in the term "psycholinguistics." The marriage between psychology and linguistics rejected the old bond between its partners, namely, behaviorism, and espoused the "freer theorizing" about such concepts as the "language acquisition device" which was, of course, an attempt to speculate about the inside of the black box which had been rejected by both behaviorists and linguists of old. No attempt will be made here to go into the "pros" and "cons" of the generative model of grammar, but one aspect of the model is very pertinent to our discussion. In 1965, when George Miller stated a number of basic principles which he felt had to be adhered to, in order to make a contribution to the field of psycholinguistics, he stated that the study of animal language was likely to contribute no more than 1% of the knowledge necessary for an understanding of human language. This kind of statement is based upon the contention of investigators such as Lenneberg (1967) who claim that the processes by which language is realized are "deeply-rooted, species-specific, innate properties of man's biological nature." Lenneberg goes on, further, to reject, as not heuristic, the study of communication systems in animals now extent, saying that "no living animal represents a direct primitive ancestor of our own kind and, therefore, there is no reason to believe that any one of their traits is a primitive form of any one of our traits." (Lenneberg, 1967, pp. 234-235). He rejects the notion that vocalization is very important at all in the study of communication, contending that it is our cognitive processes, entailing categorization, which are basic for the acquisition of language as man uses it. Animals, he claims, have languages based upon other considerations, such as territoriality and courting behavior. Despite this minimizing of the role of vocalizing in language, it is difficult to conceive of any other function besides language that animal vocalization (other than sonar) might have. The antipathy toward examining the forms of communication
in animals as precursors to human communication is, oddly enough, paired with a belief that human language is, to a great extent, biologically determined, so that the process of acquisition is given a very minor place in its analysis. It is particularly ironic that the depreciation of learning in language comes at a time when its power of analysis and control is increasingly being shown in man and animal. A notion now current among followers of the generative model approach (e.g., McNeill, 1966) is the aforementioned language acquisition device (LAD) which is said to contain "templates" the purpose of which is to filter the speech of parents so as to extract the underlying grammar which the child assays through his innate appreciation of the universal categories of language. From my own much more behavioristic point of view, I sometimes think of this concept as "LAG," that is, a language acquisition gremlin, for the concept appears to have simply moved the problem of the acquisition of language from the child, to a little man inside the child. The difference between the child and the gremlin is that the former can behave, and his behavior can be monitored, while the latter can only be speculated about. Nevertheless, it is of interest to note that at least one speaker at this symposium, namely, Marler, has suggested the concept of a template to explain the apparently selective nature of the song which birds acquire. I assume that such a concept in the bird can be more easily verified than the analogous, but much more abstract, concept in the human being. The important point about such a notion, with respect to the present argument, however, is that it may, contrary to the opinion of many psycholinguists, pay to examine communicative behavior in animals. It is my contention that there are a number of ways in which the study of communicative behavior in animals can serve to elucidate the problem of language in human beings. The importance of the study of animal language for its own sake need not even be mentioned in a symposium such as this.

The significance of the study of animal language for understanding human language lies in the following:

1. The law of parsimony is more easily followed when examining simple rather than complex behavior. In fact, the reason often given for neglecting animal language, namely, its simplicity, is the very quality which produces testable models for studying human verbal behavior. Furthermore, it tends to minimize subjective elements in the model since scientists are less likely to anthropomorphize than to empathize.

2. The theory of evolution which has, of course, served as a unifying factor for many aspects of biology, including ethology, could help in providing students of language with the appropriate extrapolatory statements for generalizing correctly from findings in animal communication to hypotheses and data in human verbal behavior. Hockett (1963) has recently shown the importance of examining animal communication systems for the problem of discovering the universal features in human communication. A better understanding of animal communication can also shed light on the theory of evolution, and although most of the data must obviously come from examination of current species, anatomical examination of current and past animals' speech mechanisms, can shed further light on the problem.
3. Perhaps the most important reason for studying animal communication is the one most often given for using animals: the greater degree of experimental control which can be exerted over animals than over man. Such control allows for the utilization of physiological, biochemical, neurosurgical and genetic intervention, as well as extreme modification of the environmental conditions involved in the maturation and learning of verbal behavior.

Despite these cogent reasons for studying animal language, its application to the study of human verbal behavior has been retarded by much controversy and philosophical discussion concerning the definition of language. Perhaps the most useful treatment of whether animals are capable of language comes from the fruitful restatement of the problem by Hockett (1959, 1960a, 1960b, 1963) in terms of which (rather than whether) properties of human language are within the capabilities of different animals. I will list these properties and comment on them:

1. **Vocal-auditory channel.** Many animals make use of channels of communication other than the vocal-auditory one (e.g., bee dancing, ant odor trails, spider "web-plucking"). Furthermore, in some animals (e.g., crickets) the channel is auditory but not vocal. One of the advantages of the vocal-auditory system of communication, however, is that it leaves the primate's hands and other potential communicating parts of the body free for other activities. It is also, of course, an example of remote control, keeping pace with the development of the distance receptors. That this channel of communication is not essential for the definition of human language, however, is obvious, as soon as one assays the other channels which are used by human beings (writing, for example, or sign language in the deaf and dumb, or the even more extreme example of the constricting of communication channels as in Helen Keller's case).

2. **Broadcast transmission and directional reception.** These two aspects of communication result directly from the first property, but are inherent in any sound communication system. The fact that sounds are broadcast can, of course, allow enemies to receive messages which are intended for friends. The survival value of this aspect of communication will be referred to again below when we discuss the conditionability of vocalization in various animals. The property of directional reception makes it possible for an animal to transmit information about location, without having to include it as an explicit part of the message; for example, a food call made by a gibbon merely states that food is available, while the property of directional reception provides the receiving animal with the information about the location of the food.

3. **Rapid fading.** Sound production has the property of fading in a short time, thus making it possible to send a new message immediately after the old. This differs, of course, from information transmission by trails or spoor, which fade slowly. It also differs from olfactory signals, which have the disadvantage of being propagated slowly over any distance. Finally, the possible disadvantage of fading can be overcome by repetitive transmission.

4. **Interchangeability.** Adult human beings can generally reproduce any message they can understand. Among animals, there are many exceptions to this rule,
such as the specialized calls of males and females. Hockett recognizes many exceptions to this rule among humans but considers them marginal.

