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11. Cellular cyclic AMP was assayed by the protein binding assay of A. Gilman [*Proc. Natl. Acad. Sci. U.S.A.* **67**, 305 (1970)]. Measurable cyclic AMP of both WT and $I^R.1$ cells was completely destroyed by beef heart cyclic AMP phosphodiesterase (obtained from Sigma).
12. The adenylate cyclase assay (M. E. Maguire and A. Gilman, *Biochim. Biophys. Acta*, in press) can reproducibly measure cyclic AMP production as low as 0.5 pmole per milligram of protein per minute. The apparent discrepancy between measurable cyclic AMP in intact $I^R.1$ cells and undetectable adenylate cyclase activity in $I^R.1$ particulate fractions is not surprising, however, since cyclic AMP synthesis has consistently been found much greater in intact mammalian cells than in broken cells (*1*), probably because the enzyme is damaged by homogenization.
13. Specifically, when crude particulate extracts (prepared as described in the legend to Fig. 2) of WT and $I^R.1$ cells were mixed, adenylate cyclase activity was identical to that measured in parallel tubes containing WT particulates alone. In addition, the supernatant fraction of a homogenate of WT cells centrifuged at 10,000*g* (see legend to Fig. 2), which contained negligible adenylate cyclase activity, failed to restore activity of $I^R.1$ particulate fractions, and similar supernatant fractions from $I^R.1$ cells did not affect WT enzyme activity.
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# Early Signs of Language in Child and Chimpanzee


Abstract. *In a sequel to Project Washoe, chimpanzees are being taught American Sign Language from birth by humans who are fluent in the language, including persons who are themselves deaf or whose parents were deaf. The first two subjects began to use signs when they were 3 months old, and these early results indicate that the new conditions are significantly superior to the conditions of Project Washoe. More valid comparisons can now be made between the acquisition of language by children and by chimpanzees.*


The exposure of children to their native language begins at birth, and most theories of language acquisition assume that the exposure during the earliest years is particularly significant. What evidence there is on this point is, at best, indirect. Long-term negative effects of an impoverished linguistic environment can be demonstrated for children reared in orphanages during the first years of life (*1*). Favorable effects of early exposure to language—in this case, sign language—can also be demonstrated by comparing deaf children of deaf parents with deaf children of hearing parents on tests of the ability to speak, read, or write English (*2*). Moreover, with the recently developed techniques for recording behavior of neonates, it has been shown that the human infant is responsive to characteristics of adult speech, such as segmentation and the distinction between phonemes, within a month of birth (*3*). It seems likely that the beneficial effects of early exposure to language can also be demonstrated in attempts to teach language to animals.

Project Washoe was the first attempt to teach sign language to a chimpanzee. Washoe was about 11 months old when her training in American Sign Language (Ameslan) began. Within 51 months, she had acquired 132 signs of Ameslan, as determined by criteria for reliable usage developed during the research (*4*). As with humans using words, Washoe used her signs for classes of referents rather than for particular objects or events, and used signs in combinations (*5*). Brown (*6*), Klima and Bellugi (*7*), and other investigators of child language have commented on the many ways in which Washoe's acquisition of sign language parallels the acquisition of spoken language by children, as, for example, in Washoe's generalization of the meaning of signs, in the gradual increase in length of her sign combinations, and in the types of semantic relations expressed by early combinations. Thus, Project Washoe demonstrated that Ameslan is a suitable medium of communication for a chimpanzee, and that, given a suitable medium, a significant level of two-way communication could be achieved. Since then, several chimpanzees in several laboratories have acquired a vocabulary of signs (*8*), and it is appropriate to pose questions about individual differences, about limits, and about the effectiveness of different methods of teaching sign language. In our current project of teaching sign language to several chimpanzees, we are capitalizing upon our experience in the research with Washoe by improving key features of procedure, and we plan to maintain these more favorable conditions until the subjects reach intellectual maturity. In this way, we can come much closer to describing the highest level of two-way communication that can be achieved by chimpanzees taught a form of human language.

One of the significant improvements in procedure is that several fluent signers, including deaf persons and persons who have deaf parents, are research personnel in the current project. These "native speakers" of Ameslan provide far more adequate models of the language than those we provided for Washoe.

