Teaching Sign Language to a Chimpanzee

A standardized system of gestures provides a means of two-way communication with a chimpanzee.

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The extent to which another species might be able to use human language is a classical problem in comparative psychology. One approach to this problem is to consider the nature of language, the processes of learning, the neural mechanisms of learning and of language, and the genetic basis of these mechanisms, and then, while recognizing certain gaps in what is known about these factors, to attempt to arrive at an answer by dint of careful scholarship (*1*). An alternative approach is to try to teach a form of human language to an animal. We chose the latter alternative and, in June 1966, began training an infant female chimpanzee, named Washoe, to use the gestural language of the deaf. Within the first 22 months of training it became evident that we had been correct in at least one major aspect of method, the use of a gestural language. Additional aspects of method have evolved in the course of the project. These and some implications of our early results can now be described in a way that may be useful in other studies of communicative behavior. Accordingly, in this article we discuss the considerations which led us to use the chimpanzee as a subject and American Sign Language (the language used by the deaf in North America) as a medium of communication; describe the general methods of training as they were initially conceived and as they developed in the course of the project; and summarize those results that could be reported with some degree of confidence by the end of the first phase of the project.

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Preliminary Considerations

The chimpanzee as a subject. Some discussion of the chimpanzee as an experimental subject is in order because this species is relatively uncommon in the psychological laboratory. Whether or not the chimpanzee is the most intelligent animal after man can be disputed; the gorilla, the orangutan, and even the dolphin have their loyal partisans in this debate. Nevertheless, it is generally conceded that chimpanzees are highly intelligent, and that members of this species might be intelligent enough for our purposes. Of equal or greater importance is their sociability and their capacity for forming strong attachments to human beings. We want to emphasize this trait of sociability; it seems highly likely that it is essential for the development of language in human beings, and it was a primary consideration in our choice of a chimpanzee as a subject.

Affectionate as chimpanzees are, they are still wild animals, and this is a serious disadvantage. Most psychologists are accustomed to working with animals that have been chosen, and sometimes bred, for docility and adaptability to laboratory procedures. The difficulties presented by the wild nature of an experimental animal must not be underestimated. Chimpanzees are also very strong animals; a full-grown specimen is likely to weigh more than 120 pounds (55 kilograms) and is estimated to be from three to five times as strong as a man, pound-for-pound. Coupled with the wildness, this great strength presents serious difficulties for a procedure that requires interaction at close quarters with a free-living animal. We have always had to reckon with the likelihood that at some point Washoe's physical maturity will make this procedure prohibitively dangerous.

A more serious disadvantage is that human speech sounds are unsuitable as a medium of communication for the chimpanzee. The vocal apparatus of the chimpanzee is very different from that of man (*2*). More important, the vocal behavior of the chimpanzee is very different from that of man. Chimpanzees do make many different sounds, but generally vocalization occurs in situations of high excitement and tends to be specific to the exciting situations. Undisturbed, chimpanzees are usually silent. Thus, it is unlikely that a chimpanzee could be trained to make refined use of its vocalizations. Moreover, the intensive work of Hayes and Hayes (*3*) with the chimpanzee Viki indicates that a vocal language is not appropriate for this species. The Hayeses used modern, sophisticated, psychological methods and seem to have spared no effort to teach Viki to make speech sounds. Yet in 6 years Viki learned only four sounds that approximated English words (*4*).

Use of the hands, however, is a prominent feature of chimpanzee behavior; manipulatory mechanical problems are their forte. More to the point, even caged, laboratory chimpanzees develop begging and similar gestures spontaneously (*5*), while individuals that have had extensive contact with human beings have displayed an even wider variety of communicative gestures (*6*). In our choice of sign language we were influenced more by the behavioral evidence that this medium of communication was appropriate to the species than by anatomical evidence of structural similarity between the hands of chimpanzees and of men. The Hayeses point out that human tools and mechanical devices are constructed to fit the human hand, yet chimpanzees have little difficulty in using these devices with great skill. Nevertheless, they seem unable to adapt their vocalizations to approximate human speech.

Psychologists who work extensively with the instrumental conditioning of animals become sensitive to the need to use responses that are suited to the species they wish to study. Lever-pressing in rats is not an arbitrary response invented by Skinner to confound the mentalists; it is a type of response commonly made by rats when they are first placed in a Skinner box. The ex-

quisite control of instrumental behavior by schedules of reward is achieved only if the original responses are well chosen. We chose a language based on gestures because we reasoned that gestures for the chimpanzee should be analogous to bar-pressing for rats, key-pecking for pigeons, and babbling for humans.

American Sign Language. Two systems of manual communication are used by the deaf. One system is the manual alphabet, or finger spelling, in which configurations of the hand correspond to letters of the alphabet. In this system the words of a spoken language, such as English, can be spelled out manually. The other system, sign language, consists of a set of manual configurations and gestures that correspond to particular words or concepts. Unlike finger spelling, which is the direct encoding of a spoken language, sign languages have their own rules of usage. Word-for-sign translation between a spoken language and a sign language yields results that are similar to those of word-for-word translation between two spoken languages: the translation is often passable, though awkward, but it can also be ambiguous or quite nonsensical. Also, there are national and regional variations in sign languages that are comparable to those of spoken languages.