5. Complete feedback. The human sender both sends and hears the message. The stickleback's courtship dance, on the other hand, receives feedback only in terms of the other stickleback's actions. The property of complete feedback, along with interchangeability, is the combination necessary for planning future behavior. The importance of feedback to the organism can be demonstrated by delaying it (Yates, 1963) or by observing a deaf person's speech. In the former, speech is disturbed; in the latter, its acquisition is severely attenuated and the resultant speech often hard to understand. Although auditory feedback during vocalization is supplemented by kinaesthetic and proprioceptive feedback, there is no proprioceptive feedback from the larynx, thus augmenting the importance of auditory feedback itself. Orr and Cappamar (1964), in tracing the emergence of language, point out that "there are minimal internal neuroanatomical pathways between speaking and hearing" (p. 318) and that their relationship must be channeled in large part through the environment rather than the nervous system.

6. Specialization. Only a Caruso or certain animals such as dolphins and bats appear able to make direct use of their vocalizations, i.e., make use of the energy rather than the signal. The former is said to have shattered a glass by his voice, the latter use the physical nature of sonic feedback to reveal the presence of obstacles. Hockett (1960a, p. 407) describes "a communicative act, or a whole communicative system, ..., as specialized to the extent that its direct energetic consequences are biologically irrelevant." Thus, a dog's panting has a biological function of cooling him, but in addition provides or transmits information about his identity, location, and state. This communication can be characterized as being unspecialized. As Hockett himself admits, it is not always obvious where to draw the line between specialized and unspecialized communication. To the property of specialization might be added the fact that most human verbal behavior is reinforced secondarily, i.e., the organism influenced by the verbal behavior most often mediates nonbiological reinforcement to the emitter of the verbal responses.

7. Semanticity. There is a relationship between (to use Roger Brown's (1958) book title) words and things, or, to use Skinner's (1957) terminology, there are tacks (response classes under the control of the environment). Investigation of animals shows that many have semanticity, e.g., the food call of the gibbon or the dance of the bee.

8. Arbitrariness. The semantic relation is described to be "arbitrary" rather than "iconic," i.e., there is no relationship between size or loudness of words and the objects they normally describe. Thus, both mammalian and avian communication systems appear to be semantic and arbitrary. On the other hand, to the extent that Andrew's (1962a, 1963) notion of stimulus-contrast is valid, the primates' vocalizations can be said to have at least some nonarbitrary or iconic features.
9. Discreteness. Human language is characterized by discontinuities in the sense that words differ from one another by the presence or absence of phonemes, and not by a change in the value of some continuous parameter, say, loudness. It should be noted that continuous communication systems imply iconicity, as in the dance of the bee, where the rate of dancing is inversely proportional to the target location. On the other hand, a discrete system can be either iconic or arbitrary. It is interesting to note that Sebeok (1962) has discussed this property in slightly different terms, namely, as digital (discrete) and analog (continuous) coding of information.

10. Displacement. In human communication, verbal responses can refer to things remote in time and space, i.e., some verbal responses usually evoked by certain stimuli are also emitted at times when these particular stimuli are absent. Hockett notes that the calls of gibbons are never displaced in this manner, while bee dances (which are related to communicating the distance of food sources or a new living place) always are. This is opposed to human language where displacement can, but need not, occur. He also points out that without displacement, no discussion of past or future events or planning would be possible; this property is, therefore, considered to be a very important aspect of human language. He also argues that since displacement implies a delay between the reception of a stimulus and the response, it therefore requires some information storage in the brain. However, he does realize that the storage may be of another kind, as in his hypothetical example of the proto-Hominoid, who, while fleeing a predator, is stimulated to make his danger call when the predator is no longer present, by release of the odor stimulated by his own fear. Storage, mediated by other responses or with no such apparent mediation, has been demonstrated in experiments with many different animals. The very process of learning, of course, is evidence for storage and displacement. Many of the more complicated schedules of reinforcement (Ferster & Skinner, 1957) require storage and displacement. The DRL schedule (differential reinforcement of low rates), for example, requires the animal to emit responses only after a minimum period of time has elapsed following the previous response -- a perfect example of "displacing" or postponing a response. Whether animals can do this vocally is simply an experimental question, but it is not, in any case, central to the question of whether animals are capable of displacement. Therefore, this author must disagree with Hockett's statement that displacement is rare. The point I feel that Hockett could validly make is that DRL performance is not found in nature as a communication system, but whether a given type of behavior does exist hardly seems as important as whether it can exist. One can also ask whether respondent conditioning might not be considered an example of displacement as well, since the dog (to take the classical example) salivates in response to the bell (anticipates? plans for?), before the food is placed in his mouth.

One other point needs to be made concerning the property of displacement. Hockett's description of it implies that human beings are responding to stimuli which are not present at the time of the response. Human beings' verbal responses, however, are multiply determined, by external stimuli, by other verbal responses, by non-verbal responses and by the stimuli produced by these responses; and when
a person makes a response to a stimulus which is apparently not present, he is, in fact, responding to one or more of the other mediating stimuli and responses which control the emission of that response. It is important to remember that the phenomenon of displacement consists of bridging the stimulus and response in ways which should, at least in principle, be within the capacity of many animals. A more detailed analysis of displacement thus contradicts Hockett's assertion of the rarity of this phenomenon among animals.

11. Productivity or openness. New messages are produced in human language by inserting words, or more precisely, morphemes, into grammatical patterns in ways not utilized before, or by modifying the meaning of old words, as in the coining of new idioms. Thus, while bees are said by Hockett to have the ability to produce a very special sort of grammatical patterning (and thus to describe distances not ever described before) they are unable to create new idioms. By the same token, gibbon calls may be considered to be a closed system of verbal behavior, as well.

This particular property attributes to man alone the ability to be original, i.e., to put responses together in a novel way. But so-called insight (which, in at least some experiments, has been reduced to low probability, although maintaining real stimulus-response connections) has been demonstrated in animals as well as in man, viz. monkeys putting two sticks together to reach a banana otherwise out of reach. The notion of making responses that had not been made before can also be illustrated in Harlow's (1949) experiments on reversal learning. A monkey was first reinforced to make one out of two responses, and subsequently reinforced to make the other. This was repeated over a series of different problems such that first one response was correct and then the other. The results of this experiment showed that the monkeys eventually learned to make the "other" response on the trial following the first reversal trial nearly 100% of the time. In other words, they were productive, i.e., learned to make a new response after some training. I am suggesting that once we separate this property from that of vocalization, it no longer appears to be unique to man. The concepts of response class (Salzinger, 1967) and unit size (Salzinger, 1962), which are necessary to explain animal behavior, can be utilized to demonstrate the phenomenon of productivity in human language as well. Thus, by selecting concepts for analysis which are applicable both to man and animal, some of the seemingly unique properties of human language can be shown to be present in varying degrees in animals.

