Communication and Language in the Home-Raised Chimpanzee

The gestures, "words," and behavioral signals of home-raised apes are critically examined.

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Oral speech develops in the human infant as an outgrowth of his contact with older humans who are continuously using language. A deaf mute fails to speak because he never hears the acoustic patterns which make up words. He has no sound patterns to follow, no models to imitate. If the ear itself is functioning but the child is mentally retarded, he may be able to hear but not to imitate. Again, he does not learn to speak. A normal ear, a normal brain and speech organs, the continuous hearing of spoken language, and a great deal of imitation are necessary for the completion of the process.

The ear, the speech mechanism, and the capacity to imitate are furnished by the child. The linguistic models come from the human environment in which he lives. Also furnished by the child—perhaps as a result of, or in connection with, his imitation—is a long prespeech period in which he produces both vowels and consonants, but not words. This period of prattling and babbling seems to be a necessary forerunner of the words to come. Children who acquire normal speech habits do so as a kind of outgrowth and expansion of this developmental phase (*1*). In the terminology of the experimental psychologist, it may be thought of as a period of "preconditioning" or "pretraining."

If special requirements such as these are necessary for speech to occur in a young human, does any other organism below man possess them? The chimpanzee certainly has a good enough ear, as measurements of auditory sensitivity have demonstrated (*2*). So far as the larynx and speech parts are concerned, the general assumption has been that these also are sufficiently well developed to permit the articulation of words—although Kelemen (*3*) takes exception to this position. The chimpanzee is a great imitator of the movements and activities it sees performed, although it is not as good an imitator as the child (*4, 5*). It does not naturally imitate sounds and noises, like the parrot or the myna bird, which can reproduce human word sounds but are less apt at nonvocal imitation. Also, the development of the chimpanzee brain as compared with that of man remains in doubt.

But has a chimpanzee (or any of the other apes, for that matter) ever been given a really adequate opportunity to learn and to imitate human speech signals as they occur in their natural context? Has a chimpanzee been exposed to the environmental sound-models which are necessary—for as long a time and in the same way as human children?

The Ape-Rearing Experiment

The ape-rearing experiment should furnish an answer to such questions. If communication were ever to evolve, it would seem that the environment of a human household would offer the most favorable conditions. To be sure, the keeping of infrahuman primates as pets or playthings is by no means a novel practice and can be traced historically as far back as the ancient Greeks and Egyptians (*6*). Apes as household pets are not uncommon today and several books by lay authors attest to the problems involved (*7*). Such ventures have never given any indication of the development of human language. But pet behavior is not child behavior, and pet treatment is not child treatment.

It is quite another story, therefore, for trained and qualified psychobiologists to observe and measure the reactions of a home-raised pongid amid controlled experimental home surroundings. Such research is difficult, confining, and time-consuming. Too often, unfortunately, its purpose is misunderstood. Since 1932 reports of five such experiments by qualified investigators have been published in the United States and one in Russia. Four of the U.S. studies were sponsored by the Yerkes Laboratories of Primate Biology at Orange Park, Florida (*8*). The animals used in all instances were chimpanzees.

The Russian research and two of those conducted in America had a human child or children as permanent in-house controls. In the other experiments the chimps were raised in a household with adult humans alone. Table 1 gives some of the characteristics of the different experiments, including the approximate duration of each, the number of child controls, the ages of the chimpanzees, and the names of the investigators. In the present article we shall deal only with those aspects of these researches having to do with communication and language. The work of Kohts (*9*), Kellogg and Kellogg (*5, 10–12*), C. Hayes (*13*), Hayes and Hayes (*4, 14–18*), and Gardner and Gardner (*19*) is of special importance in this connection. The observations of Jacobsen *et al.* (*20*) do not deal with this topic, and Finch himself never published any of his findings.

The Pronunciation of Words

The results of such projects show in general that the infant chimp, when properly handled in the home situation, reacts in many ways as a young child does. It adapts rapidly to the physical features of the environment (*11, 18*), shows a strong attachment for its caretaker or experimental mother, passes a good many of the preschool developmental tests designed for children, and imitates acts performed by adults without special training. Up to the age of perhaps 3 years, its "mental age" is not far behind that of a child. At the same time, its skeletal and muscular development are much more rapid than those of a child.

With regard to the problem of communication, the results at first glance are disappointing. For even in the ex-

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Table 1. Prinicipal chimpanzee-raising experiments.