We chose for this project the American Sign Language (ASL), which, with certain regional variations, is used by the deaf in North America. This particular sign language has recently been the subject of formal analysis (*7*). The ASL can be compared to pictograph writing in which some symbols are quite arbitrary and some are quite representational or iconic, but all are arbitrary to some degree. For example, in ASL the sign for "always" is made by holding the hand in a fist, index finger extended (the pointing hand), while rotating the arm at the elbow. This is clearly an arbitrary representation of the concept "always." The sign for "flower," however, is highly iconic; it is made by holding the fingers of one hand extended, all five fingertips touching (the tapered hand), and touching the fingertips first to one nostril then to the other, as if sniffing a flower. While this is an iconic sign for "flower," it is only one of a number of conventions by which the concept "flower" could be iconically represented; it is thus arbitrary to some degree. Undoubtedly, many of the signs of ASL that seem quite arbitrary today once had an iconic origin that was lost through years of stylized usage. Thus, the signs of ASL are neither uniformly arbitrary nor uniformly iconic; rather the degree of abstraction varies from sign to sign over a wide range. This would seem to be a useful property of ASL for our research.

The literate deaf typically use a combination of ASL and finger spelling; for purposes of this project we have avoided the use of finger spelling as much as possible. A great range of expression is possible within the limits of ASL. We soon found that a good way to practice signing among ourselves was to render familiar songs and poetry into signs; as far as we can judge, there is no message that cannot be rendered faithfully (apart from the usual problems of translation from one language to another). Technical terms and proper names are a problem when first introduced, but within any community of signers it is easy to agree on a convention for any commonly used term. For example, among ourselves we do not finger-spell the words *psychologist* and *psychology*, but render them as "think doctor" and "think science." Or, among users of ASL, "California" can be finger-spelled but is commonly rendered as "golden playland." (Incidentally, the sign for "gold" is made by plucking at the earlobe with thumb and forefinger, indicating an earring—another example of an iconic sign that is at the same time arbitrary and stylized.)

The fact that ASL is in current use by human beings is an additional advantage. The early linguistic environment of the deaf children of deaf parents is in some respects similar to the linguistic environment that we could provide for an experimental subject. This should permit some comparative evaluation of Washoe's eventual level of competence. For example, in discussing Washoe's early performance with deaf parents we have been told that many of her variants of standard signs are similar to the baby-talk variants commonly observed when human children sign.

Washoe. Having decided on a species and a medium of communication, our next concern was to obtain an experimental subject. It is altogether possible that there is some critical early age for the acquisition of this type of behavior. On the other hand, newborn chimpanzees tend to be quite helpless and vegetative. They are also considerably less hardy than older infants. Nevertheless, we reasoned that the dangers of starting too late were much greater than the dangers of starting too early, and we sought the youngest infant we could get. Newborn laboratory chimpanzees are very scarce, and we found that the youngest laboratory infant we could get would be about 2 years old at the time we planned to start the project. It seemed preferable to obtain a wild-caught infant. Wild-caught infants are usually at least 8 to 10 months old before they are available for research. This is because infants rarely reach the United States before they are 5 months old, and to this age must be added 1 or 2 months before final purchase and 2 or 3 months for quarantine and other medical services.

We named our chimpanzee Washoe for Washoe County, the home of the University of Nevada. Her exact age will never be known, but from her weight and dentition we estimated her age to be between 8 and 14 months at the end of June 1966, when she first arrived at our laboratory. (Her dentition has continued to agree with this initial estimate, but her weight has increased rather more than would be expected.) This is very young for a chimpanzee. The best available information indicates that infants are completely dependent until the age of 2 years and semi-dependent until the age of 4; the first signs of sexual maturity (for example, menstruation, sexual swelling) begin to appear at about 8 years, and full adult growth is reached between the ages of 12 and 16 (*8*). As for the complete lifespan, captive specimens have survived for well over 40 years. Washoe was indeed very young when she arrived; she did not have her first canines or molars, her hand-eye coordination was rudimentary, she had only begun to crawl about, and she slept a great deal. Apart from making friends with her and adapting her to the daily routine, we could accomplish little during the first few months.

Laboratory conditions. At the outset we were quite sure that Washoe could learn to make various signs in order to obtain food, drink, and other things. For the project to be a success, we felt that something more must be developed. We wanted Washoe not only to ask for objects but to answer questions about them and also to ask us questions. We wanted to develop behavior that could be described as conversation. With this in mind, we attempted to provide Washoe with an

environment that might be conducive to this sort of behavior. Confinement was to be minimal, about the same as that of human infants. Her human companions were to be friends and playmates as well as providers and protectors, and they were to introduce a great many games and activities that would be likely to result in maximum interaction with Washoe.

In practice, such an environment is readily achieved with a chimpanzee; bonds of warm affection have always been established between Washoe and her several human companions. We have enjoyed the interaction almost as much as Washoe has, within the limits of human endurance. A number of human companions have been enlisted to participate in the project and relieve each other at intervals, so that at least one person would be with Washoe during all her waking hours. At first we feared that such frequent changes would be disturbing, but Washoe seemed to adapt very well to this procedure. Apparently it is possible to provide an infant chimpanzee with affection on a shift basis.

All of Washoe's human companions have been required to master ASL and to use it extensively in her presence, in association with interesting activities and events and also in a general way, as one chatters at a human infant in the course of the day. The ASL has been used almost exclusively, although occasional finger spelling has been permitted. From time to time, of course, there are lapses into spoken English, as when medical personnel must examine Washoe. At one time, we considered an alternative procedure in which we would sign and speak English to Washoe simultaneously, thus giving her an additional source of informative cues. We rejected this procedure, reasoning that, if she should come to understand speech sooner or more easily than ASL, then she might not pay sufficient attention to our gestures. Another alternative, that of speaking English among ourselves and signing to Washoe, was also rejected. We reasoned that this would make it seem that big chimps talk and only little chimps sign, which might give signing an undesirable social status.

