

Language acquisition by a lowland gorilla: Koko's first ten years of vocabulary development*

1. Introduction. What makes language human? Is language uniquely human? The answers to these questions—central to the fields of linguistics, anthropology, and psychology—can be sought through the study of the cognitive capabilities of our closest biological relatives, the great apes. Apes have shown in less developed form most of the abilities and behaviors often assumed to be unique to humans, including language (Hayes, 1951; Premack, 1976; Rumbaugh, 1977; Patterson and Linden, 1981). The benchmark for success in language acquisition by apes is vocabulary. Attempts to teach apes spoken language resulted in vocabularies of at best a half dozen words; however, attempts at symbolic communication in the visual mode overcame the limitations of ape vocal tract anatomy, yielding success rates many times greater than that of spoken language. Studies employing human sign language rather than synthetic symbol systems have been the most successful, and they hold the greatest potential for helping us to understand the origin of language and the complex network of factors influencing its development.

Common chimpanzees have been the subjects of choice in ape language research; gorillas, because of their great size and apparent untrainability, were not considered suitable subjects for such studies. However, Project Koko, initiated in 1972 with a one-year-old female gorilla, challenged that idea. In the longest uninterrupted study of ape language abilities ever undertaken, the gorilla Koko has been continuously exposed to bimodal, bilingual communication through sign language and spoken English. Signing has become an integral part of her daily life. Koko is acquiring a large number of words through instruction, imitation, and her own innovation. Her progress has been recorded and measured within the framework of these objectives:

- 1) To obtain a linguistic data base similar in nature and scope to that being compiled on human children and on chimpanzees.
- 2) To use this and other behavioral data to elucidate the role of cognition in language development and use.

- 3) To use language as a probe to better understand the intellectual, emotional, and social development of the gorilla.

This article describes efforts to meet the first of these objectives in the initial decade of Project Koko, through discussion of vocabulary development, the means of gorilla language production, and comparisons with deaf and hearing human children. Procedures were developed during the project to allow room for Koko's own individual ways of using language, while establishing empirically that Koko knew and correctly used the specific words she was taught. Standard tests have measured the objective, empirical success of the project.

2. Methods. The subject, Koko, a female lowland gorilla (*Gorilla g. gorilla*), was born July 4, 1971, at the San Francisco Zoo. Project Koko began in July 1972 when Koko lived in the nursery of the San Francisco Zoo. She lived with her mother in a gorilla group until she was six months old. Then, owing to illness, she was removed from the group and raised in a human family for six months. Consequently, Koko has been exposed to spoken English from age six months to the present. She has been exposed to a variant of American Sign Language (ASL or Ameslan), a rule-based syntactic language system conveyed with a lexicon of gestural signs, since she was one year old. This variant is a combination of signed English and true ASL.

The study was carried out in full public view during the first 11 months of the project. Koko was in the presence of one or more signing human companions for approximately five hours daily. She was taught by fluent ASL signers (these included native signers, that is, persons with deaf parents) for 10 to 20 hours each week, beginning with the second month of the project. Koko's exposure to signing companions and teachers increased to 8½ hours each day when the project moved to Stanford University after the first two years. The move allowed the project to increase in intensity, through greatly reduced public contact and the availability of additional hours of signed instruction (Patterson, 1979, 1980).

Koko was not isolated from spoken English, unlike subjects in other language studies of cross-fostered primates (Gardner and Gardner, in press). When the project began, little data existed to suggest that a gorilla could learn to understand English. Then, as now, some scientists believed that if Koko could not generate spoken words, she could not understand them. This belief was based on the motor theory of speech perception (Liberman et al., 1967).

Each teacher communicated with Koko in his or her native lan-

guage, but deaf persons were also encouraged to use their voices, and hearing individuals were required to accompany their speech with sign. Although English has been used along with sign throughout the course of the project, all actual language instruction has been given exclusively in sign.

Koko began to show that she understood the significance of the gestures she was seeing as early as the second week of the project. During that week volunteers reported that she made the signs *food* and *drink* several times during the mornings. No one had molded Koko's own hands to make signs at that point, but Koko had observed signs being made.

Project staff continued to use any and all opportunities over the following two weeks to show Koko the signs *food*, *drink*, and *more*. Before handing Koko her bottle, it was presented visually, and the sign *drink* was demonstrated. If she responded by signing *drink*, she received the bottle. If she made no response, she would be asked, What's this? If she still made no response, her hand would be molded into the sign *drink* before she received the bottle. Zoo volunteers included some signing in their daily routine when project staff members were unavailable.

Over the years, two different techniques to teach vocabulary and to elicit signing have been employed: molding and imitation (modeling). Molding requires the teacher to shape the subject's hands into an appropriate configuration and to guide them through the proper motions. Imitation requires the subject to form the sign after observing its use by the teacher. Both of these techniques have often been used in conjunction with the spoken word, especially in the the initial stages of teaching a vocabulary item. Later on, prompting could be more subtle, by pointing to or touching the appropriate body part, or simply by voicing the English word alone.

3. Sign acquisition criteria. Specific performance criteria were developed to assure reliability throughout Project Koko, based in part on assessment of those developed for the chimpanzee Washoe by the Gardners (1969, 1972). In Project Koko, a sign was first considered reliable if observed and recorded by two independent observers and used spontaneously and appropriately on at least half the days of a given month. Thus, a sign reported 15 times but only by one observer would not be considered a part of Koko's vocabulary. Of course, any criterion is arbitrary; for example, Koko used the sign cucumber ("slice green") 13 days in a row during two different months in 1975,

and she has consistently used the sign in an appropriate manner ever since—but not necessarily on consecutive days. According to the Gardner and Gardner criterion, which required a word to be used spontaneously and appropriately for 14 consecutive days, this means that the word would not be included as part of Koko's qualified vocabulary. Obviously, in ordinary use of language by a developing child, one does not expect each new word to be repeated on 14 consecutive days; once the vocabulary becomes large, such a criterion is clearly inappropriate.

As it became clear that our criterion was also conservative, significantly underestimating the actual number of words that Koko was consistently using, a third criterion was developed: spontaneous and appropriate use on one or more occasions, to be grouped as 'emitted vocabulary.' Consequently, Koko's signing vocabularies were first organized under three labels: the 'G' (Gardner and Gardner) criterion, the 'P' (Patterson) criterion, and the 'E' (emitted) criterion. Efforts to establish more accurately representative criteria continue both in this project and in other ape-language research.

4. Language samples and establishing reliability. Specific guidelines were established for recording a sign or a combination of signs to document sign acquisition. Notes were kept on whether any given sign was prompted, molded, or imitated. If Koko used a sign incorrectly or held a sign, that was recorded. An utterance was defined to be a single string of words that was terminated if any of the following events occurred: Koko's hand returned to a resting position; she used her hands in some activity other than signing; or she sought eye contact, indicating that she expected a response from her human companion.

Recording contextual information in permanent form is essential for studying early vocabulary acquisition, as has been noted by other researchers (Folven and Bonvillian, 1987). Towards that end, Project Koko developed multiple means of reporting daily signing and related activities. In addition to keeping a daily diary in which everything Koko said or did was noted, one-hour samples of all signs, activities, and responses to which Koko was exposed were recorded periodically. This sampling involved logging the statements of her human companions while also maintaining accurate records of Koko's sign use. Daily sign checklists instituted in the ninth month of the project also noted (and continue to note) all of the signs Koko used during any given day, the combinations in which the signs occurred, the number of times each sign was repeated, and any unusual occurrence.

Monthly filming sessions, videotaping sessions, and audiotape recordings were also instituted. The audiotape recordings, which began in the fortieth week of the project, consisted of running commentary on conversations and activities with Koko. A minimum of ten 1-hour sessions and one 8-hour session were recorded each month. Audiotapes were recorded with great frequency throughout the first five years of the project and have been recorded at a reduced rate of frequency in more recent years. Beginning in February 1974 (month 19), two of the eight 1-hour audio samples taken per month were designated as either sign-only or voice-only samples. The teacher restricted utterances in these samples to just one mode (sign or speech), to assess separately the gorilla's understanding of sign language and spoken English.

Videotapes were initiated in the sixteenth month of the project and have served as an excellent control for checking the accuracy of project records of Koko's utterances. Beginning in March 1976, videotape was used to record the formal samples previously recorded on audiotape. Thirty-minute sessions were recorded until August 1977; 60-minute sessions were used thereafter, along with a control session employing simultaneous communications. The frequency of this monthly sampling from March 1976 until August 1981 was considerably greater than that of most child language-acquisition studies. Less frequent video sampling has continued to the present time.

Transcribing the samples required yet another set of rules so that an independent observer could examine a record of a sign sample and know not only what Koko said but also any peculiarities of context or of Koko's execution of the gesture. These efforts have made transcription a labor-intensive process. Ten hours are required to complete the transcription of a one-hour audiotape sign sample, and one-hour videotape samples can require approximately 100 hours to transcribe. If Koko uses a sign incorrectly, that is noted in the transcription; if Koko signs two signs simultaneously, that is noted as well. Similarly, if one of Koko's gestures is prompted, this is also recorded, as well as the way in which the gesture was prompted (touch prompted, molded, or imitated). These rules have allowed recreation of the conditions in which Koko used a word and the manner in which she executed a sign.

