Acquisition and Testing of Gestural Signs in Four Young Chimpanzees

Abstract. *Two male and two female chimpanzees were each taught ten signs of American Sign Language. The acquisition rates of the signs were compared on the basis of the number of minutes required in training to reach a criterion of five consecutive unprompted correct responses. After the ten signs had been acquired, the chimpanzees were tested in a double-blind procedure for nine of the signs. All four chimpanzees acquired all of the signs. Some signs were consistently easier to acquire than others, and individual differences between the four chimpanzees were found in the acquisition rates and tests.*

Gardner and Gardner (*1*) have shown that a chimpanzee (Washoe) is capable of acquiring a human form of communication, American Sign Language for the deaf (ASL). Since only one chimpanzee was used in that study, it was difficult to apply these results to the general population of chimpanzees. In this regard, it has been suggested that Washoe might be an exceptionally bright chimpanzee and that other chimpanzees might not have the ability to acquire signs in ASL. The Gardners were also unable to make certain comparisons that were suggested by Washoe's behavior. For example, they were unable to determine whether the signs that were difficult for Washoe to acquire were a function of Washoe or the particular sign being taught. The purpose of the present study was to determine (i) whether Washoe is an exceptional chimpanzee, (ii) whether there is any consistency in the ease with which signs are acquired, and (iii) whether there are individual differences in the acquisition of signs by different chimpanzees.

Four young chimpanzees—Booee, Bruno, Cindy, and Thelma—at the Institute for Primate Studies were used as subjects. Booee, a male, was born in captivity and home-reared for more than 30 months. His cerebral hemispheres and spine except for the medulla had been surgically split. He was 36 months of age at the beginning of training. Bruno, another male, born in captivity, was home-reared for 24 months and partially home-reared for 8 months. He was 32 months of age when training began. Females Cindy and Thelma were collected in the wild and had had an undetermined amount of human contact, although they could be readily handled by humans. Cindy was estimated to be 45 to 51 months of age when training began; Thelma was 33 to 39 months of age.

The training was carried out inside metal cages measuring 123 by 184 by 184 cm. There were bench seats at both ends of the cage, with enough room for a chimpanzee to sit on one seat facing a human teacher on the other.

The chimpanzees were taught standard ASL signs, which are analogous to words in spoken language (*1*, *2*). The signs taught, selected from a vocabulary list for Washoe (*1*), were "hat," "shoe," "fruit," "drink," "more," "look," "key," "listen," "string," and "food." The exemplars used in teaching nine of the signs were actual objects representing the signs (a hat for the "hat" sign, a ticking wristwatch for the "listen" sign, a pair of glasses for the "look" sign, and a piece of rope for the "string" sign). The remaining sign, "more," was taught in association with a noun sign; the situation was of asking for more fruit by the combination of "more" and "fruit" signs (*3*).

The experimenters were the author, with more than 4 years of experience with this type of research, and inexperienced student volunteers (*4*). The volunteers were first instructed in ASL and the training procedure and then observed an actual training session. They next interacted with the chimpanzees in a casual play situation before they began teaching the chimpanzees.

The method of teaching a sign was molding, found for Washoe (*5*) to be more efficient than two other methods (imitation and a combination of imitation and molding). The experimenter physically molded the chimpanzee's hands into the correct position for the particular sign in the presence of an exemplar for that sign. The experimenter gave the chimpanzee a raisin or other food (if raisins were not effective) after he had molded the chimpanzee's hands or when the chimpanzee made the sign without the experimenter's aid. As the chimpanzee began to make the sign without the experimenter's aid, the experimenter gradually stopped the molding until the chimpanzee was making the sign entirely by himself. This is similar to a fading technique used in teaching autistic children to produce consonant sounds (*6*).

The training sessions lasted for 30 minutes and were conducted as often as three times a day, 5 days a week, depending on the chimpanzee's cooperativeness on a given day. Each training session was begun with a warm-up period, during which the chimpanzee could readjust to the situation and experimenter. If the chimpanzee appeared to be overactive or hyperexcited, the session was terminated. After the first sign was acquired, subsequent training sessions included a review of previously acquired signs. This was to ensure differentiation of the signs from each other and also to reduce the possible stress of a training session in which the chimpanzee failed to acquire a new sign.

The experimenter recorded the times for (i) the first correct response

Table 1. Acquisition of sign language by four chimpanzees. The criterion for each sign was five consecutive unprompted responses.

Sign taught	Minutes to criterion				
	Bruno	Booee	Cindy	Thelma	Mean
Hat	178	78	99	297	163.00
Shoe	60	14	18	20	28.00
Fruit	177	80	20	195	118.00
Drink	36	15	25	18	23.00
More	225	10	15	24	68.50
Look	345	115	54	420	233.50
Key	40	10	25	40	28.75
Listen	2	12	10	15	9.75
String	287	129	476	372	316.00
Food	14	80	55	190	84.75
Mean	136.4	54.3	79.7	159.1	

that immediately followed the molding of the chimpanzee's hands, (ii) the first correct response not preceded by a prompt or any aid from the experimenter, and (iii) the first five consecutive correct unprompted responses to the exemplar. After each training session the chimpanzee was returned to his quarters and the experimenter wrote a summary of the chimpanzee's behavior during the session; the summary included types of consistent errors, attentiveness to the task, the form of the sign, and any combination of signs the chimpanzee put together. The ten signs were taught in a random order, which was the same for all chimpanzees (Table 1).

