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Can an Ape Create a Sentence?

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Summary. More than 19,000 multisign utterances of an infant chimpanzee (Nim) were analyzed for syntactic and semantic regularities. Lexical regularities were observed in the case of two-sign combinations: particular signs (for example, *more*) tended to occur in a particular position. These regularities could not be attributed to memorization or to position habits, suggesting that they were structurally constrained. That conclusion, however, was invalidated by videotape analyses, which showed that most of Nim's utterances were prompted by his teacher's prior utterance, and that Nim interrupted his teachers to a much larger extent than a child interrupts an adult's speech. Signed utterances of other apes (as shown on films) revealed similar nonhuman patterns of discourse.

The innovative studies of the Gardners (*1-3*) and Premack (*4-6*) show that a chimpanzee (*Pan troglodytes*) can learn substantial vocabularies of "words" of visual languages. The Gardners taught Washoe, an infant female chimpanzee, signs of American Sign Language (ASL) (*7, 8*). Premack taught Sarah, a juvenile female, an artificial language of plastic chips of different colors and shapes. In a related study, Rumbaugh *et al.* (*9*) taught Lana, also a juvenile chimpanzee, to use Yerkish, an artificial visual language. These and other studies (*10*), one of which reports the acquisition of more than 400 signs of ASL by a female gorilla named Koko (*11*), show that the shift from a vocal to a visual medium can compensate effectively for an ape's inability to articulate many sounds (*12*). That limitation alone might account for earlier failures to teach chimpanzees to communicate with spoken words (*13*).

Human language makes use of two levels of structure: the word and the sentence. The meaning of a word is arbitrary. This is in contrast to the fixed character of various forms of animal communication. Many bird species, for example, sing one song when in distress, one song when courting a mate, and one song when asserting territory. Such rigidity is typical of the communicative behavior of other genera, for example, bees communicating about the location and quality of food or sticklebacks engaging in courtship behavior (*14*).

Human language is most distinctive because of a second level of structure that subsumes the word—the sentence (*15*). A sentence characteristically expresses a complete semantic proposition through a set of words and phrases, each bearing particular grammatical relations to one another (such as actor, action, object). Unlike words, most sentences cannot be learned individually. Psychologists, psycholinguists, and linguists are in general agreement that using a human language indicates knowledge of a grammar. How else can one account for a child's ultimate ability to create an indeterminate number of meaningful sentences from a finite number of words?

Recent demonstrations that chimpanzees and gorillas can communicate with humans via arbitrary "words" pose a controversial question: Is the ability to create and understand sentences uniquely human? The Gardners (*1, 3*), Premack (*6*), Rumbaugh (*9*), and Patterson (*11*) have each proposed that the symbol sequences produced and understood by their pongid subjects were governed by grammatical rules. The Gardners, for example, note that "The most significant results of Project Washoe were those based on comparisons between Washoe and children, as . . . in the use of order in early sentences" (*3*, p. 73).

If an ape can truly create a sentence there would be a reason for asserting, as Patterson (*11*) has, that "language is no longer the exclusive domain of man." The purpose of this article is to evaluate that assertion. We do so by summarizing the main features of a large body of data that we have collected from a chimpanzee exposed to sign language during its first 4 years. A major component of these data is the first corpus of the multisign utterances of an ape. Superficially, many of its utterances seem like sentences. However, objective analyses of our data, as well as of those obtained by other studies, yielded no evidence of an ape's ability to use a grammar. Each instance of presumed grammatical competence could be explained adequately by simple nonlinguistic processes.

Project Nim

Our subject was a male chimpanzee, Neam Chimpsky (Nim for short) (*16, 17*). Since the age of 2 weeks, Nim was raised in a home environment by human surrogate parents and teachers who communicated with him and amongst themselves in ASL (*7, 8*). Nim was trained to sign by a method modeled after the techniques that the Gardners (*2*) and Fouts (*18*) have referred to as molding and guidance. Our methods of data collection paralleled those used in studies of the development of language in children (*19-24*). During their sessions with Nim, his teachers whispered into a miniature cassette recorder what he signed and whether his

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signs were spontaneous, prompted, molded, or approximations of the correct sign (*25*).

Nim satisfied our criterion of acquiring a sign when (i) on different occasions, three independent observers reported its spontaneous occurrence and (ii) it occurred spontaneously on each of five successive days. By spontaneously we mean that Nim signed the sign in an appropriate context and without the aid of molding, prompting, or modeling on the part of the teacher. As of 25 September 1977, Nim had acquired 125 signs (*26*).