Reliability controls included the simultaneous recording of gorilla utterances by two people present at the scene, the independent transcription of videotaped sessions by two assistants familiar with Koko's signing, and the independent comparison of simultaneous audio and video samples.

5. Vocabulary development. Koko signed her first word after only days of formal training. On August 9th she consistently responded with close approximations of *food* when offered bits of fruit. At that time, no data yet existed to suggest that Koko's acquisition of this first word would ultimately lead to the communication of thousands of words and concepts between Koko and her teachers.

Studies of the development of such sign acquisition and production reveal aspects of cognitive functioning and organization crucial not only to an understanding of linguistic ability but also to broader areas of mental life. Word production is influenced by such diverse factors as the general intelligence of the subject, motivational level, environment, general linguistic competence, production handicaps, production mode, and assessment techniques.

Measurement of attained vocabulary serves as a valuable index of cognitive and linguistic development. Learning-set tasks (Harlow, 1949) have been considered to be the best index of nonhuman primate intelligence, although tests of vocabulary have long been considered the best single index of human intelligence. The subject is given a restricted number of trials on each of a series of different object-discrimination problems in the standard learning-set task. Performance on the problems improves as the subject 'learns how to learn' in the limited number of trials allowed. Gorillas and orangutans rank slightly above chimpanzees with respect to intelligence as measured by the transfer index, a refined measurement of learning-set ability in which species and individual differences in motivation and perceptual-motor skills are controlled (Rumbaugh and Gill, 1973). Fouts (1973) has shown that individual differences exist in the rates at which chimpanzees acquire sign vocabulary items and that certain signs are more difficult to learn than others. These observations suggest that vocabulary may be another sensitive and reliable index of intelligence in apes, as it is in humans.

Regimented training procedures proved depressing to Koko's motivation and were consequently used sparingly. Instead, every attempt was made to provide Koko with a stimulating environment, replete with objects and activities that might serve as conversational topics and prompt her to use her developing skills. Thus, Koko learned *large* and *small* and *same* and *different* through the sizes of the glasses she used at meals and snacks. Her response to objects encountered in her environment and her performance on standardized intelligence tests provided evidence that she could generalize from concepts introduced in that manner to other stimuli.

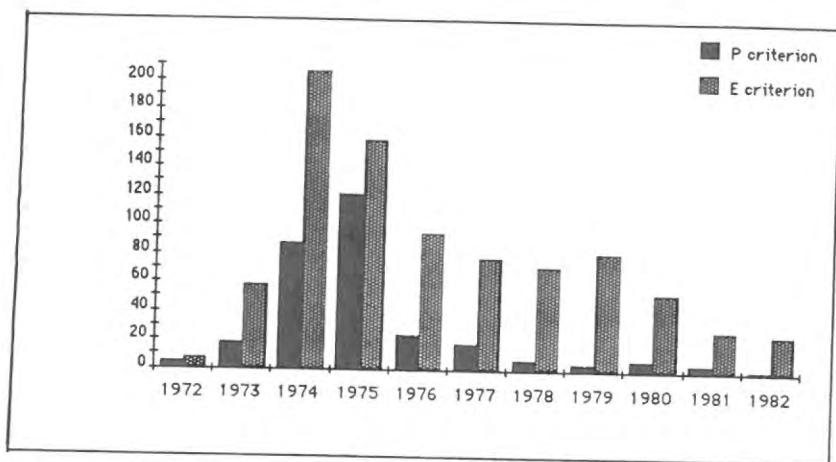


Figure 1. Number of new words added annually to Koko's vocabulary (P and E criteria) for the first ten years of Project Koko. Total distinct words: 290 words (P criterion) and 876 words (E criterion).

in word production occurs between the ages of 2 and 4 years (M.E. Smith, 1926). The timing of this stage in humans is subject to a variety of individual differences (Acredolo and Goodwyn, in press). Koko added approximately 200 signs per year (E criterion) during this developmental growth spurt. She added an average of about 80 words each year between 1976 and 1979 and about 35 new words annually between 1980 and 1982.

The indices of qualified vocabulary reveal that when Koko's lexicon increased beyond 180 signs, she seemed to have reached a point at which she did not or could not produce all of the words in her vocabulary during the course of a given day, a limitation which also occurs in human development. As the size of Koko's (or a child's) working vocabulary increases, a growing group of signs with no use or a relatively low frequency of use is generated (Rescorla, 1980); signs from this group become less and less likely to be emitted on a given day. Unless deliberate drill is instituted, new signs will be less likely to meet a criterion of use on 15 out of 30 (or 14 consecutive) days of a given month.

Daily inventories show that as new signs are learned, many old signs continue to be active in Koko's vocabulary. One indication of this tendency is the large number of different signs Koko uses appropriately and without prompting during the course of a day. For two

representative examples, on July 8, 1976, Koko spontaneously used 124 different signs, in addition to those prompted or molded. On the same date in 1979, she spontaneously used 90 different signs. Years of observation confirm that the nature and quantity of Koko's daily sign production is also highly sensitive to factors such as health and significant alterations in her social and physical environment.

6. Comparisons with children. Comparing Koko's vocabulary with that of human children is difficult; hearing human children are exposed from birth to the language in which they will ultimately communicate, whereas Koko was a year old when the project began. By the time she was 3½ years old, Koko had a P-criterion vocabulary of approximately 100 signs and an E-criterion vocabulary of 283 different signs. These figures place her below the normal range for human children, who often have vocabularies of 1,000 or more words between their second and third years (R.L. Smith, 1972; Suppes, Smith, and Leveille, 1972). Her vocabulary at this age was closely comparable in size to those of hearing children of average intelligence a year younger than herself (who averaged 180 to 360 words); to children of retarded performance of approximately the same chronological age, with mental ages of 26 months to 32 months (20 to 360 words [M.E. Smith, 1926]); and to certain linguistically disadvantaged children. For example, one report of a deaf child inventories 132 signs at age three (Olson, 1972). While Koko's vocabulary generally has been smaller than that of children at equivalent ages, the more meaningful comparison between Koko and children using sign language shows a closer correspondence (Patterson, 1978).

Overall, age-dependent acquisition rates for Koko and normal children show a striking similarity, although the normal child has a considerable advantage in terms of absolute size of vocabulary. As noted earlier, dramatic increases in a child's vocabulary can take place between the ages of two and four years: At 2½ years, the child is using six times the number of words used at two, and at 3½ years, three times the number used at 2½ years. After the age of 3½, the rate of increase diminishes (Menyuk, 1971). Koko's most significant increase in vocabulary size took place between the ages of 2½ and 4½: At age three she was using five times the number of signs she used at 2½, and at four, 3 times the number she used at age three. After the age of four years, the rate of increase diminished. These proportions closely parallel those of children, but with a six-month lag.

One distinct difference between Koko and hearing human children

is the limited size of her later emitted vocabulary. By the time children reach age five, their vocabularies are normally well over 1,000 words, and in some cases as high as 5,000 by the time they reach age six (Nelson, 1974). In contrast, at age five Koko was emitting 500 to 600 signs.

One would expect that an ape's capacity to acquire words would be surpassed by that of the human child. While this difference most likely is due to differences in the cognitive capacities of the two species, it may also reflect other factors, including differences in criteria for establishing words as items in the vocabulary; in the nature of lexical items in sign language as opposed to spoken English; and to differences in the social environments.

Great discrepancies exist in estimates of the sizes of children's vocabularies. Such figures (M.E. Smith, 1926, and Templin, 1957) are difficult to interpret, owing to such factors as sampling bias, the kind of vocabulary measured (use versus recognition), and differences in the methods of securing and recording words. Estimates of the size of recognition vocabulary are larger than those of vocabulary use. Some investigators count every possible variant of a word or every part of speech for which a word is used as an independent entry; others do not. Also, no general rule exists for determining what constitutes intelligent use of a word. The dictionary method (listing the first word on every page of the dictionary, checking those known, and multiplying by the average number of words on a page) is not applicable to children with vocabularies totaling fewer words than the multiplication constant. These difficulties were at least partially overcome by Descoedres (1921), for French-speaking children, and M.E. Smith (1926), who designed easily administered tests based on a combination of data from published child vocabularies and the dictionary method. Smith found that the average number of words in the vocabularies of 273 children increased to more than 2,500 at age six, with an average gain of almost 575 words per year between the ages of two and six. However, these figures apply only to hearing children, and they include some words which the child did not produce but correctly defined or responded to appropriately.