12. Tradition. The conventions of language are learned and taught by other members of the same species who, in turn, have learned the language from other members of the species. For some language conventions in some species the transmission is genetically determined. For others it is learned. Hockett reports the existence of shortlived traditions among chimpanzees in captivity, but leaves unspecified the kind of learning and teaching process involved. Its importance will be discussed below.

13. Duality. Every human language is said to have both phonological and grammatical subsystems, i.e., a very large number of different morphemes can be formed on the basis of a small number of phonemes. Hockett (1963) states that
"no animal system known to the writer shows any significant duality." Yet, animals can be conditioned to emit relatively complicated chains of responses (with each response acting as a phoneme and each chain of responses as a morpheme) both with verbal as well as with nonverbal responses, as will be shown below. The emission of a series of responses in one order may signify (since it is followed in the experiment by orange juice) as a communication, "give me orange juice" while the emission of the same responses in a different order may signify as a communication (at least to the experimenter who supplies the banana in response to that pattern), "give me a banana." Here we see how experimentation can uncover an ability in animals which the customary environment does not call forth.

14. Peareification. Verbal responses can be false or logically meaningless. Hockett ascribes the admittedly doubtful property of truthfulness to animals other than man. The implication here, as with the properties of displacement and productivity, appears to be that an organism can will to lie. A more reasonable explanation concerning such response classes (lying) is that the verbal response is controlled by different stimuli and reinforcement contingencies than those expected by the hearer in terms of his own reinforcement history. Thus, whether an organism is lying is not related to the degree of stimulus control over verbal responses but rather to the class of stimuli which do the controlling. The difference between man and animal concerning this characteristic might be better described by noting that displacement or mediation through other stimuli occurs more frequently in man than animal. The latter is simply more frequently controlled by more immediate stimuli.

15. Reflexiveness. This is sometimes called metacommunication, and refers to the fact that man can talk about his talking, but bees are destined never to dance about their dancing. It is another example of the differences which exist in types of stimuli which can control verbal responses in man and animal. Like properties 5, 7, 10, and 14, it makes reference to the fact that man's verbal responses are evoked by a larger number of different types of stimuli than animals' responses. How much training would be required to extend the number of types or classes of such stimuli in animals, is an interesting empirical question.

16. Learnability. A speaker of one language can learn another language. Sebeok has suggested that there is a property of multiple coding potential, which should perhaps be included here. It is "the transmutation of one set of verbal signs (e.g., speech) into another set (e.g., script)." (Sebeok, 1962, p. 431 fn.). Some animals lack this property altogether, but some, Hockett tells us, have probably developed communication systems with this property. Together with property 12 this suggests that it would be useful to examine the role of learning in the comparative analysis of languages in man and animal, particularly in order to determine how much animal language can be made to resemble human communication. The next section will deal with this problem.
Conditioning of verbal behavior

The importance of conditioning lies in the fact that it allows us to go beyond Hockett's list of the properties of language itself by characterizing the properties of the speaker.

Comparisons of the language of man and animals is incomplete as long as only their behavior in nature is examined. It is obvious that many animals have the capacity to behave in ways not called forth by their usual environment. The experimental work carried out in the context of behavior theory has supplied us with ample evidence for this. The absence of language development cannot be assumed to mean the absence of the ability to develop language. Thus, the first reason for examining the relation between learning and language development is to determine which animals have what kind of language development potential. There are many methods which can be used for such investigation, such as the modification techniques of imprinting, respondent conditioning, or operant conditioning. Ginsburg (1963) suggested instrumentality as a property to be added to Hockett's list. Here instrumentality will be subsumed in what I shall call property number 1, language learning potential.

A second reason for examining the relation is to determine to what extent animals throughout the phylogenetic scale show general learning capacities necessary for the development of language. To give an obvious example, an animal whose behavior is only minimally influenced by the environment could certainly not be expected to develop a language like the human one. Furthermore, if environmental influence is possible, it is reasonable to ask what kind -- imprinting, respondent conditioning or operant conditioning. Finally, conditioning studies can make available information on the complexity of the learning possible for different animals. This I shall label property number 2, general learning capacity.

A third reason for scrutinizing the conditioning literature, is to examine the general rate of verbal response. It is well known that the operant level of a response (response rate before reinforcement is applied) is of importance for conditioning, even if only for the purpose of making a valid estimate of the probable effect of the reinforcement which is to be applied. Such an estimate is necessary to effect the response differentiation necessary for language. This I shall call property number 3, verbal response availability.

A fourth reason for utilizing the learning theory model for language comparisons is to discover the relative conditionability of verbal vs. nonverbal behavior. An animal whose nonverbal responses are more efficient in procuring reinforcement than its verbal responses will show less verbal conditionability and will therefore be less likely to develop language. This is property number 4, relative verbal response conditionability.

The fifth reason for examining the relationship between learning theory and language is to determine how the verbal response classes affect other verbal and nonverbal response classes. There has been increasing interest in both the
U.S.S.R. and this country in the regulating function of verbal behavior over nonverbal behavior, a function which appears to increase with age. This is property number 5, the regulating function.

Let us now look at the literature with respect to these properties:

1. Language learning potential. Studies relevant to this property can be divided into two types: those that address themselves directly to the conditioning of human speech in animals, and those that are concerned with vocalization in general. It should be noted that it would be at least as important to apply the conditioning techniques, which will be described below, to communication systems other than vocal ones, such as the dancing of the bee or the odor trails of fire ants, since the critical problem to investigate is the extent to which the communication systems of different animals can be modified by the environment so as to further increase their development.