Publication date	Investigator	Approx. duration	Approx. age of chimp at start	Sex and name of chimp	No. of child controls
1932	Jacobsen, Jacobsen, and Yoshioka (*20*)	1 year	A few days	F; Alpha	0
1932–67	Kellogg and Kellogg (*5, 10–12*)	9 months	7½ months	F; Gua	1
1935	Kohts (*9*)	2½ years	1½ years	M; Joni	1
None	Finch	3 years	3 days	M; Fin	2
1951–54	Hayes and Hayes (*4, 14–18*)	6½ years	3 days	F; Viki	0
1967	Gardner and Gardner (*19*)	In progress	9–15 months	F; Washoe	0

perimentally controlled environment in which a home-raised chimpanzee is given the same linguistic and social advantages as a human baby, the chimp displays little evidence of vocal imitation. Despite its generally high level of imitative behavior, it never copies or reproduces human word sounds. Yerkes has written with reference to this matter that in neither the studies of Kellogg nor of Finch "were attempts to imitate speech or other indications of learning to use human language observed" (*21*). Kohts noted also that her home-raised chimpanzee displayed not the slightest evidence of trying to reproduce any human vocalizations (*9*, p. 576).

Moreover, no ape has ever been known to go through the long period of babbling and prattling which, in the human baby, seems to be the necessary prerequisite to the subsequent articulation of word sounds. Vocalized play of this sort was absent in the Kelloggs' chimp, who made no sounds "without some definite provocation . . . and in most cases this stimulus was obviously of an emotional character" (*5*, p. 281). The Hayeses noted also that their ape was much "less vocal" and was relatively silent as compared to a child (*15*, p. 106; *16*).

Despite these observations, the usual chimpanzee noises—such as the food-bark, the "oo oo" cry, and screeching or screaming—were present in all of these experiments and were vigorously employed. The use of these and other sounds as natural communicative signals has been examined by Goodall (*22*) for chimpanzees in the wild, and by Yerkes and Learned (*23*) for captive animals. It is a question whether such sounds can be modified or shaped to fit the human language pattern.

On the positive side belong the remarkable cases of so-called talking apes. A trained chimpanzee studied by Witmer as far back as 1909 was reported to be able to pronounce the word "mama" but only with great difficulty. The "m" of "mama" was well done, but the "ah" was not voiced (*24*).

A few years later, Furness (*25*), working diligently with a young orangutan, finally succeeded in getting it to say "papa" and "cup." In training the animal to say "papa," Furness found it necessary to place his fingers on the animal's lips and to open and close them in the proper rhythm.

Table 2. Early gesture signals of chimpanzee Gua.*

Behavior pattern	Human interpretation
Biting or chewing at clothing or fingers of experimenter	"Hungry"
Climbing into high chair	Same
Protruding lips toward cup	"Drink"
Pushing cup away	"Enough"
Removing bib from her neck	"Finished eating"
Taking hand of experimenter and hanging on it	"Swing me"
Throwing self prone on floor	"Sleepy" or "Tired" (goes to sleep at once when put to bed for nap)
Pulling hand of experimenter to coke bottle	"Help me" or "Lift this for me"
Holding of genitalia	"Need to urinate (or defecate)"

* Adapted from Kellogg and Kellogg (*5*, pp. 275–278).

The best known and most successful of these linguistic efforts is that of the Hayeses (*13*), who were able to get their chimpanzee Viki to emit recognizable versions of the words "papa," "mama," and "cup." A beginning was also made toward the sound of "up." Viki thereby exceeded the vocabulary level of either of the other apes, although interestingly enough, she pronounced the same words that they had. She had only one vowel for all of her word sounds, a hoarse and exaggerated stage whisper.

The first step in Viki's speech training was designed to teach her to produce a sound—any sound—on demand. This was done by reinforcing whatever noises she made during the training session, such as the pleasure barks elicited by showing her food, or the "oo oo" which resulted from withdrawing the food. It was 5 months, however, before the animal could emit a sound promptly on cue, and the noise she made then was a new one; a hoarse "ah," quite unlike the normal chimpanzee vocalizations which had been previously rewarded.