When deaf children are assessed for acquisition of signs, a different picture emerges. As few as 250 signs may be sufficient to meet the basic needs of a young deaf child entering school (Dale, 1974). Far fewer signs exist than English words. A signer fluent in ASL may have a vocabulary of only 500 to 1,000 basic signs, supplemented to a great extent by fingerspelling; classifiers and modulational variants (facial

expression, bodily attitudes, and changes in the manner of making a sign); and probably pantomime or the creation of iconic signed representations. Dale notes that "Even when a far greater number of signs are known, it is tempting, for the sake of speed, to use just the bare essentials, for example, to say 'shop me' rather than 'I am going up to the shop'" (Dale, 1974:15). Most signed statements appear 'telegraphic' in comparison with spoken statements; sign language uses few prepositions. Spatial relations generally are conveyed in ASL by verbs, and case relations are represented through morphological devices (Newport and Meier, 1985).

A study of Griswold and Commings (1974) examined the sign vocabulary growth of 19 preschool deaf children between the ages of 21 months and 52 months. These children had varying degrees of experience with the total-communication approach to language instruction, but all had exposure in both home and teaching environments to ASL or signed English and spoken English. All of the children in this study were of average or higher intelligence, and over half had immediate family members who were also deaf. The total corpus of 493 different words (most of them signs) were recorded by mothers in diary form. Signs were counted as two words if they functioned as two different parts of speech. The categories used are those generated for and applicable to English words rather than signs, but they are useful here for the direct comparisons made. Where important differences exist, the specifics of usage in sign are delineated in the discussion that follows.

The early vocabularies of deaf children include nominals as the predominant part of speech, as is also true for the early vocabularies of both Koko and hearing children. An average of 55 percent of the signs in the vocabularies of these deaf two-year-olds were nominals. Koko's vocabulary expanded in every conceptual domain, but the greatest increase occurred in the nominal categories, which made up 64 percent of her early lexicon, P criterion (Table 2). This also parallels the development of young hearing children, whose early vocabularies may contain between 50 percent and 62 percent nominal words (Dewey, 1894; Weir, 1962; Nelson, 1973).

Deaf children use first and second person pronouns, but fail to employ demonstrative and third person pronouns. This contrasts with hearing children, who begin to use *this*, *that*, and *it* by two years. One explanation is that in ASL, these words are usually indicated simply by pointing; pointing gestures are, in fact, discrete linguistic units (Newport and Meier, 1985). Perhaps Griswold and Commings (whose study

was in the context of a total communication program) did not include pointing as a sign. The signs *this* and *that* as used by Koko are pointing gestures.

Modal and auxiliary verbs are also absent from the vocabularies of deaf children (e.g., *be*, *have*, *can*, *could*, *might*, *must*, and *will*). *Do* is present only in the negative form of *don't*. *Have*, *do*, and *can't* are the only verbs in these categories present in Koko's vocabulary. This again may be due at least in part to the nature of ASL; no sign is used for *be*. In contrast, hearing children begin to use modals and auxiliaries at about the age of three years. A similar explanation holds for the words *a*, *the*, and *and*, which are rarely signed and do not occur in the vocabularies of deaf children, although they occur frequently in the early vocabularies of hearing children.

Verbals and negative forms made up 19 percent of the vocabularies of the Griswold and Commings' deaf preschoolers. They made up 22 percent of Koko's vocabulary and between 13 percent and 28 percent of hearing children's lexicons (Dewey, 1894; Bateman, 1914; Templin, 1957; Weir, 1962).

Modifiers were relatively infrequent in the vocabularies of these deaf children; the two-year-olds used an average of 11 per child, and even the oldest group of children averaged only 15. After ten years of training (at age 11), modifiers made up 15.8 percent of Koko's vocabulary. (See Table 3, which provides a complete listing by semantic categories of the first ten years of P-criterion words acquired by Koko.) Hearing children may not use many words of this class until after the age of two; Nelson (1973) reports 9 percent modifiers in her samples from children between the ages of two and three years, and Weir (1962) reported 10 percent. Templin (1957) reported a mean of 12 percent modifiers in the vocabularies of the six-year-olds in her study.

Temporal words are rare in the vocabularies of both deaf children and gorillas. In Griswold and Commings' sample, only six temporal words occurred, and only one of these—*finished*—was used by 50 percent of the children. Koko uses several words relating to the concept of time (e.g., *now*, *time*, *finished*), and uses a compound, *good finished*, to mean the opposite of now, just as did one of Schlesinger's (1976) young deaf subjects and as do other users of ASL.

Both deaf and hearing children use only two or three prepositions by the age of three. In order of frequency, the most common are *on*, *in*, *off*, *under*, *out*, and *with*. After ten years of language study, Koko had acquired six prepositional signs (in order of frequency of use): *on*, *in*, *out*, *down*, *up*, and *around*. These words represented 1.9 per-

cent of her vocabulary; 5.9 percent of the words used by the hearing six-year-old children in Templin's study were prepositions.

Koko's first 100 words (P criterion, listed by semantic categories) can be found in Table 4. A complete alphabetical listing of all words emitted by Koko during the first ten years of the project is recorded in Table 5, along with the acquisition type (Acqtype), which describes how Koko came to use a particular sign. The acquisition types used are as follows:

- T:** Taught to Koko by human molding or modeling.
- I:** An innovative creation of Koko's.
- N:** A natural gesture of noncaptive gorillas.
- G:** Learned from Michael (the other Project Koko gorilla); not taught to Koko by humans.
- M:** Modulated or compounded by Koko from a signed word or words taught by human teachers; modulation comprises adding or modifying meaning by altering the articulation.

Interestingly, those elements underrepresented in the vocabularies of deaf children and Koko (articles, particles, conjunctions, inflections, and copula) are infrequent in ASL and are the same kinds of elements universally missing from early child speech (Slobin, 1970).

A greater number of deaf children in the Griswold and Commings study used *no* than used *yes* or *ok*, a finding true for hearing youngsters as well. Koko acquired *no* earlier than *yes* and used both signs appropriately but infrequently. Deaf children in the Griswold and Commings study used question words as frequently as hearing children, with where being the most common interrogative, followed by *what*, *how*, and *why*.

Koko has not consistently used question signs corresponding to words such as *who*, *what*, or *why*, although she can appropriately answer questions employing these signs and words. At 6 years 11 months, Koko responded *What?* when she was told that she couldn't come out of a room because of an unspecified problem. Koko started asking *why* questions in June 1978: When the statement was made to Koko to 'Open your mouth and close your eyes,' she signed *Why?*

Many children in the early stages of language acquisition do not use Wh-words to express questions (Bowerman, 1973; Klima and Bellugi, 1972; Bonvillian, Nelson, and Charrow, 1976; Fischer, 1974). Additionally, language-disordered children produce fewer

questions than normal children with the same MLU (6 percent as compared with 19 percent of all utterances [Ingram, 1972]), and most of the Wh-questions asked by such children are of the form 'What that?' (Wilcox and Leonard, 1978). One-sixth of the children in the Wilcox and Leonard study produced questions without Wh-words. Almost half of the questions asked by either language delayed or normal children in the Ingram study were yes-no questions.

In the early stages of language acquisition, yes-no questions may be asked by children through the use of rising intonation or by staring at the listener or both (Clark and Clark, 1977). Although Koko has rarely used Wh-words, since the third month of study she consistently has used gestural intonation (retaining her hands in the sign position at the end of an utterance and seeking direct eye contact) to express questions.

7. Articulation. Certain words are more difficult for Koko to articulate than others, as is true for hearing and deaf children. She often simplifies signs which require a great deal of manual dexterity. For example, *water* and *rubber* are simplified from the *w* and *x* hand configuration to a forefinger extended from a loose hand or compact fist. Manual dexterity is not the only problem; some signs are physically impossible for Koko to articulate correctly (e.g., *sand*, *purple*) because of the small size of her thumb.

Koko acquired non-touch signs (signs in which the hands do not contact the body) more slowly than touch signs. Prior to the time when Koko could properly articulate non-touch signs such as *finished* and *milk*, she tried to convert these signs into touch signs by changing the place of articulation from a point away from the body to one on the body. Koko articulates certain signs involving motion toward the body (e.g., *glove* and *long*) with motion away from the body. Similar tendencies have been reported for human children learning signs (Newport and Meier, 1985).

Human children acquiring sign language consistently produce distorted or simplified versions of signs parallel to 'baby talk' in spoken languages (I.M. Schlesinger, 1971; Bellugi, 1975; Newport and Meier, 1985). Koko has produced forms which might also be called baby sign, some of which are identical to forms used by human children. H. Schlesinger (1976) explains that in signs one must reproduce a mirror-like image of the input received; consequently, young signers invert signs to themselves. Koko inverts the sign *bird* by pinching her lips with the her thumb and index finger, as do children who are

learning to sign (Schlesinger, 1976; Newport and Meier, 1985). An early variant of Koko's *eat* sign was a simplification in which only her index finger contacted her lips. This form is frequently reported for human infants acquiring sign.

Motivational constraints, rather than perceptual-motor or maturational constraints, seem to be operating in other cases of articulation delays. Koko learned to articulate the signs for *swing*, *berry*, *soap*, and *pinch* within minutes of exposure; each appeared to offer a highly desirable outcome for her. On the other hand, the signs for *egg* and *lotion* took Koko literally months to acquire and are frequently misarticulated or imprecisely formed—quite possibly because Koko likes neither eggs nor having her nightly hand lotion applied.