The experimental production of speech, or at least of some words, in primates is, of course, tempting to accomplish because of the resemblance of these animals to man in other characteristics. An early study along these lines was reported by Furness (1916). The first word he taught his orangutan was "Papa" which took 6 months of daily training. He selected this particular word because it combined two elements of vocalization not generally used by orangutans, namely, the lips and expired vowel sounds. He trained the orangutan by enunciating the word repeatedly for minutes at a stretch, while at the same time, bringing the animal's lips together and apart in imitation of his own lip movements. He also practiced the motions together with the ape in front of a mirror, so as to make available more stimuli for the production of the word. Then, when the sound was finally produced, the experimenter "praised and petted her enthusiastically." After that, she apparently retained the response. Finally, he was able to train the animal to make the association between the word "Papa" and himself. The next word which Furness taught the orangutan to produce was the word "cup", and, by this time, it had become much easier to train the animal since she had learned to respond to verbal stimuli, such as, "open your mouth," or "stick out your tongue." It is instructive to trace the training procedure for the word "cup" as described by Furness in his own words: "The first move in teaching her to say cup was to push her tongue back in her throat as if she were to make the sound 'Ka.' This was done by means of a bone spatula with which I pressed lightly on the center of her tongue. When I saw that she had taken a full breath I placed my finger over her nose to make her try to breathe through her mouth. The spatula was then quickly withdrawn and inevitably she made the sound 'Ka.' All the while facing her I held my mouth open with my tongue in the same position as hers so that her observation, curiosity, and powers of imitation might aid her, and I said "Ka" with her emphatically as I released her tongue." (Furness, 1916, p. 284). The orangutan eventually learned to draw back her tongue before the spatula touched it; she then learned to place the experimenter's finger over her nose, and to say "Ka" without any use of the spatula; then she placed her own finger over her nose and finally made the "Ka" sound whenever asked to. The final consonant was eventually added by having the experimenter close the animal's lips with his fingers as soon as the animal made the "Ka" sound. By showing the orangutan the cup she used for drinking
as he emitted "cup," Furness was able to make the word "cup" a discriminative response under the control of the SD (discriminative stimulus) "What is this?" He was even able to obtain evidence for the orangutan's use of the word "cup" as a mand (Skinner, 1957) for water, although apparently the animal had had no special training for it. This particularly well trained animal was conditioned to emit the "th" sound but apparently died before the sound could be incorporated into other sound sequences to produce words.

In discussing the general training procedures he employed, Furness called special attention to the fact that "the enticement of food has never been used as an incentive to actions, and praise and petting have been the only rewards. In other words my object has been to endeavor to make them show signs of thought rather than a perfunctory performance of tricks." (Furness, 1916, p. 285). Today's psychologist might find it somewhat surprising that an experimenter would avoid using the strongest possible reinforcement and would certainly dispute the claim that verbal behavior reinforced by praise and petting is more closely associated with thought than behavior reinforced by food. Nevertheless, the administration of reinforcement by means of the intervention of another organism brings it closer to language as man knows it; in other words, conditioned reinforcement is far more important than primary reinforcement in the control and maintenance of the verbal behavior of humans.

Kellogg and Kellogg (1933) raised a female chimpanzee, beginning at 7½ months of age, along with their 9½ months old son for a period of 9 months. Although they made no special effort to teach the chimpanzee to talk, she was, of course, exposed to speech in the same situations as the human child. Although she did not learn to say any English words during the first 5 months, she surpassed her human sibling in the number of verbal stimuli to which she could respond appropriately. Furthermore, she demonstrated an ability to communicate even though her communication procedures were not always vocal.

The Hayoses (Hayes, C., 1951; Hayes, K. J., 1950; Hayes & Hayes, 1954) raised their chimpanzee beginning at an earlier age (6 weeks) and for a longer time (some 6 years) than the Kelloggs. They taught her to say 3 words (mama, papa, cup) under appropriate circumstances, i.e., in response to certain SDs and to use at least one of them (cup) in the form of a request for something to drink (Skinner's mand). Furthermore, they assigned meanings to certain sounds already within the repertory of the animal by reinforcing these sounds with the delivery of different objects. At one point, they attributed the animal's limited language acquisition to a neurological condition much like aphasia, but later taking note of the obvious difference in degree of vocal practice between the chimpanzee and the child, they attributed the limited language acquisition to a difference in "motivation" to vocalize. Lilly (1962) has more recently become interested in teaching dolphins to talk, and has reported some success and plans for further research in this area. And finally, I would like to cite a study by Ginsburg (1963), who reported, in a controlled experiment, the instatement of two discriminative verbal responses, "Hello" and "What's up?", in the mynah bird.

These experiments can be summarized to show that a number of different animals can, with some difficulty, be trained to emit verbal responses, similar to those emitted by human beings, which show some of the same functions as human
verbal behavior, namely, external (sight of an object) and internal (dry throat) discriminative control. Although responses to verbal stimuli in the chimpanzees showed more than simply intonational control, new combinations of old words were not as easily understood as by the human child. In most cases, new combinations of old words had to be learned all over again. Not enough controlled research of this kind has been done, however, probably because of the difficulty, certainly in working with chimpanzees, merely with the process of getting them to emit English words in the first place. Experiments which utilize animal sounds already in the animal's repertory, or even nonvocal responses, might serve better to investigate the animal's ability to acquire language.

Two studies were recently reported using nonvocal response systems with chimpanzees. The first of these consisted essentially of describing a plan for such an experiment (Premack & Schwartz, 1966). These investigators decided to eschew the use of vocalization in the chimpanzee and substituted instead a sound producing joystick, i.e., a lever which can be displaced from its central resting position (vertical) to a maximum of 40 degrees from the vertical in any direction. The side of the stick also has a pressure gauge which registers the strength of the animal's grip. The displacement of the stick produces a sound which can be described in terms of the following five different dimensions: degree of tilt (corresponding to the frequency of the sound), displacement in the north-south plane (corresponding to a superimposed white noise), displacement in the east-west plane (corresponding to a vibrato in the tone, i.e., a pulsing), pressure on the stick (corresponding to the amplitude of the sound), and length of time that the stick is away from the resting position (corresponding to the duration of the sound). The training procedure was to be a simulation of the usual mother-father and parent-child interaction in order to teach the chimpanzee child the language. Thus, the chimpanzees would be exposed to the interaction between the mother's and father's joysticks, as well as being involved in their own interactions. Some provision would also be made for monitoring babbling, which would, in this case, consist of the manipulation of the stick.