After acquiring all ten signs, the animal was tested on nine of the signs by a double-blind procedure similar to that described by Gardner and Gardner (*7*). In this procedure, an exemplar of a sign was placed in a covered box in the training cage by an assistant who was completely hidden behind a blind. The chimpanzee sat directly in front of the box. The first observer, who was sitting next to the box and unable to see its contents, removed the end of the box and asked the chimpanzee, "What that?" (in ASL) and recorded the answer. A second observer, outside the cage and unable to see the exemplar, also recorded the chimpanzee's response. Each of the nine exemplars was presented twice during a test, and two tests were given to each chimpanzee. The tenth sign, "more," was excluded because an exemplar for it could not be put in a box.

The results for acquisition are presented in Table 1. The mean acquisition times for the various signs differ markedly, and these results are statistically reliable (Table 2).

All four chimpanzees acquired "string," and "hat" with considerable difficulty, while they acquired "listen," "key," "drink," and "shoe" with relative ease (Table 1). The chimpanzees differed in their ability to acquire signs. Booee and Cindy seemed to be better students in acquisition than Bruno and Thelma; the mean time to criterion for Booee was approximately one-third that for Thelma.

The proportion of correct responses for both double-blind box tests was 26.4 percent for Cindy, 58.3 percent for Booee, 59.7 percent for Thelma, and 90.3 percent for Bruno. The data from the two observers were pooled for analysis because the interobserver reliability was high (over all testing situations median agreement between the two observers was 94 percent, with a range of 83 to 100 percent).

Table 2. Analysis of variance for the differences among signs across chimpanzees.

Source	Mean square	Degrees of freedom	*F*	*P*
Between chimps	236.66	3	3.38	.05
Within chimps	156.64	36		
Signs	416.49	9	5.947	.0003
Residual	70.03	27		
Total	162.80	39		

Test results for Booee and Thelma indicate that some of the errors were related to conceptual similarities. Errors made when a food exemplar was presented were, for the most part, signs in the food category ("fruit," "food," or "drink"). All of Booee's errors were the "drink" sign when fruit or food was the exemplar, and 90 percent of Thelma's errors were signs in the food category when a food, fruit, or drink was the exemplar.

The gestural similarity between individual signs may have accounted for some of the errors. "Listen," "look," and "key" are somewhat similar in form. "Listen" is an index finger placed on the ear, "look" is an index finger placed next to the eye, and "key" is an index finger placed in the palm of the other hand. When a listen, look, or key exemplar was presented, 77 percent of Booee's errors were one of the three form-related signs.

Three of the four chimpanzees were performing at more than a chance level. Cindy, who had the poorest performance, was correct on the first test 4 out of 18 times ($P > .0918$) according to the first observer and 3 out of 18 times ($P > .1802$) according to the second observer; both observers scored 6 out of 18 correct responses ($P > .008$) on the second test. If she were operating at a chance level, the expected performance would be 2 correct responses out of 18. Therefore, even Cindy was not performing at a chance level on the second test.

It might be assumed that the differences in performance of the chimpanzees in acquisition as compared to their performance in the double-blind box tests may be due to intrinsic differences in learning ability. These differences might be partially explained by the chimpanzee's behavior during the acquisition phase. Booee during acquisition can best be described as a chimpanzee who was willing to sell his soul for a raisin. This is probably why he did so well in acquisition. Cindy, also good in acquisition, was almost too willing to please. For example, when teaching Cindy the first sign ("hat") the experimenter would place Cindy's hand on her head. Cindy would leave her hand exactly where the experimenter had placed it but she would then turn her head away and look elsewhere, hand in place. Later she began to take a more active part in the training. Bruno and Thelma were slower in acquisition as compared to Booee and Cindy. Bruno was not particularly cooperative during acquisition. When Bruno was trained on the first sign he initially refused to respond. The reward was changed from raisins to apple slices to banana slices to soft drinks without a noticeable change in Bruno's behavior. Finally, the experimenter threatened him and he immediately began to make the sign. Thelma, on the other hand, can best be described as easily distracted by any other focus of attention (for instance, a fly in the cage).

Thus, some of the differences in the mean acquisition times of the four chimpanzees may have been because of their individual behavior during acquisition. This might also explain Cindy's poor performance in the double-blind test. In acquisition Cindy thrived on the close attention and praise of the experimenter. However, in the box test the attention and praise were not used. The observer in the cage did not interact with her for fear of accidentally seeing the object in the box, and he did not praise her because he did not know if her answer was correct. During the box tests Cindy was the least attentive, and her attentiveness appeared to decrease as the tests progressed.