8. Generalization. Like human children, Koko has spontaneously generalized and overgeneralized her signs to new objects and situations (Leopold, 1949; E.V. Clark, 1973; Rescorla, 1980). The sign *open*, for example, which Koko first used in reference to doors, she later generalized to request the opening of purses, boxes, covered cans, drawers, and cupboards. During the latter half of her third year, she overgeneralized this sign to request that objects be given to her, to ask that a sweater be put on after she had failed to do so herself (*Open open sweater*), to request that her companion sit down, and to be allowed access to a pocket.

Overextensions in the language of children are most common between the ages of 1 year and 2½ years (E.V. Clark, 1973). For Koko they were common for a longer period of time. Table 6 provides a representative sampling of Koko's early overgeneralizations, from the age of 1 year 1 month to 3 years 5 months. Koko made two basic types of overextensions: referential and requester. Referential overextensions are related to Koko's mislabeling of objects in the environment and typically have been categorical overinclusions. Requester overextensions are related to Koko's demands for goods and services. Within the requester type are two subtypes, general and specific. For example, *eat* and *more* were used initially as general requesters, whereas *out* functioned as a requester specific to certain situations involving movement of individuals or objects. A later example of interest is Koko's analogical overextension of the word *straw*, learned initially with reference to drinking straws (acquired at the age of 3 years 2 months), which was later spontaneously used to label plastic tubing, a clear plastic hose, cigarettes, a pen, and a car radio antenna. *Nut* (2½ years), first learned as a name for packaged nuts, was later used to refer to

pictures of nuts in magazines, peanut butter sandwiches, and sunflower seeds. *Tree* (acquired at three years) was learned with reference to acacia branches and celery. Koko later overgeneralized tree to extend to green onions; asparagus; and other tall, thin objects presented vertically. *Grass*, acquired at 2 years 10 months as a label for grass and dandelion greens, was also used by Koko to refer to bean sprouts, spaghetti squash, pretzels, and a shiny, metal dog choke chain (*grass metal mine*).

Perceptual similarity is the basis for most of Koko's overextensions, as is true for human children. In the above examples, shape, texture and patterns, movement, and size are critical attributes—rather than color. Color is also rarely used by human children as a dimension of generalization (E.V. Clark, 1973). However, Koko has also used the sign *grass* to refer to a variety of green objects, including toy animals (*grass pig* for a green pig) and heads of lettuce (*lettuce grass*). These and the overextensions that follow do not fit into the categories identified by Clark. In Koko's second year of language use, she signed *More bean* to request a first helping and *More swing* for another push on her trapeze. She signed *More red* after attempting to take a red blanket. Her early use of *more* as a simple request form and in conjunction with verbs and even adjectives are patterns of overgeneralization reported in other studies in the child-language literature (Bloom, 1970; Brown, 1973).

The lexical stem for the glosses *eat* and *food* was acquired during the first months of training by Koko and was overgeneralized to refer to any object, edible or inedible, which was desired and—as is also the case with human infants—mouthed. Soon after Koko had mastered the sign for *baby*, the sign was a favorite for several days and was used not only to refer to dolls, but as a general requester for other goods and services.

When Koko was young, from time to time she would generate uninterpretable gestures with no obvious referent that were used for short periods of time (usually no more than a few days) as general requesters, usually inserted into her utterances in place of the name of an object or activity for which she knew a name. Early occurrences appeared to be related to form overextension (e.g., use of a sign appearing to be halfway between *open* and *big*), but some occurrences may suggest a more interesting interpretation. For example, Koko used a gesture that resembled *on* in its articulation but which was used in contexts where the standard meaning for the word was inappropriate. Only after studying the context of the utterances in which the gesture

occurred (i.e., Koko impatiently awaiting goods or services that were slow in coming), and after realizing that the phrase 'come on' was voiced to Koko frequently, did researchers realize that her sign was, indeed, a request to 'come-on.'

A second phenomenon resembling overgeneralization present in the early months of the study was Koko's misuse of signs closely related in form. For example, she might use the sign *clean* to request to be allowed to go out or to be carried off the counter. The signs *out* and *off* are closely related to the sign *clean*, both in motion and in configuration, with the two extended hands in active contact with each other. Koko seemed to overgeneralize the sign on the basis of similarities in the form of the gestures, rather than on the basis of perceptual similarities between the referents.

Undergeneralization is a phenomenon much less extensively reported in the child language literature. Bowerman (1976) notes that one child restricted the word *off* to taking clothing off. Bloom (1973) cites an instance of a child using *car* to refer only to cars seen from a window. Although most of the signs in Koko's vocabulary tend to generalize and overgeneralize spontaneously, a few have been undergeneralized; that is, they have been restricted to one specific situation or use. Two such signs included *nothing* (acquired at about age 4½) and *night* (acquired at about age 6). Koko uses the sign *nothing* exclusively in connection with the hand guessing game to label the empty hand if her choice has been incorrect.

Night is used with references to her 'night dish,' a pre-bedtime treat served in a metal dish. *Night* may have been restricted in its use because Koko has rarely been out in the dark, and her bedtime seldom corresponds with nightfall. Thus, her experience of night as a phenomenon distinct from day by virtue of darkness is limited. *Nothing* may have failed to generalize for a different reason, which may, in fact, be motivational in nature; 'nothing' is not a desirable outcome for Koko, and as a response to questions such as 'What do you have?' or 'What do you see?' no response at all may serve the purpose as well as the word *nothing*.

A third sign, *ask*, was formerly undergeneralized by Koko for exclusive use as a requester such as please or want. For example, when instructed to 'ask first,' rather than just grabbing an object, Koko might respond *ask banana*.

The ability to generalize is not unrelated to the ability to create new names for previously unknown objects. Koko, like many young children, has generated a wide variety of new names comprising two or

more lexical stems (Newport and Meier, 1985; Patterson, Patterson, and Brentari, 1987), compounded either sequentially or simultaneously. As noted above, a number of these names might be classified as errors in reference or overextension, such as the labeling of green toys as *grass*. An analysis of the context of such utterances and of Koko's lexical knowledge at the time of a given occurrence indicates that: 1) Koko did not know the literal name of the object or property in question; and 2) she was not engaging in symbolic play with the object. Other novel word uses, by Koko and by other signers, appear to be deliberate attempts to describe or request an unnamed object—for example, a deaf child's labeling of a mantelpiece as a *fireplace wall shelf* (H.S. Schlesinger, 1976) and Koko's labeling of pomegranate seeds as both *red corn drink* and *fruit red drink*. Koko has also called a frozen banana a *fruit lollipop* and a chewable vitamin pill a *candy bean*. A variety of Koko's early compound-name creations are listed in Table 7.

9. Evaluation. Ever since the horse Clever Hans was revealed to be a master not of mathematics but rather of the subtle cues given by the humans around him, some individuals have suspected that animals who are credited with intellectual accomplishments approaching those of humans might merely be accomplished observers of human behavior (Ristau, 1982). While such observation is unquestionably remarkable enough in itself, the burden of proof of language still remains with any researcher teaching an animal a human language. Because Koko uses sign language primarily in social situations in which she and her companions are cognizant of the context surrounding linguistic exchanges and have direct access to objects and events that serve as topics, it might be argued that her use of signs and our interpretation of them are dependent upon these extrinsic factors. Without solid, supporting evidence, Koko's use of sign language could be interpreted not as truly spontaneous but as elicited by cues and prompts received from human companions.

To guard against such cueing, researchers developed a built-in system of safeguards. Chief among these was double-blind testing of vocabulary items, in which Koko could see the test object to be identified, but not the tester; and the tester could see Koko's response, but not the object. In a typical experiment, one person entered the test room and put an object into a wooden box with a transparent front. The person covered the box and left the room. Koko entered from another room, without having seen the first individual. Standing behind the box was a second researcher, who then asked Koko, 'What do you see

in the box?' or 'What's that?' and wrote down Koko's response. The procedure was then repeated. At no time did Koko see the first researcher, and at no time did the second researcher see the object. Random changes in the order of presented objects prevented Koko from using memorization. In a second version of the same experiment, one experimenter baited the box with a random selection from a pool of objects representing 30 of the nouns in Koko's vocabulary. At no time did Koko see the person who baited the box, and at no time did the testing assistant see the objects selected.

Koko's interest and cooperation in such tests were limited typically to five trials per day and two sessions per week. Koko's responses on these tests were correct about 60 percent of the time. She gave the correct response on 31 of 50 trials (62 percent) in a series of tests administered when she was four years old. Koko's methods of avoiding the task when she did not want to participate were varied; she would either respond to all objects with the same sign, refuse to respond at all, or regress to an earlier pattern of asking to have the box opened.

Koko's errors on the box test were of four basic types (in order of frequency): 1) Requests to have the box opened (*key box* and *key open*), 12 percent of the trials; 2) conceptually related errors, in which the response was for another item in the same class of objects (e.g., *candy* for *cracker*), 8 percent of the trials; 3) perseverative errors (e.g., *clown* on two trials following one in which it was the correct response), 4 percent of the trials; and 4) formally related errors in which the sign given was similar in articulation to the sign for the correct response (e.g., *clown* instead of *flower*), 4 percent of the trials.