Another experiment, performed by Gardner and Gardner (1968), utilized a system of language which did not even produce a sound. Beginning with the knowledge that chimpanzees have difficulty vocalizing some of the sounds easily produced by human beings, the investigators decided to deal with the problem by assuming that the chimpanzee is essentially deaf and dumb, and that he therefore should be taught American sign language for the deaf. They began working with a female chimpanzee 10½ months old, by raising her in a house trailer, situated in a garden with trees and a jungle gym. The animal is always accompanied by human beings who use sign language, both in communicating with her and with other human companions, in her presence. No voiced communication takes place in her presence with the exception of the imitation of any sounds the chimpanzee herself makes. Although all the exact procedures are not now available (apparently they include the usual operant techniques), the authors have made available a summary of a diary which they kept on the progress made in a number of areas of functioning, including social behavior, imitation, perceptual-motor development, and, of course, gestures. By the time the chimpanzee reached the age of 14 months she was able to understand the following 9 signs: come, look, good-bye, stay (come down), no-no, scolding, in, swing, hug. At that time she had only one arbitrary sign ("more"), which she
could emit herself. By the time she reached the age of 18 months she showed the attribute of productivity in the use of the word "more". Thus, while she had been exposed to seeing the sign, "more," in the context of continued hairbrushing, and continued tickling, she spontaneously used it to ask for continued whispering in her ear, for continued pillow fighting, and for further listening to the ticking of a watch. Some evidence for the overgeneralization of this response was also shown when she used it for a first cup of formula. By the age of 18 months she showed that she understood some 32 different signs and was able to produce five signs (come, more, goodbye-hi, up, sweet). By the time the chimpanzee reached the age of 22 months she was combining signs, such as "gimme more." At 32 months of age the chimpanzee used some 29 different two-sign combinations and four different three-sign combinations. The experimenters point out that the order in which many, but not all, of these combinations occur, appears to vary, even though the particular combinations do occur with some frequency. Finally, the investigators noted that the chimpanzee actually signed to herself when leafing through a picture book and also when she was up in a tree. Since the investigators simply present the summaries of the diary, rather than interpreting the results, I will limit my own remarks about them also. But it should be obvious from the little reported here, that this particular technique has gotten further than any other in examining the acquisition of language in an animal other than the human being. Furthermore, the results, especially the combinations of words (signs), the productive use of language, and the rehearsing and talking to oneself are all very much reminiscent of the observations made by those of us who have studied the acquisition of language in the human child. In our own experience, it was the productivity, and the spontaneous combination of words which we had separately taught a speech-deficient boy, which foreshadowed greater progress in his acquisition of language (Salzinger, Feldman, Cowan, and Salzinger, 1965).

While one cannot expect the same results with a bird, or even a dog, as with a chimpanzee, it is nevertheless of interest to determine whether the "natural" vocalizations made by these animals, as well, can be modified by conditioning. Studies on the conditioning of animal vocalization have generally dealt with the modification of sounds the animal already has within its repertory. Using a somewhat unique approach, Lane and Shinkman (1963) circumvented at least some of the problems of comparability of human and animal (chick) vocal behavior, not, as is usually done, by modifying the animal's response in the direction of the human being, but by modifying the human's response by restricting it to a single sound, /u/. Then, the changes in the physical parameters of the human and the bantam chick responses were compared and found to be quite similar in terms of the relative changes which occurred in response topography as the reinforcement contingency was shifted from one schedule to another. This experiment and Lane's (1960, 1961) other experiments have shown that, contrary to the implication of refractoriness (Skinner, 1957) to operant conditioning, animal vocalizations could indeed be conditioned by operant techniques, being responsive to different reinforcement schedules in much the same way as nonvocal (e.g., pecking) responses. Lane (1960) showed that the increase in chirping behavior was, in fact, due to the effect of the experimental administration of reinforcement, and was not simply an elicited response, i.e., one which was emotional in character, by demonstrating that a free feeding situation elicited no more chirps than a situation which contained no feeding at all.
Grosslight, Harrison and Weiser (1962) conditioned vocalization in the mynah bird, demonstrating its operant nature by a yoked arrangement, i.e., whenever Bird A was reinforced for emitting a vocalization, Bird B also received food, the presentation of which was, of course, independent of Bird B's behavior. Under these circumstances it was again possible to demonstrate that vocalizations of birds could be conditioned by an operant technique. Furthermore, these investigators also showed that it was possible to establish discriminative control over the vocalizations and that the duration of each response unit could be modified.

Experiments with shell parakeets were undertaken by Ginsburg (1960) who demonstrated that the bird's chirp could be conditioned operantly, that it responded differentially to interval and ratio schedules of reinforcement, and that discriminative control could be established over it.

Perhaps the greatest impetus for work with the vocalizations of birds has come from Nowrzer (1950). He maintained that the way to train "talking" birds to emit a word was to say the word just before feeding the bird. The animal should then learn the response because the experimenter's emission of the word would become an SD for the reinforcement; later, the bird's own emission of the word, or initially sounds similar to it, would also produce the SD for food and would therefore function as a secondary reinforcer as well, which, in turn, should reinforce the animal's further emission of words.

Nowrzer's description of this procedure was an anecdotal one and the theory was later subjected to a stricter experimental test by Foss (1964). In this experiment, two different kinds of whistle (not originally in the bird's repertory) were played to mynah birds, under two different conditions, and then their rate of occurrence was compared. One condition consisted of preparing and placing food in the cage of the birds while playing the sounds; the other consisted of playing the sounds only, with nothing else being shown to the birds at the time, i.e., neither a human being nor food. The results showed that approximately the same number of whistles were reproduced under the two different conditions. The author concluded that learning theory could not explain the acquisition of the new sounds and that "mynah birds have a tendency to mimic." In another test of Nowrzer's theory, Grosslight and Zaynor (1967) found an actual reduction of vocal behavior during the food-speech pairing situation, thereby not supporting the theory. Grosslight and Zaynor reviewed a number of the difficulties encountered in trying to work with vocalization in the mynah bird and pointed out that the major one consisted of the fact that it is difficult to find the precise conditions under which mynah birds can reliably be made to talk. According to these investigators much more needs to be learned about the mynah bird before we extrapolate to man.

The operant conditioning of barking has not enjoyed as much popularity as that of bird vocalization. Nevertheless, Konorski (1948) reported conditioning of barking to the sound of a metronome, and Lavicka (1957) described a procedure in which he measured the latency of response to discriminative stimuli of very short duration. A more complete description of the operant conditioning of barking was given by Salzinger and Waller (1962). In this study beagles and a wirehaired...
fox terrier were conditioned operantly on a fixed ratio reinforcement schedule; discriminative control was demonstrated over the vocal response; the control was extended to a multiple schedule reinforcement both the vocal component and a bar pushing component; and finally, the multiple schedule was converted to a chain schedule requiring a sequence of 10 bar responses followed by 10 vocal responses before the administration of reinforcement.