The environment we are describing is not a silent one. The human beings can vocalize in many ways, laughing and making sounds of pleasure and displeasure. Whistles and drums are sounded in a variety of imitation games, and hands are clapped for attention. The rule is that all meaningful sounds, whether vocalized or not, must be sounds that a chimpanzee can imitate.

Training Methods

Imitation. The imitativeness of apes is proverbial, and rightly so. Those who have worked closely with chimpanzees have frequently remarked on their readiness to engage in visually guided imitation. Consider the following typical comment of Yerkes (*9*): "Chim and Panzee would imitate many of my acts, but never have I heard them imitate a sound and rarely make a sound peculiarly their own in response to mine. As previously stated, their imitative tendency is as remarkable for its specialization and limitations as for its strength. It seems to be controlled chiefly by visual stimuli. Things which are seen tend to be imitated or reproduced. What is heard is not reproduced. Obviously an animal which lacks the tendency to reinstate auditory stimuli—in other words to imitate sounds—cannot reasonably be expected to talk. The human infant exhibits this tendency to a remarkable degree. So also does the parrot. If the imitative tendency of the parrot could be coupled with the quality of intelligence of the chimpanzee, the latter undoubtedly could speak."

In the course of their work with Viki, the Hayeses devised a game in which Viki would imitate various actions on hearing the command "Do this" (*10*). Once established, this was an effective means of training Viki to perform actions that could be visually guided. The same method should be admirably suited to training a chimpanzee to use sign language; accordingly we have directed much effort toward establishing a version of the "Do this" game with Washoe. Getting Washoe to imitate us was not difficult, for she did so quite spontaneously, but getting her to imitate on command has been another matter altogether. It was not until the 16th month of the project that we achieved any degree of control over Washoe's imitation of gestures. Eventually we got to a point where she would imitate a simple gesture, such as pulling at her ears, or a series of such gestures—first we make a gesture, then she imitates, then we make a second gesture, she imitates the second gesture, and so on—for the reward of being tickled. Up to this writing, however, imitation of this sort has not been an important method for introducing new signs into Washoe's vocabulary.

As a methd of prompting, we have been able to use imitation extensively to increase the frequency and refine the form of signs. Washoe sometimes fails to use a new sign in an appropriate situation, or uses another, incorrect sign. At such times we can make the correct sign to Washoe, repeating the performance until she makes the sign herself. (With more stable signs, more indirect forms of prompting can be used—for example, pointing at, or touching, Washoe's hand or a part of her body that should be involved in the sign; making the sign for "sign," which is equivalent to saying "Speak up"; or asking a question in signs, such as "What do you want?" or "What is it?") Again, with new signs, and often with old signs as well, Washoe can lapse into what we refer to as poor "diction." Of course, a great deal of slurring and a wide range of variants are permitted in ASL as in any spoken language. In any event, Washoe's diction has frequently been improved by the simple device of repeating, in exaggeratedly correct form, the sign she has just made, until she repeats it herself in more correct form. On the whole, she has responded quite well to prompting, but there are strict limits to its use with a wild animal—one that is probably quite spoiled, besides. Pressed too hard, Washoe can become completely diverted from her original object; she may ask for something entirely different, run away, go into a tantrum, or even bite her tutor.

Chimpanzees also imitate, after some delay, and this delayed imitation can be quite elaborate (*10*). The following is a typical example of Washoe's delayed imitation. From the beginning of the project she was bathed regularly and according to a standard routine. Also, from her 2nd month with us, she always had dolls to play with. One day, during the 10th month of the project, she bathed one of her dolls in the way we usually bathed her. She filled her little bathtub with water, dunked the doll in the tub, then took it out and dried it with a towel. She has repeated the entire performance, or parts of it, many times since, sometimes also soaping the doll.

This is a type of imitation that may be very important in the acquisition of language by human children, and many of our procedures with Washoe were

devised to capitalize on it. Routine activities—feeding, dressing, bathing, and so on—have been highly ritualized, with appropriate signs figuring prominently in the rituals. Many games have been invented which can be accompanied by appropriate signs. Objects and activities have been named as often as possible, especially when Washoe seemed to be paying particular attention to them. New objects and new examples of familiar objects, including pictures, have been continually brought to her attention, together with the appropriate signs. She likes to ride in automobiles, and a ride in an automobile, including the preparations for a ride, provides a wealth of sights that can be accompanied by signs. A good destination for a ride is a home or the university nursery school, both well stocked with props for language lessons.

The general principle should be clear: Washoe has been exposed to a wide variety of activities and objects, together with their appropriate signs, in the hope that she would come to associate the signs with their referents and later make the signs herself. We have reason to believe that she has come to understand a large vocabulary of signs. This was expected, since a number of chimpanzees have acquired extensive understanding vocabularies of spoken words, and there is evidence that even dogs can acquire a sizable understanding vocabulary of spoken words (*11*). The understanding vocabulary that Washoe has acquired, however, consists of signs that a chimpanzee can imitate.

Some of Washoe's signs seem to have been originally acquired by delayed imitation. A good example is the sign for "toothbrush." A part of the daily routine has been to brush her teeth after every meal. When this routine was first introduced Washoe generally resisted it. She gradually came to submit with less and less fuss, and after many months she would even help or sometimes brush her teeth herself. Usually, having finished her meal, Washoe would try to leave her high-chair; we would restrain her, signing "First, toothbrushing, then you can go." One day, in the 10th month of the project, Washoe was visiting the Gardner home and found her way into the bathroom. She climbed up on the counter, looked at our mug full of toothbrushes, and signed "toothbrush." At the time, we believed that Washoe understood this sign but we had not seen her use it. She had no reason to ask for the toothbrushes, because they were well within her reach, and it is most unlikely that she was asking to have her teeth brushed. This was our first observation, and one of the clearest examples, of behavior in which Washoe seemed to name an object or an event for no obvious motive other than communication.