Ten percent of Koko's responses contained errors that were not classifiable in any of the above categories. For example, in one interesting trial, Koko frowned, then signed *cat red* when the box contained a red stereoscopic viewer. Upon examination, the slide in the viewer was found to depict a lion. While this may be an unrelated error, it is possible that Koko may have been recalling what she last saw in the viewer.

In addition to the information that such tests yield on categorization and performance errors, they also show that Koko's appropriate use of signs is not dependent upon cueing from her teachers and companions, but is the result of an ability to retrieve and produce linguistic symbols spontaneously. Other factors contributing to her correct use of signs in naturalistic situations are context and the signs of her companions.

This form of double-blind test is of limited usefulness. The testing situation is structured in such a way that it often fails to elicit the

gorilla's cooperation. A substantial number of Koko's replies were perseverative or repetitive responses apparently emitted in an attempt to terminate testing. Thus, her 62-percent correct-response level may not accurately reflect her knowledge of the appropriate object-sign correspondence.

The probability of the subject emitting the correct response by chance or as a result of Clever Hans-type cueing is quite small when the response required in a test situation is verbal, rather than forced choice. Given a vocabulary of 245 signs, the chance of a gorilla producing the appropriate sign spontaneously or by chance in response to a question is about one in 245. The chances of her producing a correct string of signs by accident are even more remote. In contrast, Clever Hans-type phenomenon are dependent upon a binary or other forced-choice situation in which the subject has available a highly restricted number of options. Therefore, through these tests and our daily records, solid evidence exists that Koko has the ability to retrieve, manipulate, and combine linguistic symbols appropriately under naturalistic conditions.

Standardized infant and preschool intelligence tests and comprehension tests also were administered to Koko at intervals throughout the first five years of the study in order to make direct quantitative comparisons of cognitive development between Koko and humans. While that topic is not the subject of this paper, it is worth noting simply that Koko's performance on the following standardized tests and other tests produced relatively consistent results, rating her IQ at between 70 and 95: Bayley Scales of Infant Development, Cattell Infant Intelligence Scale, Denver Developmental Screening Test, Kuhlmann-Anderson Test, McCarthy Scales of Children's Abilities, Peabody Picture Vocabulary Test, Ordinal Scales of Psychological Development in Infancy, Stanford-Binet Intelligence Scale, Wechsler Preschool and Primary Scale of Intelligence, and the Assessment of Children's Language Comprehension Test.

In daily, spontaneous conversations with her teachers, Koko has routinely demonstrated that she is using the interactive function of language, as is shown in the following examples:

Barbara Hiller: Would you like to be able to fly like a bird?

Koko: Down.

Barbara: You'd rather stay on the ground?

Koko: Down floor.

Barbara: I think you're smart.
(Koko laughs.)

Barbara Hiller: You teach me [to speak] gorilla?

Koko: Love Koko hurry.

Barbara: What do gorillas say when they're happy?

Koko: You know—smile.

Barbara: What do gorillas say when mad?

Koko: Koko knows—good Koko.

Barbara: Well, what?

(Koko beats her chest, then signs:)

Koko: Gorilla Koko.

Barbara: What do gorillas say when they're scared?

Koko: Hurry drapes.

(Indeed, when Koko is afraid, she asks us to put the drapes up in her room and frequently signs *Hurry*.)

Barbara: What scares gorillas?

Koko: Trouble.

Barbara: How do you feel when you've eaten too much cake?

Koko: Sad bad stomach.

10. Conclusions. The data in this article suggest that in many respects gorilla acquisition and production of sign language appears to parallel that of the human child learning language, with the closest parallels to human children learning signs; however, the pace of gorilla language development has been significantly slower than that of the normal human child. In this respect, Koko's language development resembles that of the child of retarded performance whose development follows the same general pattern as that of the normal child but proceeds at a slower rate and reaches a plateau sooner (Blount, 1968; Graham and Graham, 1971). Koko's vocabulary size and content are restricted in comparison with the normal human child's; she has asked fewer questions; and she overgeneralized words for a more extended period of time.

At first glance, this lower level of achievement might seem to be explained by the single fact that Koko is a gorilla and not a human. However, Koko's tested IQ is at a level in which a child's language development would not be delayed. What specific factors might account for the developmental delay? There are several worthy of our consideration: Koko has had a more limited social environment than the average human child; for obvious reasons, she is unable to interact with

perfect freedom in an unrestricted environment. And as is true of other captive great apes, she has not had the advantage of living in a gorilla social group of normal size and makeup. Another important factor is that the use of the hands for other activities must compete with signing function in a quadruped animal. Too, the gorilla attention span, motivational level, and activity level are all different from that of the human. While native signers have been involved with the project intermittently from its inception, the times when such teachers were unavailable have inevitably affected gorilla sign production and competence.

Regardless of such factors, Koko's has acquired hundreds of signs and has independently generated novel referential gestures. She has also modulated lexical stems in ASL to convey slight changes in meaning; has used signs simultaneously; and has created compound names that appear to be intentional metaphors. These findings and others, together with documentation of her sign acquisition and production capabilities, offer a strong case for arguing that—with the added requirement of direct teacher intervention—vocabulary acquisition by a gorilla can indeed occur, with vocabulary milestones that appear to closely parallel those of the human child.

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ENDNOTE

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APPENDIX

Table 1. Koko's first 50 words, including those meeting P (Patterson) criterion and E (emitted) criterion. Each list is given in order of acquisition.

Koko's 1st 50 words, P criterion			34. cabbage	16. blow
1. up	35. grass	17. bottle		
2. eat, food	36. bracelet	18. brush		
3. drink	37. go	19. open		
4. more	38. red	20. orange		
5. out	39. banana	21. clean		
6. hat	40. cat	22. egg		
7. key	41. chase	23. home		
8. open	42. me	24. key		
9. clean	43. teeth, glass	25. Koko		
10. come, gimme	44. sit, chair	26. listen		
11. toothbrush	45. berry	27. on, come-on		
12. bean	46. butter	28. water		
13. candy	47. cookie	29. candy		
14. blanket	48. bag, purse	30. flower		
15. catch	49. swing	31. mouse		
16. sweater	50. mine	32. pen, write		
17. apple		33. sleep, bed		
18. flower	Koko's 1st 50 words, E criterion			34. sorry
19. nut	1. up	35. sweater		
20. pick, groom	2. come, gimme	36. sweet		
21. listen	3. drink	37. watch, time		
22. sorry	4. eat, food	38. wiper		
23. tickle	5. more	39. ball		
24. bottle, cup	6. toothbrush	40. in		
25. match	7. dog	41. please		
26. cheese	8. hat	42. stupid		
27. orange	9. out	43. cheese		
28. look, see	10. mouth	44. comb		
29. egg	11. don't, not	45. hurry		
30. pen, write	12. nose	46. hurt		
31. please	13. pretty	47. milk		
32. brush	14. scratch	48. play		
33. there	15. tickle	49. bear		
		50. get		

Table 2. Percentages by categories of Koko's 50-word vocabulary (P and E criteria, as derived from daily signing records) and children studied by Nelson (1973).*

Category	Percentages		
	Nelson's children	Koko E	Koko P
<i>1. Nominal specific</i>			
People	12	2	0
Animals	1	0	0
Objects	1	0	0
Total	14	2	0
<i>2. Nominal general</i>			
Objects	31	36	50
Substances	7	10	10
Animals & people	10	6	2
Letters & numbers	1	0	0
Abstractions	1	2	0
Pronouns	3	0	2
Total	51	54	64
<i>3. Action words</i>			
Demand-descriptive	11	24	24
Notice	2	0	0
Total	13	24	24
<i>4. Modifiers</i>			
Attributes	1	6	2
States	6	4	2
Locatives	2	4	2
Possessives	1	0	2
Total	9	14	8
<i>5. Personal-social</i>			
Assertions	4	2	0
Social-expressive	4	4	4
Total	8	6	4
<i>6. Function</i>			
Question	2	0	0
Miscellaneous	2	0	0
Total	4	0	0

*Note: Categories are after Nelson (1973).

Table 3. First 10 years of words acquired by Koko (P criterion), listed by semantic categories, August 1972–July 1982. While 290 discrete words are used, percentages are based on a total of 322 words, owing to multiple usage.