Molliver (1963) showed that the cat's "meow" is as conditionable by means of an operant paradigm, as the bark of the dog. More recently, Burnstein and Wolff (1967) used intracranial stimulation to reinforce vocalization in the guinea pig. They were able to show not only that one can modify the rate of vocalization, but also, by reinforcing vocalizations in different frequency ranges, that one can shape the response topography, as well.

The operant conditioning paradigm was also extended to marine life. Lilly and Miller (1962) used electrical stimulation of the brain of a dolphin in order to differentially reinforce vocalization of a particular frequency, duration and amplitude. In a more recent paper, Lilly (1965) reported mimicking behavior in a dolphin. In this interesting experiment, he reinforec the dolphin for matching the number of its own sonic emissions to the number of nonsense syllables emitted by the experimenter. This was accomplished by first reinforcing any emission of sound, then gradually raising the requirement. It should be noted here that, basically, this procedure is a multiple schedule of reinforcement, with each component being characterized as having a different fixed number of responses per reinforcement. Such multiple schedules have been worked on extensively using nonvocal responses (Ferster and Skinner, 1957) but have also been applied to vocal responses such as those described above. Both Lane (1961) and Salzinger and Waller (1962) used schedules requiring chains of 10 vocal and 10 nonvocal responses. In Lilly's experiment, it might have been interesting to compare the rate of acquisition of responses when the discriminative stimuli consisted of the appropriate number of bursts, i.e., when the response had to match the stimulus in number, with the acquisition of responses when the discriminative stimuli had no such relationship to the responses required. The reader is invited to read a more comprehensive review of the dolphin's accomplishments in Lilly (1967). Among the interesting points, is the fact that the sound production need not be continuously reinforced by food, some conditioned reinforcement apparently taking over.

The conditionability of the sea lion was recently demonstrated by Schusterman and Feinstein (1965). These investigators instated a click response in a sea lion that had never emitted such a response in the laboratory, and then brought the response under the control of the size of a circular stimulus.

Thus far then, it has been shown that a number of different animals' vocalizations can be conditioned by operant techniques. But Mowrer, Palmer, and Sanger (1948) were unable to operantly condition a vocal avoidance response in the rat, although in the same study they were able to condition a running avoidance response.
They utilized an escape-avoidance procedure to condition the two different responses: vocalization in one group and running in the other. The procedure consisted of the following: a flickering light was turned on, and if the rat did not make the required response in 5 seconds, it received an electric shock which was terminated, along with the flickering light, only when the required response was made. Thus, if the rat made the required response before the end of the 5 seconds, an avoidance response was emitted; if the rat learned to respond after the shock was turned on, an escape response was emitted. It should be noted that electric shock elicits respondent components of the running response (Schoenfeld, 1950) thus amplifying the operant conditioning effect for that response; it also elicits a vocalization response which has been successfully conditioned by respondent, not operant, techniques (Warner, 1932; Schlosberg, 1934; Cowles & Pennington, 1943; Herbert, 1946). On the average, vocalization responses occurred after the shock stimulus went on. By the tenth day of 10 trials each, avoidance responses had reached a level of 90% for the running response, but only 6% for vocalization. Further conditioning at an increased shock intensity for 5 additional days did not alter the results. The failure to obtain operant conditioning of the vocal response under the same conditions in which a running response could be conditioned, led the authors to the following inferences: Vocalization in rats must have survival value only if the animal has already been caught (respondent conditioning is generally carried out when the animal's movement is severely curtailed as it would be if it were caught by a predator); however, when it is only in danger of being caught (corresponding in the experiment to the condition where the warning signal is on), vocalization does not have survival value, for it might simply bring the predator to the animal. Thus, they argue that, over many generations, there must have been selection of those rats who would not vocalize under avoidance conditions. Furthermore, the authors also maintain that, in many animals, vocalization is a respondent, and not an operant. More recent studies, however, have indicated that both kinds of conditioning paradigm can be applied to many different responses. To determine whether a given vocalization response can be conditioned by an operant or respondent paradigm, one has to observe whether vocalization can be modified by positive reinforcement; the argument concerning survival value of vocalization would not apply with equal force to "non-danger" situations, i.e., to situations where vocalization is followed by such "pro-survival" events as food.

Mowrer and his colleagues go on to speculate more generally about the survival value of vocalization in different animals, discussing the greater survival value of vocalization in domesticated animals than in those in nature. Finally, they suggest that both man and birds were able to develop vocalization to a higher degree than many other animals because of their sejourn in the trees, which presumably offered them more protection. They account for other highly vocal animals by postulating the development, in these animals, of special escape routes or camouflage which enables them to escape the notice their vocalization calls to them. Speculative as this reasoning is, it has suggested the importance of comparing operant and respondent conditioning of vocal responses.

Whether a response class such as vocalization is an operant or a respondent (Salzinger and Waller, 1966) ought to be determined empirically for vocalization
Further experimentation relevant to the questions raised by Mower has recently been performed. Sapon (1965) conditioned vocalization in rats deprived of water by using water as the positive reinforcement. He was able to instate the response of vocalization by two different methods. One consisted of differentially reinforcing ever louder respiratory sounds until the animal vocalized loudly. The other method consisted of piping rat vocalizations into the cage. These were paired with presentation of positive reinforcement. After some two hours of this procedure which reduced considerably the latency of approach, upon hearing the sound, to the water dipper, the regular shaping procedure was engaged in. It is of interest to note parenthetically the similarity of these shaping procedures to those used in the instatement of barking (Salzinger & Waller, 1962). Two of the dogs which had never been in the experimental enclosure produced a whine, the intensity of which could be slowly increased by reinforcing ever louder sounds until they evolved into barks, which constituted the desired response. Another dog which had been accustomed to the experimental enclosure, produced no sounds which could be differentially reinforced. Barking was instated in him by having the experimenter bark at him; that, in turn, provoked the dog to bark, at which point he could be reinforced, and eventually his barks turned into a free operant by increasing the relative number of dog-barks to experimenter-barks before a positive reinforcement was given. Apparently, similar techniques work with different animals in the instatement of vocalization.