The Hayeses taught Viki to say "mama" by manipulating her lips as she said "ah," then gradually reduced the amount of manipulation as she learned to make the lip movements herself. In this way the animal finally came to say "mama," softly and hoarsely, and without help (although she persisted in putting her own forefinger on her upper lip). Viki's later words were learned more quickly, making use of existing consonant-like mouth sounds which she had often produced in play. Fortunately, her articulation and vocal behavior have been preserved in a sound motion picture film (*14*).

These then, "mama," "papa," "cup," and possibly "up," represent the acme of chimpanzee achievement in the production of human speech sounds. But they were learned only with the greatest difficulty. And, even after she could reproduce them, the animal's words were sometimes confused and were used incorrectly. The most important finding of the Hayeses was perhaps not that their chimp could enunciate a few human sounds. It lay rather in the discovery that these sound patterns were extremely hard for the ape to master, that they never came naturally or easily, and that she had trouble afterward in keeping the patterns straight.

Comprehension of Language

The ability of a home-raised chimpanzee to "understand" or react characteristically to spoken words or phrases is perhaps best illustrated by the Kelloggs' ape Gua. These investigators kept a daily record of the language units which both the chimpanzee and her human control were able to discriminate. In the case of the chimpanzee, the words reacted to varied from such relatively simple commands as "No no" and "Come here" to statements like "Close the door," "Blow the horn" (of a car), "Don't put that in your mouth," and "Go to Daddy," "Go to Mama," "Go to Donald" (as the case might be). In the first 4 months of the study, the chimp was slightly ahead of the child in the total number of spoken phrases to which she could respond correctly. This was no doubt due to her superior locomotor ability since, in the beginning, the human subject was obviously unable to comply with such commands as "Get up on the chair." During the last 5 months of the period of comparison, the child surpassed the ape in comprehension. The total score for the entire 9 months was 68 specific response patterns for the child and 58 for the chimpanzee (*5*).

Although the ape was only slightly behind her human control at the end, it is noteworthy that she had earlier scored higher than he. This means that she was overtaken by the child, who accelerated at a more rapid rate. Had the comparison continued for a longer period, all indications are that the human subject would have left the animal far behind in the comprehension of words.

Spontaneous Gesturing

Does an anthropoid ape, maintained in the human household, ever use or develop any system of motions or gestures which carry special significance or meaning? The answer is "yes," the amount and type of gesturing depending upon the particular home environment and the particular animal. Regarding this matter, the Hayeses have written about Viki that she "makes relatively little use of gestures of the hand alone" (*17*, p. 299). She would nevertheless take hold of the experimenter's hand and lead him where she wanted to go, an activity earlier observed by Yerkes (*26*) in an orangutan with which he worked.

Mrs. Kohts reports that gestures were commonly employed by her chimpanzee Joni and, surprisingly, that many of the chimp gestures were like those used by her son. "Both infants sometimes show a nearly similar gesture language. Thus 'request' is expressed by extending hand forward, 'rejection of food' by turning face and head aside, 'thirst' by putting hand to mouth, 'desire to draw attention to oneself' by tugging at dress" (*9*, p. 544).

The Kelloggs' chimpanzee Gua also employed a kind of language of gesture or of action, but in this instance the gesturing of the ape was generally different from that of the child. Most of Gua's gestures consisted of movement patterns which occurred regularly just before or in advance of some subsequent or final act. In this way they served as preparatory signals for the terminal response to come later. Viewed objectively, these signaling movements can be interpreted as anticipatory reactions which were consistent with and occurred in specific situations. It need not be presumed, therefore, that they necessarily represented conscious or purposeful efforts on the part of the animal to "tell" others what she wanted. Their reliability was confirmed by numerous repetitions. The principal instances of this language of action are given in Table 2.

The most significant of the gestures listed in Table 2 are probably those for "sleep" or "sleepiness," those indicating bladder and bowel needs, and the "help me" signal in drinking a coke. The latter occurred spontaneously during a minor test problem. The animal was seated upon the floor with legs spread apart, and a bottle of Coca Cola with cap removed was placed between her feet. Although she could hold the bottle at the proper angle while drinking, she had not yet learned how to transport it from the floor to her mouth. Unsuccessful attempts consisted of licking or sucking at the opening of the bottle and of overturning it in the crude attempt to pick it up. Finally, after staring at the bottle and looking up at the experimenter, she took his hand in one of her own and drew it gently down to the base of the bottle. This was by no means an isolated instance, since it appeared several times during repetitions of the test. Similar reactions of placing the experimenter's hand on objects to be manipulated were also observed by the Hayeses with their chimpanzee Viki.