Following this observation, the toothbrushing routine at mealtime was altered. First, imitative prompting was introduced. Then as the sign became more reliable, her rinsing-mug and toothbrush were displayed prominently until she made the sign. By the 14th month she was making the "toothbrush" sign at the end of meals with little or no prompting; in fact she has called for her toothbrush in a peremptory fashion when its appearance at the end of a meal was delayed. The "toothbrush" sign is not merely a response cued by the end of a meal; Washoe retained her ability to name toothbrushes when they were shown to her at other times.

The sign for "flower" may also have been acquired by delayed imitation. From her first summer with us, Washoe showed a great interest in flowers, and we took advantage of this by providing many flowers and pictures of flowers accompanied by the appropriate sign. Then one day in the 15th month she made the sign, spontaneously, while she and a companion were walking toward a flower garden. As in the case of "toothbrush," we believed that she understood the sign at this time, but we had made no attempt to elicit it from her except by making it ourselves in appropriate situations. Again, after the first observation, we proceeded to elicit this sign as often as possible by a variety of methods, most frequently by showing her a flower and giving it to her if she made the sign for it. Eventually the sign became very reliable and could be elicited by a variety of flowers and pictures of flowers.

It is difficult to decide which signs were acquired by the method of delayed imitation. The first appearance of these signs is likely to be sudden and unexpected; it is possible that some inadvertent movement of Washoe's has been interpreted as meaningful by one of her devoted companions. If the first observer were kept from reporting the observation and from making any direct attempts to elicit the sign again, then it might be possible to obtain independent verification. Quite understandably, we have been more interested in raising the frequency of new signs than in evaluating any particular method of training.

Babbling. Because the Hayeses were attempting to teach Viki to speak English, they were interested in babbling, and during the first year of their project they were encouraged by the number and variety of spontaneous vocalizations that Viki made. But, in time, Viki's spontaneous vocalizations decreased further and further to the point where the Hayeses felt that there was almost no vocal babbling from which to shape spoken language. In planning this project we expected a great deal of manual "babbling," but during the early months we observed very little behavior of this kind. In the course of the project, however, there has been a great increase in manual babbling. We have been particularly encouraged by the increase in movements that involve touching parts of the head and body, since these are important components of many signs. Also, more and more frequently, when Washoe has been unable to get something that she wants, she has burst into a flurry of random flourishes and arm-waving.

We have encouraged Washoe's babbling by our responsiveness; clapping, smiling, and repeating the gesture much as you might repeat "goo goo" to a human infant. If the babbled gesture has resembled a sign in ASL, we have made the correct form of the sign and have attempted to engage in some appropriate activity. The sign for "funny" was probably acquired in this way. It first appeared as a spontaneous babble that lent itself readily to a simple imitation game—first Washoe signed "funny," then we did, then she did, and so on. We would laugh and smile during the interchanges that she initiated, and initiate the game ourselves when something funny happened. Eventually Washoe came to use the "funny" sign spontaneously in roughly appropriate situations.

Closely related to babbling are some gestures that seem to have appeared independently of any deliberate training on our part, and that resemble signs so closely that we could incorporate them into Washoe's repertoire with little or no modification. Almost from the first she had a begging gesture—an extension of her open hand, palm up, toward one of us. She made this gesture in situations in which she wanted aid and in situations in which

we were holding some object that she wanted. The ASL signs for "give me" and "come" are very similar to this, except that they involve a prominent beckoning movement. Gradually Washoe came to incorporate a beckoning wrist movement into her use of this sign. In Table 1 we refer to this sign as "come-gimme." As Washoe has come to use it, the sign is not simply a modification of the original begging gesture. For example, very commonly she reaches forward with one hand (palm up) while she gestures with the other hand (palm down) held near her head. (The result resembles a classic fencing posture.)

Another sign of this type is the sign for "hurry," which, so far, Washoe has always made by shaking her open hand vigorously at the wrist. This first appeared as an impatient flourish following some request that she had made in signs; for example, after making the "open" sign before a door. The correct ASL for "hurry" is very close, and we began to use it often, ourselves, in appropriate contexts. We believe that Washoe has come to use this sign in a meaningful way, because she has frequently used it when she, herself, is in a hurry—for example, when rushing to her nursery chair.

Instrumental conditioning. It seems intuitively unreasonable that the acquisition of language by human beings could be strictly a matter of reiterated instrumental conditioning—that a child acquires language after the fashion of a rat that is conditioned, first, to press a lever for food in the presence of one stimulus, then to turn a wheel in the presence of another stimulus, and so on until a large repertoire of discriminated responses is acquired. Nevertheless, the so-called "trick vocabulary" of early childhood is probably acquired in this way, and this may be a critical stage in the acquisition of language by children. In any case, a minimal objective of this project was to teach Washoe as many signs as possible by whatever procedures we could enlist. Thus, we have not hesitated to use conventional procedures of instrumental conditioning.

Anyone who becomes familiar with

Table 1. Signs used reliably by chimpanzee Washoe within 22 months of the beginning of training. The signs are listed in the order of their original appearance in her repertoire (see text for the criterion of reliability and for the method of assigning the date of original appearance).