To get back to Sapon's experiment, however, it is important to note that it was possible to condition vocalization in the rat, and what is even more interesting perhaps, it was found to be relatively difficult to extinguish the vocalization response, although the experiment was, unfortunately, not carried out long enough to assess this completely. Thus, the genetic effect suggested by Mower and his colleagues to have produced the refractoriness of conditioning of vocalization in the rat would definitely have to be referred only to the avoidance situation.

In a series of recent experiments there appeared to be difficulty in conditioning vocalization in rats even by means of a respondent conditioning procedure (Badia, Suter, & Lewis, 1966; Badia, Lewis, & Suter, 1967; Lewis, Suter, & Badia, 1967). These investigators found, contrary to the experiments previously cited, no vocalization to the conditioned stimulus. To complicate the issue further, a recent paper by Lal (1967) reported conditioned avoidance vocalization in rats, although, to be sure, only 4 out of 10 rats acquired high rates of vocalization, five other rats avoided 20% to 70% of the shocks, and one rat which had learned to escape from practically all shocks by vocalizing, avoided none of the shocks. It turns out that all of these seemingly discrepant results can be explained by the same variable which Mower and his colleagues had, of course, pointed out in their original experiment, namely, the variable of confinement. All of the experiments which had success in conditioning with an aversive stimulus, whether operant or respondent, had the rats confined in a restraining holder of some sort, while all of the experiments which were unable to show conditioning with an aversive stimulus allowed the rats to roam freely in the cage. Thus, the recent experiments by Badia, Lewis and Suter which
appeared to have shown failure to condition even by means of the respondent paradigm, allowing the rats to roam, while the experiment by Lal, which appeared to have shown successful avoidance conditioning, had his rats confined in a rat holder. All of these results appear to be in agreement with the hypothesis about the survival value of vocalization under conditions of captivity (when vocalization would be helpful to the survival of other members of the species as a warning of a predator) and the contra-survival value under conditions of being in danger of being captured by a predator (when vocalizations would only lead to being discovered by the predator). A historical footnote should be added to this discussion, and that is a quotation from Schlosberg (1934, p. 332), who was examining a variable he called depth of conditioning: "It makes no great difference whether the rat terminates or prevents the shock by its response (escape or avoidance conditioning), or whether, on the contrary, the duration of the shock is held constant (respondent conditioning)." [The parenthetical remarks were added by this author.] The point is that a careful reading of Schlosberg's old experiment would have shown even then, that it is not the kind of conditioning paradigm that is the important variable, but the state of confinement which is the critical factor.

The property of language learning potential thus reveals a number of interesting aspects of vocalization as a precursor to language in man. Although the extrapolation to man must be cautious indeed, the lawful relations to the environment, both within an experiment and within the much larger context of evolution, make the examination of this variable a promising one.

2. General learning capacity. This property has already been touched on in a number of different ways. Any thorough review of this area would take us too far afield to be useful here. But the reader is invited to inspect the current learning literature, as found in the Journal of Comparative and Physiological Psychology, The Journal of the Experimental Analysis of Behavior, and the Journal of Experimental Psychology for many experiments requiring different kinds of animals to perform quite complex tasks, many of which reveal the capacity to acquire language. The experiments discussed above (Furness, the Kelloggs and the Hayeses, all of whom were interested in the acquisition of language in primates) agreed on the complexity of verbal behavior to which these primates were able to respond appropriately. Lilly has argued that the dolphin learns easily, although Andrew (1962b) did not appear equally impressed by the dolphin's intelligence. Findley (1962) recently presented some descriptions of what he called "multi-operant behavior repertoires" where animals' training procedures consisting of increasing complexity were outlined. Of special interest here is the fact that response chains of greater complexity (with a given response leading to a choice of several responses rather than one) are more resistant to extinction than simple response chains. Harlow's (1949) reversal learning paradigm revealed that primates could learn what some of the linguistics-influenced psychologists would call a rule, but which can be otherwise described in terms of learning theory as stimulus and response generalization. This particular learning procedure was likened by Brown (1958) to the semantic linguistic process of negation, where the absence of a positive reinforcement could be viewed as an SD (like the words "not this, the other") for the other response.
Reversal training on the same kind of problem was traced phylogenetically by Bitterman (1965). He found that the monkey, rat, pigeon, turtle and decorticated rat showed progressive improvement, whereas the fish, cockroach and earthworm showed none in reversal learning of spatial problems; with respect to visual reversal problems he found progressive improvement only in the monkey, rat and pigeon. He traced probability learning ability for the same animals and was able to set up performance comparisons on this task with results similar to those cited above. Schusterman (1966, 1967) recently showed reversal learning in the sea lion, showing a learning capacity equal to that of the chimpanzee. Thus, having general learning techniques available for phylogenetic comparison provides us with the opportunity for systematic comparison of performance on those relatively complex tasks with natural language acquisition, as well as with the degree of language conditionability in the laboratory.

Lilly's (1965) recent experiment described above, shows the dolphin's ability to match number of responses vocally. It is worthwhile to point out that other animals have acquired what one can loosely call "counting" responses, although this term may not fully describe what the animals were actually doing. Koehler (1956) was interested in birds' ability to count and showed that they were able to match numbers of objects, as well as to select a given number of objects out of a larger group depending only on the specific discriminative stimulus (color of the lid) provided by the experimenter.

A recent experiment by Ferster (1964) produced behavior in chimpanzees which he felt was very much related to the problem of acquisition of verbal behavior. The chimpanzees went through the following procedures: All their food had to be earned by the behavior in the experiment. Correct responses were reinforced by a brief tone followed after a given number of successive correct responses by food. Incorrect responses were followed by "time-out," a short black-out during which time no response on the part of the animal would be positively reinforced. The chimpanzees, who, incidentally, in contrast to the subjects worked on by the Kelloggs, Hayeses and Farnese, were not handled but were put through automatic stimulus and response devices, worked 4 to 5 hours per day (4000-7000 trials during that time). The chimpanzees were first trained to match colors, i.e., to press a key under that color which matched the color in the window. After they had been trained to make the matching color response, they were trained to match binary numbers expressed as unlit (0) and lit (1) circles by selecting which of a pair of 3 unlit and lit circles matched a standard set. They were also given training in matching number symbols to given numbers of objects. Thus, they were eventually able to match the correct binary number to one through seven objects with an accuracy of better than 95%. They were then trained to "write" the binary numbers by allowing them to turn on the lights in such a way as to produce a binary digit number. By the end of the experiment, the chimpanzees had learned to identify from one to seven objects, writing the correct binary number with only 1 to 2 errors per 1000 trials. The development of this complex behavior required a very large number of trials (hundreds of thousands for the entire repertory) made possible only by the automatic aspects of the experiment.