Combinations of Signs

The Gardners' analyses of Washoe's sign combinations prevents one from studying their grammatical structure. With but two minor exceptions, the Gardners did not report the order of signs of Washoe's multisign combinations (*27*). For example, *more tickle* and *tickle more* were both reported as instances of *more tickle*, the conventional English juxtaposition of these signs. Accordingly, there is no basis for deciding whether Washoe's multisign combinations obeyed rules of sign order (*28*). One could conclude that Washoe had learned that both *more* and *tickle* were appropriate ways of requesting that tickling reoccur and that when Washoe signed both signs it was because of her prior training to sign each sign separately.

Table 1. Number of tokens and types of combinations containing two, three, four, and five or more signs.

Length of combination	Tokens	Types
Two signs	11,845	1,138
Three signs	4,294	1,660
Four signs	1,587	1,159
Five or more signs	1,487	1,278

We defined a combination of signs as the occurrence of two or more different signs that were not interrupted by the occurrence of other behavior or by the return of the hands to a relaxed position (*29*). Of Nim's combinations, 95 percent consisted of sequences of distinct signs that occurred successively. These are referred to as "linear sequences." Two other kinds of combinations were not included in the corpus: contractions of two or more signs and simultaneous combinations in which two distinct signs occurred at the same time. Even though such combinations can occur in ASL, they were excluded from our corpus because it was impossible to specify the temporal order of the signs they contained. Figure 1 shows a typical linear combination, *me hug cat*, in which there is no temporal overlap between any of the signs.

In no instance were specific sequences, contractions, or simultaneous combinations reinforced differentially. Indeed, Nim was never required to make a combination of signs as opposed to a single sign. However, Nim's teachers often signed to him in stereotyped orders modeled after English usage, and they

Fig. 1. Nim signing the linear combination, *me hug cat* to his teacher (Susan Quinby). (Photographed in classroom by H. S. Terrace.)

may also have unwittingly given him special praise when he signed an interesting combination. Such unintentional reactions do not, however, appear to differ from the reactions parents exhibit when their child produces an interesting utterance or one that conforms to correct English.

Nim's linear combinations were subjected to three analyses. First, we looked for distributional regularities in Nim's two-sign utterances: did Nim place particular signs in the first or the second position of two-sign combinations? Second, having established that lexical regularities did exist in two-sign combinations, we looked for semantic relationships in a smaller corpus of two-sign combinations for which we had adequate contextual information. The results of these analyses were equivocal. A third, "discourse," analysis of videotape transcripts shows that Nim's signs were often prompted by his teacher's prior signs.

Corpus and distributional regularities. From Nim's 18th to 35th month his teachers entered in their reports 5235 types of 19,203 tokens of linear combinations of two to five or more signs. Different sequences of the same signs were regarded as different types (for example, *banana eat* or *eat banana*). The number of types and tokens of each length of combination (Table 1) in each case grew linearly (*30, 31*).

The sheer variety of types of combinations and the fact that Nim was not required to combine signs suffices to show that Nim's combinations were not learned by rote. The occurrence of more than 2700 types of combinations of two- and three-sign combinations would strain the capacity of any known estimate of a chimpanzee's memory. As was mentioned earlier, however, a large variety of combinations is not sufficient to demonstrate that such combinations are sentences; that is, that they express a semantic proposition in a rule-governed sequence of signs. In the absence of additional evidence, the simplest explanation of Nim's utterances is that they are unstructured combinations of signs, in which each sign is separately appropriate to the situation at hand.

The regularity of Nim's combinations suggest that they were generated by rules and was most pronounced in the case of two-sign combinations. As shown in Table 2, *more* + *X* is more frequent than *X* + *more*, *give* + *X* is more frequent than *X* + *give*, and *verb* + *me* or *Nim* is more frequent than *me* or *Nim* + *verb*. An example of the regularities in Nim's two-sign combinations, consisting of all transitive verbs combined with all references to himself (*me* or *Nim*), is shown in Table 3 (*32*). The number of tokens with the verb in the first position substantially exceeds the reverse order. Also, Nim combined transitive verbs as readily with *Nim* as with *me* (*33*). Nim's preference for using *me* and *Nim* in the second position of two-sign combinations was also evident in requests for various ingestible and noningestible objects (Table 2).