Signs	Description	Context
Come-gimme	Beckoning motion, with wrist or knuckles as pivot.	Sign made to persons or animals, also for objects out of reach. Often combined: "come tickle," "gimme sweet," etc.
More	Fingertips are brought together, usually overhead. (Correct ASL form: tips of the tapered hand touch repeatedly.)	When asking for continuation or repetition of activities such as swinging or tickling, for second helpings of food, etc. Also used to ask for repetition of some performance, such as a somersault.
Up	Arm extends upward, and index finger may also point up.	Wants a lift to reach objects such as grapes on vine, or leaves; or wants to be placed on someone's shoulders; or wants to leave potty-chair.
Sweet	Index or index and second fingers touch tip of wagging tongue. (Correct ASL form: index and second fingers extended side by side.)	For dessert; used spontaneously at end of meal. Also, when asking for candy.
Open	Flat hands are placed side by side, palms down, then drawn apart while rotated to palms up.	At door of house, room, car, refrigerator, or cupboard; on containers such as jars; and on faucets.
Tickle	The index finger of one hand is drawn across the back of the other hand. (Related to ASL "touch.")	For tickling or for chasing games.
Go	Opposite of "come-gimme."	While walking hand-in-hand or riding on someone's shoulders. Washoe usually indicates the direction desired.
Out	Curved hand grasps tapered hand; then tapered hand is withdrawn upward.	When passing through doorways; until recently, used for both "in" and "out." Also, when asking to be taken outdoors.
Hurry	Open hand is shaken at the wrist. (Correct ASL form: index and second fingers extended side by side.)	Often follows signs such as "come-gimme," "out," "open," and "go," particularly if there is a delay before Washoe is obeyed. Also, used while watching her meal being prepared.
Hear-listen	Index finger touches ear.	For loud or strange sounds: bells, car horns, sonic booms, etc. Also, for asking someone to hold a watch to her ear.
Toothbrush	Index finger is used as brush, to rub front teeth.	When Washoe has finished her meal, or at other times when shown a toothbrush.
Drink	Thumb is extended from fisted hand and touches mouth.	For water, formula, soda pop, etc. For soda pop, often combined with "sweet."
Hurt	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's skin or by tears in clothing.
Sorry	Fisted hand clasps and unclasps at shoulder. (Correct ASL form: fisted hand is rubbed over heart with circular motion.)	After biting someone, or when someone has been hurt in another way (not necessarily by Washoe). When told to apologize for mischief.
Funny	Tip of index finger presses nose, and Washoe snorts. (Correct ASL form: index and second fingers used; no snort.)	When soliciting interaction play, and during games. Occasionally, when being pursued after mischief.
Please	Open hand is drawn across chest. (Correct ASL form: fingertips used, and circular motion.)	When asking for objects and activities. Frequently combined: "Please go," "Out, please," "Please drink."

young chimpanzees soon learns about their passion for being tickled. There is no doubt that tickling is the most effective reward that we have used with Washoe. In the early months, when we would pause in our tickling, Washoe would indicate that she wanted more tickling by taking our hands and placing them against her ribs or around her neck. The meaning of these gestures was unmistakable, but since we were not studying our human ability to interpret her chimpanzee gestures, we decided to shape an arbitrary response that she could use to ask for more tickling. We noted that, when being tickled, she tended to bring her arms together to cover the place being tickled. The result was a very crude approximation of the ASL sign for "more" (see Table 1). Thus, we would stop tickling and then pull Washoe's arms away from her body. When we released her arms and threatened to resume tickling, she tended to bring her hands together again. If she brought them back together, we would tickle her again. From time to time we would stop tickling and wait for her to put her hands together by herself. At first, any approximation to the "more" sign, however crude, was rewarded. Later, we required closer approximations and introduced imitative prompting. Soon, a very good version of the "more" sign could be obtained, but it was quite specific to the tickling situation.

In the 6th month of the project we were able to get "more" signs for a new game that consisted of pushing Washoe across the floor in a laundry basket. In this case we did not use the shaping procedure but, from the start, used imitative prompting to elicit the "more" sign. Soon after the "more" sign became spontaneous and reliable in the laundry-basket game, it began to appear as a request for more swinging (by the arms)—again, after first being elicited with imitative prompting. From this point on, Washoe transferred the "more" sign to all activities, including feeding. The transfer was usually spontaneous, occurring when there was some pause in a desired activity or when some object was removed. Often we ourselves were not sure that Washoe

Table 1. (continued)