Some signs in ASL are apparently easier for a chimpanzee to acquire than others. This may be because some of the signs are similar to preexperimental behaviors in the chimpanzee's

repertoire. For example, some chimpanzees suck their thumb, which is similar to the "drink" sign. On the other hand, the "look" sign—touching the index finger near the eye—might not only be absent from the chimpanzee's behavioral repertoire, but might also be an aversive experience because of the natural response to protect the eyes when something is poked in or even near them. These results are consistent with a hypothesis of Hayes and Hayes (*8*) that ability to show imitative behavior depends on the prior existence of that behavior in the chimpanzee's repertoire.

All of the signs were acquired by all of the chimpanzees, and some of the signs were acquired in remarkably short time. Thus it does not appear that Washoe is exceptional in her ability to acquire signs in ASL. Individual chimpanzees differ in their ability to acquire these signs. Some of the errors during the double-blind box tests were possibly influenced by being conceptually related, which is consistent with Washoe's errors in testing (*1*). Also, the gestural similarity between signs and preferences for a sign or signs were noted as possible sources for errors.

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References and Notes

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2. W. C. Stokoe, D. Casterline, C. G. Croneberg, *A Dictionary of American Sign Language* (Gallaudet College Press, Washington, D.C., 1965).
3. The chimpanzees were exclusively trained with fruit to acquire the "more" sign, but outside of the training situation they spontaneously combined the "more" sign with the "drink" sign to obtain more to drink.
4. More than 30 volunteers were used; the chimpanzees' acquisition of sign was thus not attributable to a unique trainer.
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9. I thank W. B. Lemmon, director of the Institute for Primate Studies, for his most valuable assistance, and I thank the student volunteers who assisted in training and testing.

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Visual Free Recall

Abstract. *Lists of complex pictures, not easily encoded verbally, were presented to subjects who recalled them by writing brief descriptions. The lists were 10, 20, and 40 pictures in length. Recall failed to show the primacy and recency effects seen with verbal materials, but was lower for pictures in longer lists. This argues for serial-position effects based in short-term memory and independent list-length effects arising during retrieval from long-term memory.*

In recent years, the study of memory and forgetting has relied heavily on the paradigm of free recall. In this paradigm, a series of items, usually words, are presented one at a time. Then the subject is asked to recall as many items as he can, in any order he wishes. Three basic effects are found in graphs giving the probability of recall as a function of serial presentation position. These serial-position curves show a pronounced recency effect, a smaller primacy effect, and a flat central region which is lower for longer lists. Typical sets of curves are shown in Fig. 1, A and B (*1*).

The recency effect has commonly been attributed to the operation of short-term memory. It is assumed that the items near the end of the list are still in short-term memory when the recall period begins. These are output at once, giving rise to the recency effect, and all additional recall results from retrieval from long-term memory. There is considerable evidence supporting this view. To give just a few examples, a period of arithmetic following presentation and preceding recall eliminates the recency effect, presumably by causing forgetting of the list words from short-term memory (*2*); an additional free-recall test at the end of the session for all lists in the session shows no recency effect, presumably since such a test precludes any short-term retrieval (*3*); and the elimination from recall scores of those items undergoing overt rehearsal at list termination tends to eliminate the recency effect, presumably since the rehearsed items represent the major part of the contents of short-term memory at that moment (*4*).

The primacy effect is usually thought to result from additional rehearsal given the first few items of a list. The extra rehearsal presumably results in more long-term storage for these items. Support for this hypothesis comes from the fact that controlling rehearsal so that all items receive equal amounts can eliminate the primacy effect (*5*).

The list-length effect is one of the strongest seen in memory research. When arithmetic between presentation and recall is used to eliminate retrieval from short-term store, the probability of recall for a given word can range from near 1.0 for lists of only a few items to near 0.0 for lists of many hundreds of items. I have previously suggested how a failure of retrieval from long-term store can account for the list-length effect (*6, 7*).

These various results in free recall have been perhaps the strongest evidence in favor of a memory system divided into an active limited short-term store and a passive unlimited long-term store. It should be noted, however, that some other models have been proposed, with at least partial success, which do not follow the general theoretical outline proposed above. Bernbach (*8*) and Postman and Phillips (*2*) have proposed "single" memory theories, and Norman and Rumelhart (*9*) have proposed a decay theory to explain both serial-position and list-length effects in free recall and related tasks. We cannot go into such theories in this report, but the three mentioned have the common property that the serial-position effects and list-length effects are integrally related. On the other hand, theories postulating separate short- and long-term stores propose that these effects are relatively independent. The present study is, therefore, designed to demonstrate considerable independence of the list-length effects from serial-position effects. We will demonstrate this by describing a free-recall task in which serial-position effects are absent but in which list-length effects are present and unattenuated.

The clue to the type of paradigm needed arose from a study in which we presented complex pictures to be remembered for a later recognition test (*10*). Both the presentation times of individual pictures and the times between pictures were varied. It was found that presentation time affected recognition but the time following a picture did not affect its recognition. Furthermore, recency effects were not seen. We concluded that complex pictures were not being given effective rehearsal during periods when they were not