Another improvement is that the exposure of subjects to Ameslan begins 1 or 2 days after birth. Chimpanzee Moja was born at the Laboratory of Experimental Medicine and Surgery in Primates, Tuxedo Park, N.Y., on 18 November 1972 and arrived in our laboratory on the next day. Chimpanzee Pili was born at Yerkes Regional Primate Research Center, Atlanta, Ga., on 30 October 1973 and arrived in our laboratory on 1 November.

No special difficulties were encountered in maintaining the infants in good health. Their care is similar to that of the human infant; around-the-clock feedings, diapering, inoculations, sanitary precautions such as sterilization of bottles, and so on. In addition, we provided the infants with body contact whenever they were awake. Within a few weeks, the infants appeared re-

Fig. 1. Chimpanzee Pili, at age 4 months, using the Ameslan sign *drink* (left) when shown his water bottle, and the sign *more* (right) after a bout of tickling. The position of Pili's hands and his orientation toward the human companion when signing *more* are different from those during the preceding bout of tickling (center).

sponsive to the activities of their human companions, which included a great deal of signing. Even in the earliest months, the infants were attentive and alert. They could grasp toys, imitate actions such as blowing kisses or peek-aboo, and differentiate their usual companions from strangers.

Both Moja and Pili started to make recognizable signs when they were about 3 months old (Fig. 1). In Project Washoe, we kept track of new signs by noting spontaneous and appropriate use of the sign. The day that the third of three observers reported appropriate and spontaneous occurrence was taken as the date of the appearance of the new sign in the vocabulary. By this criterion, Moja's first four signs (*come-gimme, go, more*, and *drink*) appeared during her 13th week of life. Similarly, Pili's first sign appeared during his 14th week of life, and he had a four-sign vocabulary (*drink, come-gimme, more*, and *tickle*) by his 15th week. The first four signs met the three-observer criterion within a few days of each other for both subjects. At the age of 6 months, Moja's vocabulary consisted of 15 signs, and Pili's of 13 signs. By contrast, Washoe's exposure to sign language did not begin until she was nearly 1 year old, and the effective start of the exposure was further delayed because the research participants were only beginning to learn Ameslan. After 6 months of exposure, Washoe's vocabulary consisted of the signs *come-gimme* and *more*.

In the early stages of Project Washoe, we developed a procedure to determine when a new sign had become a reliable item in the chimpanzee's vocabulary. After the third report of a new sign, the sign was added to a checklist. Each day thereafter, the first person to observe Washoe using a sign on the checklist entered a description of its form and context. As the criterion for deciding that the sign had become reliable, we chose a period of 15 consecutive days during which at least one appropriate and spontaneous use of the sign had been recorded (*5*).

These 15-day records for the present study show that, even at this early stage, signs were being used, not as mechanical routines, but with variations in form and in appropriate variations of a basic context. For example, in the set of reports on Pili's use of *tickle* during 14 to 28 February 1974, two kinds of context were described. Usually, Pili signed for continuation of tickling when his companion stopped tickling him momentarily or stopped and asked questions such as, *What we play now*? But in two reports, Pili initiated tickling with his sign. Pili also used another of his early signs, *more*, to request continuation of tickling during this period (Fig. 1). But *more* was recorded in several contexts in which *tickle* did not occur, as when we had taken away Pili's water bottle after a bout of drinking or had stopped games other than tickling, such as covering and uncovering Pili's face with a scarf. In forming *tickle*, Pili drew the index finger over the back of his other hand or the back of his companion's hand about equally often. Moja also used both her own body and corresponding parts of the addressee's body as the place for making *tickle* and other early signs; this variation in form has been reported for Washoe and for very young deaf children (*4*).

Fouts (*8*) reported that an infant female, Salome, used the sign *food* during her fourth month. While the age at which chimpanzees produce their first signs seems early compared to that for first words of humans, it is not very discrepant from the age at which the first signs appear in humans. There are parental reports of first signs between the fifth and sixth month for children exposed to sign language (*2*). Possibly, signs are easier to make than words; more likely it is easier for a parent to recognize the infant's poor approximation to a sign than his poor approximation to a spoken word.

We consider the early appearance of signs to be an important confirmation of two major procedural improvements in the current project; the exposure of subjects to fluent Ameslan signers and the exposure to language from birth. Of course, it is not the size of the early vocabulary per se that is significant but what this promises in terms of further development under the more favorable conditions for the acquisition of sign language.

R. A. GARDNER
B. T. GARDNER
*Department of Psychology, University of Nevada, Reno 89507*

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