Different frequency patterns, such as those shown in Tables 2 and 3, are not sufficient to demonstrate that Nim's sequences are constrained structurally. Nim could have a set of independent first- and second-position habits that generated the distributional regularities we observed. A conservative interpretation of these regularities, one that does not require the postulation of syntactic rules, would hold that Nim used certain categories as relatively initial or final irrespective of the context in which they occur. If this were true, it should be possible to predict the observed frequency of different constructions, such as *verb* + *me* or *verb* + *Nim*, from the relative frequency of their constituents in the initial and final positions.

The accuracy of such predictions was tested by allocating each sign of a two-sign sequence to a lexical category and then using the relative frequencies of these lexical categories to predict the probabilities of each two-sign lexical type. The predicted value of the proba-

Table 2. Frequency of particular signs in first and second positions of two-sign combinations.

Combination		Types	Tokens
more	+ X	47	974
X	+ *more*	27	124
give	+ X	51	271
X	+ *give*	24	77
Transitive verb	+ *me* or *Nim*	25	788
me or *Nim*	+ Transitive verb	19	158
Noun (food/drink)	+ *me* or *Nim*	34	775
me or *Nim*	+ noun (food/drink)	26	261
Noun (nonfood/drink)	+ *me* or *Nim*	35	181
me or *Nim*	+ Noun (nonfood/drink)	26	99

Table 3. Two-sign combinations containing *me* or *Nim* and transitive verbs [V(t)].

V(t) + *me*		V(t) + *Nim*		*me* + V(t)		*Nim* + V(t)	
Types	Tokens	Types	Tokens	Types	Tokens	Types	Tokens
bite me	3	bite Nim	2	me bite	2		
break me	2						
brush me	35	brush Nim	13	me brush	9	Nim brush	4
clean me	2	clean Nim	1	me clean	2		
				me cook	1		
		draw Nim	1				
finish me	1	finish Nim	7			Nim finish	1
give me	41	give Nim	23	me give	11	Nim give	4
						Nim go	4
groom me	21	groom Nim	6			Nim groom	1
help me	6	help Nim	4	me help	2		
hug me	74	hug Nim	106	me hug	40	Nim hug	23
kiss me	1	kiss Nim	6	me kiss	1	Nim kiss	2
open me	13	open Nim	6	me open	10	Nim open	5
		pull Nim	1				
tickle me	316	tickle Nim	107	me tickle	20	Nim tickle	16
	515		283		98		60
	Total types: 25 Total tokens: 788				Total types: 19 Total tokens: 158		

Table 4. Twenty-five most frequent two- and three-sign combinations.

Two-sign combinations		Frequency	Three-sign combinations			Frequency
play	me	375	play	me	Nim	81
me	Nim	328	eat	me	Nim	48
tickle	me	316	eat	Nim	eat	46
eat	Nim	302	tickle	me	Nim	44
more	eat	287	grape	eat	Nim	37
me	eat	237	banana	Nim	eat	33
Nim	eat	209	Nim	me	eat	27
finish	hug	187	banana	eat	Nim	26
drink	Nim	143	eat	me	eat	22
more	tickle	136	me	Nim	eat	21
sorry	hug	123	hug	me	Nim	20
tickle	Nim	107	yogurt	Nim	eat	20
hug	Nim	106	me	more	eat	19
more	drink	99	more	eat	Nim	19
eat	drink	98	finish	hug	Nim	18
banana	me	97	banana	me	eat	17
Nim	me	89	Nim	eat	Nim	17
sweet	Nim	85	tickle	me	tickle	17
me	play	81	apple	me	eat	15
gun	eat	79	eat	Nim	me	15
tea	drink	77	give	me	eat	15
grape	eat	74	nut	Nim	nut	15
hug	me	74	drink	me	Nim	14
banana	Nim	73	hug	me	hug	14
in	pants	70	sweet	Nim	sweet	14

bility of a particular sequence was calculated by multiplying the probabilities of the relevant lexical types appearing in the first and second positions, respectively. In predicting the probability of *me eat*, for example, the probability of *me* in the first position (.121) was multiplied by the probability of *eat* in the second position (.149), yielding a predicted relative frequency of .016.