Category	Order of Word Acquisition	Category	Order of Word Acquisition
NOMINALS			
<i>Food and drink</i>		spice	138
eat, food	2*	cracker	145
drink	3*	grape	150
bean	12	cake	151
candy	13	milk	153
apple	17	sandwich	154
nut	19	water	158
cheese	26	pudding	167
orange	27**	pepper	198
egg	29	jam	212
cabbage	34	medicine	226
banana	39	lollipop,	227
berry	45	ice cream	
butter	46	Jello TM	229
cookie	47	lettuce	243
cereal	54	breakfast	248
meat	55	tomato	252
potato	56	squash	259*, **
carrot	57	Coke [®]	261
corn	61	slice	269*
peach	68	lick	266*
bread	74	Total (15.2%)	49
gum	83	<i>Animals</i>	
cucumber	84	cat	40
fruit	100	bird	90
prune, raisin	105	bear	92
salad	106	monkey	94
salt	109	dog	97
bone	110	alligator	104
onion	116	skunk, stink	127**

Category	Order of Word Acquisition	Category	Order of Word Acquisition
fish	133	harmonica	204
frog	134	mask	213
tiger	136		
bug	140	Total (2.8%)	9
cow	175		
pig	179	<i>Vehicles</i>	
mouse	182	airplane	143
horse	183	boat	144
elephant	185	train	170
gorilla	195		
giraffe	205	Total (0.9%)	3
rabbit	206		
lion	211	<i>Furniture and household items</i>	
camel	219	blanket	14
Total (6.5%)	21	sit, chair	44*
<i>Clothes</i>		pillow	66
hat	6	light	88
sweater	16	soap	101
sock	107	tape	112
glove	152	string	117
pants	165	sleep, bed	121*
belt	193	sponge	131
clothes	194	telephone	161
Total (2.2%)	7	toilet	180
		hammer	203
		drapes	224
		Total (4%)	13
<i>Toys and play equipment</i>			
swing	49*	<i>Personal items</i>	
baby	69	key	7
ball	75	toothbrush	11
rubber (tire)	155**	match	25
box	171	pen, write	30*
whistle	187	brush	32*
clown	189		

continued

Category	Order of Word Acquisition	Category	Order of Word Acquisition
bracelet	36	grass	35
bag, purse	48	leaf	52
time, watch	70***	tree	64
wiper	72	feather	122
necklace	77	rock	199
lipstick	85		
cigarette	87	Total (1.9%)	6
book	95		
stamp, mail, letter	96	<i>People/Proper Names</i>	
earring	102	Koko	53
hurt	130*	Penny	91
paper	142	man	197
nail-clipper	147	Kate	221
ring	149	Mike	246
stethoscope	173	devil	257
mirror	174	Cindy	258
comb	190	girl	260
injection	200	visit, visitor	265*
oil, cream	218	Margie	268
toothpaste	251	Ron	284
eye-makeup	282		
		Total (3.4%)	11
Total (8.1%)	26		
<i>Eating and drinking utensils</i>		<i>Body parts</i>	
bottle	24	teeth, glass	43 ^{††}
teeth, glass	43 [†]	hair	98
straw	76	ear	111
fork	156	arm	114
spoon	160	pinch-skin	115*
knife, cut	163*	head	120
bowl	181	leg	123
		nose	124
Total (2.2%)	7	eye	125
<i>Outdoor objects</i>		lip	128
flower	18	mouth	139
		tongue	159

Category	Order of Word Acquisition	Category	Order of Word Acquisition
neck	164	MODIFIERS	
bottom	168	more	4
nail	172	clean	9*
finger	184	sorry	22 ⁺⁺⁺
foot	186	orange	27 [¥]
pimple	196	there	33
bellybutton	223	red	38
shoulder	231	mine	50
underarm	254	cold	51
fake-tooth	274	big	58
knee	288	hurry	59
stomach	290	this, that	60
Total (7.5%)	24	quiet	62
		sweet	63
		small	67
		hot	71
		good	82
		white	103
		dry	113*
		skunk, stink	127 ^{¥¥}
		thirsty, swallow	132*
		dirty	148
		rubber	155 ^{¥¥¥}
		yellow	157
		same	166
		all	188 ⁺
		stupid	191
		different	192
		bad	201
		pink, shame	207
		hungry	210
		black	216
		green	220
		sad	233
		mad	235
<i>Miscellaneous</i>			
trouble	263		
big-trouble	276		
blew-it	283		
sneeze	270*		
surprise	289*		
work	285*		
floor	287		
Total (2.2%)	7		
<i>Pronouns</i>			
me	42		
you	78		
myself	162		
Total (0.9%)	3		

Total distinct nominal words included: 185

continued

Category	Order of Word Acquisition	Category	Order of Word Acquisition
rotten	238	catch	15
now	241***	pick, groom	20
wrong	244	listen	21
happy	245	tickle	23
some	247 ⁺	look	28
fine, polite	249	pen, write	30 ⁺⁺
old	256	brush	32 ⁺⁺
squash	259*.*	go	37
nice	262	chase	41
away	271	sit, chair	44 ⁺⁺⁺
eager, anxious	279	swing	49*.*.*
false, fake	272	blow	65
last	277	hug, love	73
lazy	280	bite	80
obnoxious	275	ask	86
soft	267	taste	89
funny	286	pour	93
Total (15.8%)	51	scratch	108
NEGATIVES AND AFFIRMATIVES		dry	113**
can't	81	pinch-skin	115 [†]
don't, not	208	smell	118
nothing	222 ⁺	ride	119
don't-know	236	sleep, bed	121 ⁺⁺⁺
yes	239	pound	129
no	250	hurt	130 ⁺⁺
Total (1.9%)	6	thirsty, swallow	132**
VERBALS		hide-and-peek	135
eat, food	2*.	help	137
drink	3*.	finished	141***
open	8	kiss	146
clean	9**	knife, cut	163 ^{††}
come, gimme	10	smile	176
		frown	177
		sip	178
		help-myself	202
		do	209
		think	214

Category	Order of Word Acquisition	Category	Order of Word Acquisition
know	215	down	169
draw	217	Total (1.9%)	6
make, fix	225	TIME EXPRESSIONS	
break	228	time, watch	70 ⁺⁺
want	230	finished	141*
like	232	now	241**
play	234	night	253
have	237	Total (1.2%)	4
cry	255	SOCIAL-EXPRESSIVE	
squash	259**,*	sorry	22**
tell	264	please	31
visit	265 ^{††}	darn	240
lick	266*	hi, bye	242
slice	269*	unattention	278
sneeze	270 ^{†††}	Total (1.6%)	5
knock	273	NUMERICAL	
strangle	281	all	188**
work	285 ^{†††}	nothing	222 [†]
surprise	289 ^{†††}	some	247**
Total (18.9%)	61	Total (0.9%)	3
LOCATIVES		Total distinct words: 290	
up	1		
out	5		
around	79		
on	99		
in	126		

Note: nominal categories after Nelson (1973).

* also under verbals

** also under modifiers

*** also under time expressions

[†] also under body parts

^{††} also under eating utensils

^{†††} also under social-expressive

* also under food and drink

* also under animals

* also under toys and playthings

⁺ also under numerals

⁺⁺ also under personal items

⁺⁺⁺ also under furniture and household

[†] also under negatives

^{††} also under people

^{†††} also under miscellaneous

Table 4. First 100 words acquired by Koko, listed by semantic categories, P criterion. (Note: Owing to multiple usages, total does not sum to 100.)

Category	Order of Word Acquisition	Category	Order of Word Acquisition
NOMINALS			
<i>Food and drink</i>		bear	92
eat, food	2*	monkey	94
drink	3*	dog	97
bean	12	Total (4.5%)	5
candy	13	<i>Clothes</i>	
apple	17	hat	6
nut	19	sweater	16
cheese	26	Total (1.8%)	2
orange	27**	<i>Toys and play equipment</i>	
egg	29	swing	49*
cabbage	34	baby	69
banana	39	ball	75
berry	45	Total (2.7%)	3
butter	46	<i>Furniture and household items</i>	
cookie	47	blanket	14
cereal	54	sit, chair	44*
meat	55	pillow	66
potato	56	light	88
carrot	57	Total (3.6%)	4
corn	61	<i>Personal items</i>	
peach	68	key	7
bread	74	toothbrush	11
gum	83	match	25
cucumber	84	pen, write	30*
fruit	100	brush	32*
Total (21.6%)	24		
<i>Animals</i>			
cat	40		
bird	90		

Category	Order of Word Acquisition	Category	Order of Word Acquisition
bracelet	36	<i>Pronouns</i>	
bag, purse	48	me	42
time, watch	70***	you	78
wiper	72		
necklace	77	Total (1.8%)	2
lipstick	85	Total distinct nominal words included: 63	
cigarette	87		
book	95		
stamp, mail, letter	96	<i>MODIFIERS</i>	
Total (12.6%)	14	more	4
<i>Eating and drinking utensils</i>		clean	9*
bottle	24	sorry	22 ^{†††}
teeth, glass	43 [†]	orange	27 [¥]
straw	76	there	33
Total (2.7%)	3	red	38
<i>Outdoor objects</i>		mine	50
flower	18	cold	51
grass	35	big	58
leaf	52	hurry	59
tree	64	this, that	60
Total (3.6%)	4	quiet	62
<i>People/Proper Names</i>		sweet	63
Koko	53	small	67
Penny	91	hot	71
Total (1.8%)	2	good	82
<i>Body parts</i>		Total (14.4%)	16
teeth, glass	43 ^{††}	<i>NEGATIVES AND AFFIRMATIVES</i>	
hair	98	can't	81
Total (1.8%)	2	Total (.9%)	1
		<i>VERBALS</i>	
		eat, food	2 [¥]
		drink	3 [¥]
		open	8

continued

Category	Order of Word Acquisition	Category	Order of Word Acquisition
clean	9**	LOCATIVES	
come, gimme	10	up	1
catch	15	out	5
pick, groom	20	around	79
listen	21	on	99
tickle	23		
look	28	Total (3.6%)	4
pen, write	30 ⁺	TIME EXPRESSIONS	
brush	32 ⁺	time, watch	70 ⁺
go	37		
chase	41	Total (.9%)	1
sit, chair	44 ⁺⁺	SOCIAL-EXPRESSIVE	
swing	49 ^{¥¥}	sorry	22**
blow	65	please	31
hug, love	73		
bite	80	Total (1.8%)	2
ask	86		
taste	89	Total distinct words:	
pour	93	100[/110]	
Total (19.8%)	22		

Note: nominal categories after Nelson (1973).