Signs	Description	Context
Food-eat	Several fingers of one hand are placed in mouth. (Correct ASL form: fingertips of tapered hand touch mouth repeatedly.)	During meals and preparation of meals.
Flower	Tip of index finger touches one or both nostrils. (Correct ASL form: tips of tapered hand touch first one nostril, then the other.)	For flowers.
Cover-blanket	Draws one hand toward self over the back of the other.	At bedtime or naptime, and, on cold days, when Washoe wants to be taken out.
Dog	Repeated slapping on thigh.	For dogs and for barking.
You	Index finger points at a person's chest.	Indicates successive turns in games. Also used in response to questions such as "Who tickle?" "Who brush?"
Napkin-bib	Fingertips wipe the mouth region.	For bib, for washcloth, and for Kleenex.
In	Opposite of "out."	Wants to go indoors, or wants someone to join her indoors.
Brush	The fisted hand rubs the back of the open hand several times. (Adapted from ASL "polish.")	For hairbrush, and when asking for brushing.
Hat	Palm pats top of head.	For hats and caps.
I-me	Index finger points at, or touches, chest.	Indicates Washoe's turn, when she and a companion share food, drink, etc. Also used in phrases, such as "I drink," and in reply to questions such as "Who tickle?" (Washoe: "you"); "Who I tickle?" (Washoe: "Me.")
Shoes	The fisted hands are held side by side and strike down on shoes or floor. (Correct ASL form: the sides of the fisted hands strike against each other.)	For shoes and boots.
Smell	Palm is held before nose and moved slightly upward several times.	For scented objects: tobacco, perfume, sage, etc.
Pants	Palms of the flat hands are drawn up against the body toward waist.	For diapers, rubber pants, trousers.
Clothes	Fingertips brush down the chest.	For Washoe's jacket, nightgown, and shirts; also for our clothing.
Cat	Thumb and index finger grasp cheek hair near side of mouth and are drawn outward (representing cat's whiskers).	For cats.
Key	Palm of one hand is repeatedly touched with the index finger of the other. (Correct ASL form: crooked index finger is rotated against palm.)	Used for keys and locks and to ask us to unlock a door.
Baby	One forearm is placed in the crook of the other, as if cradling a baby.	For dolls, including animal dolls such as a toy horse and duck.
Clean	The open palm of one hand is passed over the open palm of the other.	Used when Washoe is washing, or being washed, or when a companion is washing hands or some other object. Also used for "soap."

wanted "more" until she signed to us.

The sign for "open" had a similar history. When Washoe wanted to get through a door, she tended to hold up both hands and pound on the door with her palms or her knuckles. This is the beginning position for the "open" sign (see Table 1). By waiting for her to place her hands on the door and then lift them, and also by imitative prompting, we were able to shape a good approximation of the "open" sign, and would reward this by opening the door. Originally she was trained to make this sign for three particular doors that she used every day. Washoe transferred this sign to all doors; then to containers such as the refrigerator, cupboards, drawers, briefcases, boxes, and jars; and eventually—an invention of Washoe's—she used it to ask us to turn on water faucets.

In the case of "more" and "open" we followed the conventional laboratory procedure of waiting for Washoe to make some response that could be shaped into the sign we wished her to acquire. We soon found that this was not necessary; Washoe could acquire signs that were first elicited by our holding her hands, forming them into the desired configuration, and then putting them through the desired movement. Since this procedure of guidance is usually much more practical than waiting for a spontaneous approximation to occur at a favorable moment, we have used it much more frequently.

Results

Vocabulary. In the early stages of the project we were able to keep fairly complete records of Washoe's daily signing behavior. But, as the amount of signing behavior and the number of signs to be monitored increased, our initial attempts to obtain exhaustive records became prohibitively cumbersome. During the 16th month we settled on the following procedure. When a new sign was introduced we waited until it had been reported by three different observers as having occurred in an appropriate context and spontaneously (that is, with no prompting other than a question such as "What is it?" or "What do you want?"). The sign was then added to a checklist in which its occurrence, form, context, and the kind of prompting required were recorded. Two such checklists were filled out each day, one for the first half of the day and one for the second half. For a criterion of acquisition we chose a reported frequency of at least one appropriate and spontaneous occurrence each day over a period of 15 consecutive days.

In Table 1 we have listed 30 signs that met this criterion by the end of the 22nd month of the project. In addition, we have listed four signs ("dog," "smell," "me," and "clean") that we judged to be stable, despite the fact that they had not met the stringent criterion before the end of the 22nd month. These additional signs had, nevertheless, been reported to occur appropriately and spontaneously on more than half of the days in a period of 30 consecutive days. An indication of the variety of signs that Washoe used in the course of a day is given by the following data: during the 22nd month of the study, 28 of the 34 signs listed were reported on at least 20 days, and the smallest number of different signs reported for a single day was 23, with a median of 29 (*12*).

The order in which these signs first appeared in Washoe's repertoire is also given in Table 1. We considered the first appearance to be the date on which three different observers reported appropriate and spontaneous occurrences. By this criterion, 4 new signs first appeared during the first 7 months, 9 new signs during the next 7 months, and 21 new signs during the next 7 months. We chose the 21st month rather than the 22nd month as the cutoff for this tabulation so that no signs would be included that do not appear in Table 1. Clearly, if Washoe's rate of acquisition continues to accelerate, we will have to assess her vocabulary on the basis of sampling procedures. We are now in the process of developing procedures that could be used to make periodic tests of Washoe's performance on samples of her repertoire. However, now that there is evidence that a chimpanzee can acquire a vocabulary of more than 30 signs, the exact number of signs in her current vocabulary is less significant than the order of magnitude—50, 100, 200 signs, or more—that might eventually be achieved.

Differentiation. In Table 1, column 1, we list English equivalents for each of Washoe's signs. It must be understood that this equivalence is only approximate, because equivalence between English and ASL, as between any two human languages, is only approximate, and because Washoe's usage does differ from that of standard ASL. To some extent her usage is indicated in the column labeled "Context" in Table 1, but the definition of any given sign must always depend upon her total vocabulary, and this has been continually changing. When she had very few signs for specific things, Washoe used the "more" sign for a wide class of requests. Our only restriction was that we discouraged the use of "more" for first requests. As she acquired signs for specific requests, her use of "more" declined until, at the time of this writing, she was using this sign mainly to ask for repetition of some action that she could not name, such as a somersault. Perhaps the best English equivalent would be "do it again." Still, it seemed preferable to list the English equivalent for the ASL sign rather than its current referent for Washoe, since further refinements in her usage may be achieved at a later date.