This brief review indicates that there are indeed experimental techniques available for the study of complex behavior in animals. In order to evaluate the
property of general learning capacity it will be necessary to apply these
techniques more widely to a large enough sample of animals up and down the
phylogenetic scale so as to make useful comparisons among the animals and their
language capacity.

3. Verbal response availability. The studies relevant to this property
have already been mentioned. Mowrer and his colleagues (1948) have suggested
systematic differences in the conditions under which animals are likely to
vocalize and which not. Hayes and Hayes (1954) pointed to the utter lack of vocal
play in primates. Whether due to lack of motivation, absence of a drive for
vocalization or a neurological deficit, the fact of lack or paucity of vocal
behavior might well provide part of the explanation for the difference in
conditionability of vocalization between monkey and dolphin, the latter finding
vocalization useful for other than communication activities. Finally, the
reader is reminded of the extensive vocal play found in human children.

From a research point of view, this property requires that a more systematic
survey be made of vocal or other potentially communicative responses available in
some form of babbling in the early years of animals, since this might well make
the difference between the animal which develops verbal behavior and the one which
does not. The experiments done on sign language in chimpanzees would seem to
corroborate this.

4. Relative verbal response conditionability. Not many studies have
addressed themselves to this problem of relative communicative response strength.
Little experimental evidence is necessary to buttress the argument for the
superior conditionability of verbal over nonverbal behavior in human beings,
although at least some such evidence has been collected (Salzinger, Feldman, &
Portnoy, 1964). The animal evidence concerning this point has already been
mentioned. Both Lane (1961) and Salzinger and Waller (1962) were able to condition
vocal as well as nonvocal behavior, obtaining similar results with both response
classes, in chick and dog, respectively, while Mowrer et al (1948) found only the
nonvocal response class conditionable (under avoidance conditions) in rats.
Lilly and Miller (1962) said in comparing vocal conditioning, using electrical
stimulation in similar systems of the brain, in monkeys and dolphins, that "one
cannot induce the monkey to use vocalization the way it uses its hands in order
to start a desired stimulus. The dolphin apparently uses vocal outputs and may
even prefer vocalization to pushing a lever with its beak." (Lilly & Miller,
1962, p. 76). Thus, it is important in tracing the evolution of verbal behavior,
not only to gauge the extent of vocalization in infancy but also to examine the
extent to which nonvocal behavior exceeds it in probability of occurrence and
therefore is more likely to be followed by reinforcement. Vocal behavior is less
likely to develop if other competing behaviors are more likely to be followed by
positive reinforcement.

5. The regulating function. More explicit attention has been paid to this
particular aspect of verbal behavior in Russian work than in work in this country.
Pavlov's second signalling system does in fact view verbal behavior as the
important regulator of human behavior, a regulator which is presumably absent in
animal behavior. Luria (1957, 1961a, 1961b, 1967) has worked extensively on the gradual development of the regulating function of verbal behavior in children. In this country, interest in verbal behavior as a regulator has been more recent. Lovaas (1961, 1964a, 1964b) has been successful in demonstrating this function by way of the operant conditioning paradigm in children.

Little direct evidence on the regulating effect of verbal behavior in animals has so far been found, although Thorndike's (1943) theory of the origin of language did, in fact, suggest that verbal behavior first evolved as a regulator of the speaker's own behavior and only subsequently acquired the function of controlling or at least stimulating the behavior of others. The odor trails left behind by an animal, which serve to communicate with other animals, can of course also serve that function with respect to communicating with itself. Furthermore, the dolphin and other animals making use of sonar or echolocation have shown a very specialized use of vocalization in guiding or regulating behavior (Griffin, 1958). In addition, the experiments mentioned with respect to the property of general learning capacity give ample evidence for the complex ways in which different response classes can be made to depend on each other's occurrence, the essence of the regulating function. The major difference would seem to lie in the fact that verbal behavior in man is peculiarly suited to this task. The search in animal behavior for such a response class, which, incidentally, need not even function as a communicative system, would be helpful in revealing the steps involved in the evolution of language.

Summary

Beginning with a short discussion of the place of animal communication in the study of psycholinguistics, this paper reviewed Hockett's system of describing the similarities and differences in communication in different animals, including man. It then went on to describe a list of some 5 properties of the human speaker which one can fruitfully look for in the communication of animals. These properties were in large part derived from behavior theory and consisted of the following: language learning potential, general learning capacity, verbal response availability, relative verbal response conditionability, and the regulating function of language. Discussion of the five speaker properties included the detailed examination of experiments which have already suggested some dimensions along which one can fruitfully compare animals up and down the phylogenetic scale.

It seems reasonable to conclude that the study of animal language will figure importantly in the elucidation of the variables which control language in man. Certainly the complexity of the communication process in animals is great enough to occupy many scientists in gaining an understanding of that process. Once we have reached an understanding of animal language, it should be far easier to comprehend the language of man.
References

Andrew, R. J. The situations that evoke vocalization in primates. Annals of the New York Academy of Sciences, 1962, 102, 296-315. (a)

Andrew, R. J. Evolution of intelligence and vocal mimicking. Science, 1962, 137, 585-599. (b)


Grosslight, J. H., Harrison, P. C., & Weiser, C. M. Reinforcement control of vocal responses in the mynah bird (Gracula Religiosa). Psychological Record, 1962, 12, 193-201.


Hockett, C. F. The origin of speech. Scientific American, 1960, 203, 89-98. (b)


Lane, H., & Shinkman, P. G. Methods and findings in an analysis of a vocal operant. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 179-188.


Lovaas, O. I. Cue properties of words: the control of operant responding by rate and content of verbal operants. *Child Development*, 1964, 35, 245-256. (a)

Lovaas, O. I. Control of food intake in children by reinforcement of relevant verbal behavior. *Journal of Abnormal and Social Psychology*, 1964, 68, 672-678. (b)


The author wishes to express his thanks to his wife Suzanne Salzinger for editing this paper and to J. Zubin for encouraging work in this area.