* also under verbals

** also under modifiers

*** also under time expressions

† also under body parts

†† also under eating utensils

††† also under social-expressive

¥ also under food and drink

¥¥ also under toys and playthings

+ also under personal items

++ also under furniture and household

Table 5. First ten years of words acquired by Koko, listed alphabetically with acquisition type (E criterion, August 1972–July 1982). Key to acquisition types (Acqtypes): T: taught; I: innovative; N: natural gorilla gesture; G: learned from other gorilla; M: modulated or compounded by Koko.

Word	Acqtype	Word	Acqtype	Word	Acqtype
A	T	away	N	berry	T
above	T	baby	T	beside	T
accident	T	back,	T	better	T
add	T	come-back		between	T
afraid, scare	T	bad	T	big	T
after	T	bag, purse	T	big-trouble	T
again	T	ball	T	bird (notice)	I
agree	T	balloon	T	bird	T
airplane	T	banana	T	birthday	T
Al	I	banana-	M	bite	I
Alice	T	lollipop		black	T
alive	T	Barbara H	T	black-pepper	T
all	T	Barbara Jean	T	blame	T
all-gone	T	Barbara K	T	blanket	T
alligator	T	Barbara W	T	blew-it	I
Allison	T	bark	T	blind	T
Andy	T	barrette	I	block	T
animal	T	bat	T	blow	I
ankle	T	bath, bathe	T	blue	T
Ann, Virginia	T	bean	T	boat	T
another, other	T	bear	T	body	T
appear,	T	beard, Tyler	T	body-hair	I
show-up		because	T	bone	T
apple, Nancy	T	become	T	book	T
apricot	I	bedroom	T	boring	T
argue	T	bee	T	both	T
arm, Eugene	T	beer	T	bottle, cup	T
around	T	behind	T	bottom	T
artichoke	T	bell	T	bow	T
ask	T	bellybutton	T	bowl, dish	T
attention	T	belt	T		

continued

Word	Acqtype	Word	Acqtype	Word	Acqtype
box	T	cheat	T	cough	T
boy	T	cheek	T	cow	T
bracelet	I	cheese	T	cracker	T
bread	T	cherry	T	crazy	T
break	T	chest	T	creative	T
breakfast	T	chew	T	cry	T
Brenda	T	chicken	T	cucumber	T
bribe	T	chimp	T	curious	T
bring	T	chin	T	D	T
brown	T	chip	T	daisy	T
brush	T	chocolate	T	dance	T
bug	T	Christmas	T	danger,	T
bus	T	Chuck	T	dangerous	
busy	T	cigarette, smoke	T	dark	T
butter	T	Cindy	T	darn	N
butterfly	T	clap	T	date	T
bye, hi	T	clay	I	Dave	T
cabbage	T	clean	T	day	T
cake	T	close (shut)	T	dead	T
calm	T	closer (near)	T	Debbie	T
camel	T	clothes	T	deer	T
camera	T	clown	T	delicious	T
can't	T	coffee	T	dental-floss	I
candle	T	Coke®	T	devil	T
candy, Candi	T	cold	T	Diane	T
cap, top	T	color	T	different	T
car	T	comb	T	dinner	T
careful	T	come, gimme	N	dirty	T
Carol	I	comfortable	T	disappear	T
carrot	T	complain	T	disappoint	T
cat	T	computer	T	disobey	T
catch	N	confess	T	do	T
Cathy	T	confused, stew	T	doctor	T
catsup	T	continue	T	doesn't-matter	T
cauliflower	T	cook	T	dog	T
ceiling	T	cookie	T	doll	T
cereal	T	cool	T	dollar	T
champagne	T	copy	T	Don	T
chase	T	corn	T	don't, not	T

Word	Acqtype	Word	Acqtype	Word	Acqtype
don't-care	T	excuse-me,	T	forehead	T
don't-know	T	forgive		forget	T
don't-think	T	eye	T	fork	T
don't-want	T	eyebrow	T	four	T
donkey,	T	eye-makeup	T	fox	T
stubborn		face	T	friend	T
dot	T	fairy	T	frog	T
down	T	fake-sneeze	I	front	T
drapes	T	fake-tooth	I	frown	T
draw	T	fall, fell	T	fruit	T
dream	T	false, fake	T	frustrated	T
drink	T	fang	I	full, fed-up	T
drip-chin	I	fast	T	funny	T
dripping	I	fat	T	fur	T
drive	T	fault	T	game	T
dry	T	feather	T	garbage, trash	T
eager, anxious	T	feces	T	Gary	T
ear	T	feel	T	Gena	T
early	T	feet	M	gentle	T
earphone	I	fence	T	get	T
earring	T	few	T	gift, present	T
earthquake	T	fight	T	giraffe	T
Easter	T	filmers,	I	girl	T
easy	T	reporters		give	T
eat, food	T	find	T	give-up	T
egg	T	fine, polite	T	glasses	I
eggplant	T	finger	T	glove	T
eight	T	finished	T	go	N
Eileen	T	fire	T	goat	T
elbow, Tami	T	first	T	gold	T
electric	T	fish	T	gone	T
elephant	T	five	T	good (yes)	T
eleven	T	flavor	T	good-bad	M
empty	T	floor	T	gorilla	N
English	T	flower	T	grab	T
enjoy	T	flute	T	grape	T
enough	T	fly	T	grapefruit	T
Esther R	T	foot	T	grass	T
everyday	T	for	T		

continued

Word	Acqtype	Word	Acqtype	Word	Acqtype
grasshopper	T	honey	T	Kate	T
grate	I	hope	T	keep-away	T
green	T	horse	T	key	T
ground, dirt, oil	T	hot	T	kick	T
guess	T	house	T	kill	T
guilty	T	how	T	kind	T
gum	T	huff	I	kiss	T
gun	T	hug, love	T	kiss-hand	I
habit	T	hungry	T	knee	T
hair	T	hurry	N	knife, cut	T
hairbow	I	hurt	T	knock	T
hamburger	T	I	T	know	T
hammer	T	ice, frozen	T	knuckle	T
hand	T	idea	T	Koko('s)	T
happen	T	ignore	T	Kong	T
happy	T	imagine	T	Kris	T
hard	T	in	T	lady	T
harmonica	T	Ingrid	G	lamb	T
hat	T	inhale	I	last	T
hate	T	injection	T	late	T
have	T	innocent	T	later,	T
he, him	T	insult	T	in-a while	
head	T	interesting	T	laugh	T
headache	T	it	T	lazy	T
head-cold	T	jam	T	leaf	T
hear	T	Jan	T	leash	T
hearing-aid	T	jealous	T	Lee	T
heel	T	Jeanne	T	leg	T
help	T	jello	T	lemon	T
help-myself	T	Joanne J	T	lemonade	T
here	T	Joanne T	T	Leslie	I
hide	T	John	T	less-than	T
hide-and-peek	T	John	T	letter, mail,	T
hip	T	(camera man)		stamp	
hit, ram	T	juice	T	lettuce	T
hit-in-face	G	jump	T	lick	T
hit-in-mouth	G	kangaroo	T	lie	T
hole	T	Karen	G	lie-down	T
home	T	(brown girl)		light	T