Table 3. Some significant gesture-language signs used by chimpanzee Washoe.

Meaning of sign	Description	Context
Come-gimme	Beckoning, with wrist or knuckles as pivot.	To persons, dogs, etc.; also for objects out of reach such as food or toys.
Up	Point up with index finger.	Wants a lift to reach object such as grapes on vine, leaves, etc., or wants to be placed on someone's shoulders.
Hear-listen	Index finger touches ear.	For loud or strange sounds: bells, car horns, sonic booms, footsteps, etc.
Toothbrush	Using index finger as brush, rub front teeth.	At end of meals. Once when Washoe noticed toothbrush in strange bathroom.
Hurt	The extended index fingers are jabbed toward each other. Can be used to indicate location of pain.	To indicate cuts and bruises on herself or on others. Can be elicited by red stains on a person.
Hurry	Shaking open hand at the wrist. [Correct ASL (American Sign Language) form: use index and second fingers extended side by side.]	Frequently follows signs such as "come-gimme," "out," "open," "go."
Sorry	Rub bent hand across chest. (Correct ASL form: rub fisted hand, circular motion.)	After biting someone, or when someone has been hurt in some other way (not necessarily by Washoe). When told to apologize for mischief.
Please	Rub open hand on chest, then extend in a begging gesture. (Correct ASL form: use fingertips and circular motion.)	Asking for objects and activities. Frequently combined: "Please go," "Out please," "Please drink," etc.

Two-Way Communication by Gesture

The spontaneous use of gesture movements by chimpanzees raises the question whether this ability to gesture can be developed into something more. Could an intelligent animal learn a series of regular or standardized signals—as a sort of semaphore system? Even though a chimp may lack the laryngeal structure or neural speech centers of man, it does not necessarily follow that it has deficiencies in general motor activity. Might it therefore be able to communicate back and forth by a series of hand movements, arm signals, and postures? Is two-way communication by gesture possible? This is the question which has recently been asked by the Gardners (*19*) and is now under active investigation by them.

It should be understood, however, that the signs and signals employed by the Gardners constitute a systematic and recognized form of voiceless communication. The alphabet language devised for the deaf, in which each word is spelled out by individual hand and finger movements, would obviously be unsuitable. What the Gardners are using is a series of more general or more encompassing hand and arm movements (not involving spelling) which serve as substitutes for entire words, phrases, or sentences. The American Sign Language meets these requirements. This is an accepted form of human language and is in active use today in Canada and the United States, principally by the deaf (*27*).

The chimpanzee subject of the Gardners' study, a young female named Washoe, has been undergoing training in the understanding and transmitting of sign-language signals since June 1966. The animal lives in a fully furnished house trailer and also has access to children's toys and equipment, as well as to extensive play areas. The human beings who come into contact with Washoe communicate with each other in Washoe's presence only by means of sign language. She hears no human words except those spoken inadvertently by workmen or others not associated with the project. Conditioning methods have been used to establish many of the signs which are employed.

In support of this new approach is the fact that both chimpanzees and gorillas in the wild state are known to use specific gestures and postures (along with noises) for communicating among themselves (*22*, *28*). Chimpanzees in laboratory experiments will also adopt characteristic attitudes as a means of communication. An example is the posture of imploring or begging observed by Wolfe (*29*). As for the home-raised chimp, the gestures of both Mrs. Kohts' Joni and the Kelloggs' Gua have already been noted (see Table 2). There would seem, therefore, to be considerable promise in the gesture method.

After 16 months of training, Washoe was able to use 19 signs reliably. Five more signs were in the developmental stage. A good many of the movements used by the animal are standard American Sign Language signals. Some are variants of the standard and a few are chimpanzee originals. There is evidence that she understands a great many more signs than she can use herself. Some of the gestures employed by Washoe are given in Table 3.

The most significant thing about these gesture signals is that they are by no means confined to the names of specific persons or things. (They are not all nouns.) Some of them—for example, "please," "hurry," "sorry"—are verbs and adjectives which apply in varying social contexts and are used effectively in different situations of the same class. As such they are far in advance of all previous chimpanzee efforts to communicate with human beings.