The differentiation of the signs for "flower" and "smell" provides a further illustration of usage depending upon size of vocabulary. As the "flower" sign became more frequent, we noted that it occurred in several inappropriate contexts that all seemed to include odors; for example, Washoe would make the "flower" sign when opening a tobacco pouch or when entering a kitchen filled with cooking odors. Taking our cue from this, we introduced the "smell" sign by passive shaping and imitative prompting. Gradually Washoe came to make the appropriate distinction between "flower" contexts and "smell" contexts in her signing, although "flower" (in the single-nostril form) (see Table 1) has continued to occur as a common error in "smell" contexts.

Transfer. In general, when introducing new signs we have used a very specific referent for the initial training—a particular door for "open," a particular hat for "hat." Early in the project we were concerned about the possibility that signs might become inseparable from their first referents. So far, however, there has been no problem of this kind: Washoe has always been able to transfer her signs spontaneously to new members of each class of referents. We have already described the transfer of "more" and "open." The sign for "flower" is a par-

ticularly good example of transfer, because flowers occur in so many varieties, indoors, outdoors, and in pictures, yet Washoe uses the same sign for all. It is fortunate that she has responded well to pictures of objects. In the case of "dog" and "cat" this has proved to be important because live dogs and cats can be too exciting, and we have had to use pictures to elicit most of the "dog" and "cat" signs. It is noteworthy that Washoe has transferred the "dog" sign to the sound of barking by an unseen dog.

The acquisition and transfer of the sign for "key" illustrates a further point. A great many cupboards and doors in Washoe's quarters have been kept secure by small padlocks that can all be opened by the same simple key. Because she was immature and awkward, Washoe had great difficulty in learning to use these keys and locks. Because we wanted her to improve her manual dexterity, we let her practice with these keys until she could open the locks quite easily (then we had to hide the keys). Washoe soon transferred this skill to all manner of locks and keys, including ignition keys. At about the same time, we taught her the sign for "key," using the original padlock keys as a referent. Washoe came to use this sign both to name keys that were presented to her and to ask for the keys to various locks when no key was in sight. She readily transferred the sign to all varieties of keys and locks.

Now, if an animal can transfer a skill learned with a certain key and lock to new types of key and lock, it should not be surprising that the same animal can learn to use an arbitrary response to name and ask for a certain key and then transfer that sign to new types of keys. Certainly, the relationship between the use of a key and the opening of locks is as arbitrary as the relationship between the sign for "key" and its many referents. Viewed in this way, the general phenomenon of transfer of training and the specifically linguistic phenomenon of labeling become very similar, and the problems that these phenomena pose for modern learning theory should require similar solutions. We do not mean to imply that the problem of labeling is less complex than has generally been supposed; rather, we are suggesting that the problem of transfer of training requires an equally sophisticated treatment.

Combinations. During the phase of the project covered by this article we made no deliberate attempts to elicit combinations or phrases, although we may have responded more readily to strings of two or more signs than to single signs. As far as we can judge, Washoe's early use of signs in strings was spontaneous. Almost as soon as she had eight or ten signs in her repertoire, she began to use them two and three at a time. As her repertoire increased, her tendency to produce strings of two or more signs also increased, to the point where this has become a common mode of signing for her. We, of course, usually signed to her in combinations, but if Washoe's use of combinations has been imitative, then it must be a generalized sort of imitation, since she has invented a number of combinations, such as "gimme tickle" (before we had ever asked her to tickle us), and "open food drink" (for the refrigerator—we have always called it the "cold box").

Four signs—"please," "come-gimme," "hurry," and "more"—used with one or more other signs, account for the largest share of Washoe's early combinations. In general, these four signs have functioned as emphasizers, as in "please open hurry" and "gimme drink please."

Until recently, five additional signs—"go," "out," "in," "open," and "hear-listen"—accounted for most of the remaining combinations. Typical examples of combinations using these four are, "go in" or "go out" (when at some distance from a door), "go sweet" (for being carried to a raspberry bush), "open flower" (to be let through the gate to a flower garden), "open key" (for a locked door), "listen eat" (at the sound of an alarm clock signaling mealtime), and "listen dog" (at the sound of barking by an unseen dog). All but the first and last of these six examples were inventions of Washoe's. Combinations of this type tend to amplify the meaning of the single signs used. Sometimes, however, the function of these five signs has been about the same as that of the emphasizers, as in "open out" (when standing in front of a door).

Toward the end of the period covered in this article we were able to introduce the pronouns "I-me" and "you," so that combinations that resemble short sentences have begun to appear.

Concluding Observations

From time to time we have been asked questions such as, "Do you think that Washoe has language?" or "At what point will you be able to say that Washoe has language?" We find it very difficult to respond to these questions because they are altogether foreign to the spirit of our research. They imply a distinction between one class of communicative behavior that can be called language and another class that cannot. This in turn implies a well-established theory that could provide the distinction. If our objectives had required such a theory, we would certainly not have been able to begin this project as early as we did.

In the first phase of the project we were able to verify the hypothesis that sign language is an appropriate medium of two-way communication for the chimpanzee. Washoe's intellectual immaturity, the continuing acceleration of her progress, the fact that her signs do not remain specific to their original referents but are transferred spontaneously to new referents, and the emergence of rudimentary combinations all suggest that significantly more can be accomplished by Washoe during the subsequent phases of this project. As we proceed, the problems of these subsequent phases will be chiefly concerned with the technical business of measurement. We are now developing a procedure for testing Washoe's ability to name objects. In this procedure, an object or a picture of an object is placed in a box with a window. An observer, who does not know what is in the box, asks Washoe what she sees through the window. At present, this method is limited to items that fit in the box; a more ingenious method will have to be devised for other items. In particular, the ability to combine and recombine signs must be tested. Here, a great deal depends upon reaching a stage at which Washoe produces an extended series of signs in answer to questions. Our hope is that Washoe can be brought to the point where she describes events and situations to an observer who has no other source of information.