Word	Acqtype	Word	Acqtype	Word	Acqtype
lighter	T	mean-love	M	necklace	T
like	T	meat	T	need, must	T
lime	T	medicine	T	Neil	T
Linda	T	medicine-candy	M	nervous	T
lion	T	melon, touch	T	never-mind	T
lip	I	mess	T	new	T
lipstick	T	metal	T	newspaper	T
Lisa	T	middle	T	next	T
listen	T	Mike	T	nice	T
little-finger	T	milk	T	night	T
lock	T	mine, my	T	nine	T
lollipop,	T	mirror	T	nipple	T
ice cream		miss	T	no	T
lonely	T	money	T	noise, loud	T
long	T	monkey	T	none	T
long-hair	I	monster	T	Noni	T
look, see	T	mood	T	noodle,	T
loose	T	moose	T	spaghetti	
lunch	T	mop	T	noon	T
Lyna	T	more	T	nose	T
Lynette	T	more-than	T	nostril	T
machine	T	morning	T	note	I
mad, anger	T	mother	T	nothing	T
magazine	T	mouse	T	now	T
magnet	T	moustache,	T	numbers	T
make, fix	T	Nick		nut	T
man, father	T	mouth	T	obey	T
many	T	move	T	obnoxious	I
Maria	T	music	T	off	T
Marion	T	myself	T	oil, cream	T
Marjie	T	nag	T	old	T
marry	T	nail	T	on, come-on	T
Mary Ann	T	nail-polish	I	one	T
mask	T	nail-clipper	T	onion	T
match	T	nailfile	I	open	T
Maureen	T	name	T	operate	T
mayonnaise	T	nap	T	opposite	T
me	T	nasty-time	M	orange	T
mean	T	neck	T		

continued

Word	Acqtype	Word	Acqtype	Word	Acqtype
out	T	pipe	T	remember	T
owl	T	plant, grow	T	responsible	T
paint	T	plastic	T	rest	T
pants	T	play	T	rhinoceros	T
paper	T	please	T	rhyme	T
past	T	pleasure,	T	ride	T
pat-bottom	M	pleasant		right, correct	T
patient	T	poke	I	ring	T
Patrick	T	poke-stomach	I	rip	T
Paul	T	police	T	rock	T
peach	T	poor	T	Ron	T
pear	T	potato	T	Ron R	T
peek-a-boo	T	pound	N	rooster	T
Peggy	T	pour	T	root-beer	T
pen, write	T	powder	T	rotten	T
penguin	T	practice	T	rough	T
Penny	T	prefer	T	rub	T
people	T	pretend	T	rub-eye	M
pepper	T	pretty	T	rubber	T
perfume	T	problem	T	rug	T
period	T	promise	T	run	T
(menstrual)		prune, raisin	T	runny-nose	I
persimmon	T	pudding	T	rutabaga, turnip	I
pet	T	pull	T	sad	T
pick, groom	T	pull-out-hair	G	salad	T
pick-teeth,	M	punish	T	salt	T
toothpick		puppet	I	same	T
pickle	I	purple	T	sandwich	T
picnic	T	push	T	Santa-Claus	T
picture	T	puzzle	T	save	T
pie	T	quiet	T	say	T
pig	T	R	T	school	T
pillow	T	rabbit	T	scissors	T
pimple	T	racoon	T	scraper	I
pin	T	rain, raining	T	scratch	T
pinch, skin	T	read	T	seal	T
pineapple	T	ready	T	search	T
pink, shame	T	really, sure, true	T	seed, peas	T
pink-red	M	red	T	seem	T

Word	Acqtype	Word	Acqtype	Word	Acqtype
selfish	T	snob	T	strong	T
sentence,	T	snow	T	stuck	T
language		soap	T	stupid, dumb	T
shake	T	sock	T	summer	T
share	T	soda	T	sun	T
sharp	T	soft	T	super	T
shell	T	some	T	surprise	T
shirt	T	sometimes	T	Susan	T
shock	T	sorry	T	sweat	T
shoe	T	sorry-please	M	sweater	T
short (height)	T	soup	T	sweep, broom	T
short (length)	T	sour	T	sweet, cute	T
shoulder	T	spank	T	sweet-potato	T
show	T	special	T	swing	T
show-off	T	spice	T	syrup	T
shy	T	spider	T	table	T
sick	T	spin	T	tadpole	T
side	T	spit	T	tail	T
sign	T	sponge, Joanna	T	talk	T
silly	T	spoon	T	tall	T
sip	I	squash, sauce	T	tape	T
sit, chair	T	squeeze	T	taste	T
six	T	squirrel	T	tea	T
skateboard	T	stand-up	T	teach	T
skirt	T	star	T	tease	T
skunk, stink	T	starve	M	teeth, glass	T
sky	T	stay, continue	T	telephone	T
sleep, bed	T	steal	T	tell	T
slice	T	stethoscope	I	tempt,	T
small, little	T	stick	T	temptation	
smart, clever	T	stinker	M	there	T
smell	T	stir	T	thermometer	I
smile	T	stomach	T	thief	T
smile-frown	M	stop	T	thigh	T
smoke-ring	T	strangle	I	thing	T
smooth	I	strap	I	think	T
snack	T	straw	T	thirsty, swallow	T
snake	T	strawberry	T	this, that	N
sneeze	T	string	T		

continued

Word	Acqtype	Word	Acqtype	Word	Acqtype
three	T	under	T	where	T
throat	T	underarm	T	whistle	T
throw	T	undereye-	I	white	T
thumb	T	makeup		who	T
tickle	I	understand	T	why	T
tiger	T	unlisten	I	will	T
time, wristwatch	T	up	N	win, won	T
tired	T	use	T	wind, windy	T
to, until	T	vacation	T	window	T
today	T	vagina	T	wipe-bottom	M
toe	T	vegetable	T	wiper	T
together	T	very	T	wire	T
toilet	T	Viewmaster®	I	wise	T
tomato	T	visit, visitor	T	witch	T
tomorrow	T	vitamin	T	with	T
tongue	T	voice	T	won't, refuse	T
too	T	waist	T	wonderful	T
toothbrush	T	wait	T	wood	T
toothpaste	T	walk	T	word	T
top-back	I	walk-up-my-	I	work	T
tough	T	back		worm	T
trade	T	walk-up-my-	I	wow	T
train	T	bottom		wrestle	T
tree, celery,	T	wall	T	wrist	T
Lynn		want, wish	T	wrong, mistake	T
trick	T	warm	T	yellow	T
trouble	T	wash	T	yes	T
truck	T	water	T	yesterday	T
try	T	watermelon	T	you	T
turkey	T	we	T	young	T
turn-around	I	week	T	yours	T
turtle	T	weigh	T	yourself	T
two	T	weird	T	yummy	T
ugly	T	wet	T	zebra	T
umbrella	T	what	T	zip, zipper	T
unattention	I	when	T	zip-mouth-shut	T

Table 6. Representative early generalizations and over-generalizations made by Koko (13 months to 41 months of age).

Lexical Item	Age (months) at First Use	First Referent	Age (Months) and Domain of Application:	
			Age	Application
drink	13	formula	13	other drinks; orange; apple; in appeasement
			14	fruit; cottage cheese; peanut butter; squash; pomegranate; while chewing notebook; banana; soybean; toothbrush; hairbrush
			27	banana; to drink from faucet; for person to click tongue
			28	baby food (strained beans); scrambled egg; to person eating peanut butter sandwich
			29	gelatin dessert; celery
			30	tofu
			31	scrambled egg
			34	strawberries (red drink and drink berries)
			37	rose petals (eaten by Koko)
			38	banana; vitamin
			38	licorice candy
			27	to have belt unbuckled
			28	requesting toy pig
			29	while trying to turn person around
open	19	open door	30	after handing person her sweater
			32	for more cheese
			33	trying to put on sweater; requesting dandelion greens; pea pod; purse to be opened; to get into pocket
			34	to have person sit; as watch is gotten out; requesting toy

continued

Lexical Item	Age (months) at First Use	First Referent	Age (Months) and Domain of Application:	
			Age	Application
				cat; trying to tickle under person's shirt (sweater open); reaching for can of soda; requesting third towel; before jumping onto swing (swing open)
			35	as bean sprouts are gotten out; requesting book; to have person put her sweater on (sweater sweater open)
			36	requesting corn; grape ice cubes; toy train
			37	to have person raise own arm
			41	broken toy dog; eggshell
ball	22	ball	31	balloon
hurt	23	injury	38	strawberry
me	23	Koko	39	indicating other person
nut	27	peanut	28	other nuts, strained beans
			30	plastic artichoke, milk, tofu
			31	flower
			32	cottage cheese
			33	peppermint-flavored dental floss (nut toothbrush)
			34	sunflower seeds (nut candy), match
			36	teeth
			37	raisin
			39	pomegranate
berry	34	strawberry	40	wheat germ
			34	pea; dandelion green; artichoke petal; orange slice
			35	sliced bananas and milk; meat; cheese; bean; vitamin
			36	sweet potato
			37	plum; carrot; banana; corn kernels; cucumber salad; dab of butter
corn	34	corn	39	piece of meat; rose
			37	bean; peas
			40	pomegranate seeds

continued

Lexical Item	Age (months) at First Use	First Referent	Age (Months) and Domain of Application:	
			Age	Application
tree	34	celery	37	toy guitar held upright; toy radio
			39	bottle (tree baby)
			41	two bracelets; green onion; green bean
cracker	35	soda cracker	35	to crack a nut

Table 7. Examples of early compound name innovations made by Koko. (Examples drawn from daily diaries and sign combination records.)

Referent	Name
celery	lettuce-tree
cigarette lighter	bottle match
frozen banana	fruit lollipop
mask	a) eye hat
	b) nose fake
tapioca pudding	milk candy
parsley	lettuce grass
pomegranate seeds	a) red corn drink
	b) fruit red seeds
stale sweet roll	cookie rock
vitamin pill	candy bean