Summary

Although often misunderstood, the scientific rationale for rearing an anthropoid ape in a human household is to find out just how far the ape can go in absorbing the civilizing influences of the environment. To what degree is it capable of responding like a child and to what degree will genetic factors limit its development? At least six comprehensive studies by qualified investigators have been directed wholly or partly to this problem. All of these studies employed young chimpanzees as subjects and some also had in-house child controls whose day-to-day development could be compared directly with that of the experimental animal. In general, the results of this sort of research show that the home-raised chimp adapts rapidly to the physical features of the household. It does many things as well as a human child and some of them better (for example, those involving strength and climbing).

By far the greatest deficiency shown by the ape in the human environment is its lack of language ability. This eliminates the verbal communication which humans enjoy, and with it the vast amount of social intercourse and learning which are dependent upon language. Even amid human surroundings a chimp never prattles or babbles as a young child does when beginning to talk. Although it imitates the behavior of others readily, it seems to lack the ability for vocal imitation. The neural speech centers of the brain are no doubt deficient in this respect and it is possible also that the larynx and speech organs are incapable of producing the complex sound patterns of human language. One long-time attempt to teach a home-raised chimp to pronounce human words succeeded only in getting the animal to mouth unvoiced whispers of the words "mama," "papa," "cup," and "up."

At the same time, a chimpanzee in the home, as in the wild state, uses gestures or movements as communicating signals. This suggests the possibility of training a home-raised ape to employ a standardized system of gestures as a means of two-way communication. Such an investigation is now under way, using a gesture language devised for the deaf. Considerable progress has already been made in both the receiving and sending of gesture signals by this method. The technique seems to offer a much greater likelihood of success than other methods of intercommunication between chimpanzees and humans.

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Science, Voters, and the Fluoridation Controversy

Conflict among perceived experts leads voters to act negatively on the fluoridation innovation.

Harvey M. Sapolsky

In science and public policy discussions, voters' preferences are rarely mentioned. The omission is understandable, for neither voters nor their representatives participate directly in many of the decisions that determine either the scale and direction of the government's investment in research and development activities or the use of the discoveries and improvements that result from that investment. Fluoridation, however, is a science issue that has involved the direct participation of voters. By closely examining the fluoridation controversy, we should be able to see more clearly the role of the citizen in a scientifically complex society. From this perspective, an analysis of the fluoridation controversy becomes a study in the relation between science and democracy.

Fluoridation is the addition of fluoride compounds to the public water supply in order to reduce tooth decay in children. Fluorine, from which fluoride compounds are derived, is a dangerous element, and fluoride compounds themselves are sold as commercial poisons for rodent extermination. These facts have produced considerable confusion among laymen and have at times precluded rational discussion of fluoride's usefulness in the reduction of dental caries.

The history of the discovery of this beneficial property of fluorides is interesting (*1*). In 1901 research was begun to find the cause of a progressive discoloration and disfiguration of the teeth (now technically identified as dental fluorosis). By the early 1930's the causative agent was identified as fluorides in the water supply. During the course of the investigation, however, it had been noted that despite their mottled teeth, those with dental fluorosis were enjoying excellent dental health. Research then shifted to establishing the threshold levels for fluorosis and to documenting the effects of fluorides on the public's health. Through elaborate longitudinal experiments it was shown that, at dosage levels of one part fluoride per million parts water, there is approximately a 60 percent reduction in the rate of tooth decay in children up to the age of 16 without any general health danger to the entire exposed population (*2*). In 1950, the U.S. Public Health Service joined several state public-health departments in endorsing a national program for controlled water fluoridation (*1*, p. 74).

The benefits expected from fluoridation are considerable. Tooth decay, always annoying and often painful, affects an estimated 95 percent of the United States population. Dental care accounts for approximately one-twelfth of combined public and private health expenditures in the United States (or about $3 billion in 1964). It has been estimated that fluoridated water systems, if available throughout the country, could in time reduce the national dental bill by one half (*3*).

The addition of fluorides to the public water supply is not the only method of obtaining these benefits. Liquids containing fluoride compounds that can be directly applied to the teeth, and pills that can be used in the home to fluoridate the family water, are also effective in the reduction of dental caries. Fluoridation of the public water, however, is the least expensive method. Annual per capita costs, depending on the characteristics of the water system, range from $0.10 to $1.25 (*3*, *4*), in comparison with the annual costs of $3 to $5 per applicant for the liquid or pill method. Moreover, treatment of the

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