At an earlier time we would have been more cautious about suggesting that a chimpanzee might be able to produce extended utterances to communicate information. We believe now that it is the writers—who would predict just what it

is that no chimpanzee will ever do—who must proceed with caution. Washoe's accomplishments will probably be exceeded by another chimpanzee, because it is unlikely that the conditions of training have been optimal in this first attempt. Theories of language that depend upon the identification of aspects of language that are exclusively human must remain tentative until a considerably larger body of intensive research with other species becomes available.

Summary

We set ourselves the task of teaching an animal to use a form of human language. Highly intelligent and highly social, the chimpanzee is an obvious choice for such a study, yet it has not been possible to teach a member of this species more than a few spoken words. We reasoned that a spoken language, such as English, might be an inappropriate medium of communication for a chimpanzee. This led us to choose American Sign Language, the gestural system of communication used by the deaf in North America, for the project.

The youngest infant that we could obtain was a wild-born female, whom we named Washoe, and who was estimated to be between 8 and 14 months old when we began our program of training. The laboratory conditions, while not patterned after those of a human family (as in the studies of Kellogg and Kellogg and of Hayes and Hayes), involved a minimum of confinement and a maximum of social interaction with human companions. For all practical purposes, the only verbal communication was in ASL, and the chimpanzee was maximally exposed to the use of this language by human beings.

It was necessary to develop a rough-and-ready mixture of training methods. There was evidence that some of Washoe's early signs were acquired by delayed imitation of the signing behavior of her human companions, but very few if any, of her early signs were introduced by immediate imitation. Manual babbling was directly fostered and did increase in the course of the project. A number of signs were introduced by shaping and instrumental conditioning. A particularly effective and convenient method of shaping consisted of holding Washoe's hands, forming them into a configuration, and putting them through the movements of a sign.

We have listed more than 30 signs that Washoe acquired and could use spontaneously and appropriately by the end of the 22nd month of the project. The signs acquired earliest were simple demands. Most of the later signs have been names for objects, which Washoe has used both as demands and as answers to questions. Washoe readily used noun signs to name pictures of objects as well as actual objects and has frequently called the attention of her companions to pictures and objects by naming them. Once acquired, the signs have not remained specific to the original referents but have been transferred spontaneously to a wide class of appropriate referents. At this writing, Washoe's rate of acquisition of new signs is still accelerating.

From the time she had eight or ten signs in her repertoire, Washoe began to use them in strings of two or more. During the period covered by this article we made no deliberate effort to elicit combinations other than by our own habitual use of strings of signs. Some of the combined forms that Washoe has used may have been imitative, but many have been inventions of her own. Only a small proportion of the possible combinations have, in fact, been observed. This is because most of Washoe's combinations include one of a limited group of signs that act as combiners. Among the signs that Washoe has recently acquired are the pronouns "I-me" and "you." When these occur in combinations the result resembles a short sentence. In terms of the eventual level of communication that a chimpanzee might be able to attain, the most promising results have been spontaneous naming, spontaneous transfer to new referents, and spontaneous combinations and recombinations of signs.

References and Notes

1. See, for example, E. H. Lenneberg, *Biological Foundations of Language* (Wiley, New York, 1967).
2. A. L. Bryan, *Curr. Anthropol.* **4**, 297 (1963).
3. K. J. Hayes and C. Hayes, *Proc. Amer. Phil. Soc.* **95**, 105 (1951).
4. K. J. Hayes, personal communication. Dr. Hayes also informed us that Viki used a few additional sounds which, while not resembling English words, were used for specific requests.
5. R. M. Yerkes, *Chimpanzees* (Yale Univ. Press, New Haven, 1943).
6. K. J. Hayes and C. Hayes, in *The Non-Human Primates and Human Evolution*, J. A. Gavan, Ed. (Wayne Univ. Press, Detroit, 1955), p. 110; W. N. Kellogg and L. A. Kellogg, *The Ape and the Child* (Hafner, New York, 1967; originally published by McGraw-Hill, New York, 1933); W. N. Kellogg, *Science* **162**, 423 (1968).
7. W. C. Stokoe, D. Casterline, C. G. Croneberg, *A Dictionary of American Sign Language* (Gallaudet College Press, Washington, D.C., 1965); E. A. McCall, thesis, University of Iowa (1965).
8. J. Goodall, in *Primate Behavior*, I. DeVore, Ed. (Holt, Rinehart & Winston, New York, 1965), p. 425; A. J. Riopelle and C. M. Rogers, in *Behavior of Nonhuman Primates*, A. M. Schrier, H. F. Harlow, F. Stollnitz, Eds. (Academic Press, New York, 1965), p. 449.
9. R. M. Yerkes and B. W. Learned, *Chimpanzee Intelligence and Its Vocal Expression* (William & Wilkins, Baltimore, 1925), p. 53.
10. K. J. Hayes and C. Hayes, *J. Comp. Physiol. Psychol.* **45**, 450 (1952).
11. C. J. Warden and L. H. Warner, *Quart. Rev. Biol.* **3**, 1 (1928).
12. The development of Washoe's vocabulary of signs is being recorded on motion-picture film. At the time of this writing, 30 of the 34 signs listed in Table 1 are on film.
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