The correlation between 124 pairs of predicted and observed probabilities was .0036. It seems reasonable to conclude that, overall, Nim's two-sign sequences are not formed by independent position habits. Furthermore, it is not possible to predict the observed relative position frequencies of lexical types of three-sign combinations from the relative frequencies of their constituents. The correlation between the 66 pairs of predicted and observed probabilities was only .05.

Relation between Nim's two-, three- and four-sign combinations. As children increase the length of their utterances, they elaborate their initially short utterances to provide additional information about some topic (*20, 22*). For example, instead of saying, *sit chair*, the child might say, *sit daddy chair*. In general, it is possible to characterize long utterances as a composite of shorter constituents that were mastered separately. Longer utterances are not, however, simple combinations of short utterances. In making longer utterances, the child combines words in short utterances in just one order; he deletes repeated elements, and he treats shorter utterances as units when they are used to expand what was expressed previously by a single word.

The apparent topic of Nim's three-sign combinations overlapped considerably with the apparent topic of his two-sign combinations (Table 4). Eighteen of Nim's 25 most frequent two-sign combinations can be seen in his 25 most frequent three-sign combinations, in virtually the same order in which they appear in his two-sign combinations. Furthermore, if one ignores sign order, all but five signs that appear in Nim's 25 most frequent two-sign combinations (*gum, tea, sorry, in*, and *pants*) appear in his 25 most frequent three-sign combinations. We did not have enough contextual information to perform a semantic analysis of Nim's two- and three-sign combinations. However, Nim's teachers' reports indicate that the individual signs of his combinations were appropriate to their context and that equivalent two- and three-sign combinations occurred in the same context.

Table 5. Most frequent four-sign combinations.

Four-sign combinations	Frequency
eat drink eat drink	15
eat Nim eat Nim	7
banana Nim banana Nim	5
drink Nim drink Nim	5
banana eat me Nim	4
banana me eat banana	4
banana me Nim me	4
grape eat Nim eat	4
Nim eat Nim eat	4
play me Nim play	4
drink eat drink eat	3
drink eat me Nim	3
eat grape eat Nim	3
eat me Nim drink	3
grape eat me Nim	3
me eat drink more	3
me eat me eat	3
me gum me gum	3
me Nim eat me	3
Nim me Nim me	3
tickle me Nim play	3

Though lexically similar to two-sign combinations, the three-sign combinations (Table 4) do not appear to be informative elaborations of two-sign combinations. Consider, for example, Nim's most frequent two- and three-sign combinations: *play me* and *play me Nim*. Combining *Nim* with *play me* to produce the three-sign combination, *play me Nim*, adds a redundant proper noun to a personal pronoun. Repetition is another characteristic of Nim's three-sign combinations, for example, *eat Nim eat*, and *nut Nim nut*. In producing a three-sign combination, it appears as if Nim is adding to what he might sign in a two-sign combination, not so much to add new information but instead to add emphasis. Nim's most frequent four-sign combinations (Table 5) reveal a similar picture. In children's utterances, in contrast, the repetition of a word, or a sequence of words, is a rare event (*34*).

Differences Between Nim's and a Child's Utterances

The fact that Nim's long utterances were not semantic or syntactic elaborations of his short utterances defines a major difference between Nim's initial multiword utterances and those of a child. These and other differences indicate that Nim's general use of combinations bears only a superficial similarity to a child's early utterances (*35–38*).

The mean length of Nim's utterances. As the mean length of a child's utterances (MLU) increases, their complexity also progressively increases (*20–22*). In English, for example, subject-verb and verb-object construction merge into subject-verb-object constructions.

Figure 2 shows Nim's MLU (the mean number of signs in each utterance) between the ages of 26 and 45 months (*39*). The most striking aspect of these functions is the lack of growth of Nim's MLU during a 19-month period. Figure 2 also shows comparable MLU functions obtained from hearing (speaking) and deaf (signing) children (*40*), including the smallest normal growth of MLU of a

speaking child that we could locate. All children start at an MLU similar to Nim's at 26 months, but, unlike Nim, the children all show increases in MLU.

Another difference between Nim's and childrens' MLU has to do with the value of the MLU and its upper bound. According to Brown, ". . . the upper bound of the (MLU) distribution is very reliably related to the mean. . . . At MLU = 2.0 the upper bound will be, most liberally, 5 ± 2" (*41*). Nevertheless, with an MLU of 1.6 Nim made utterances containing as many as 16 signs (*give orange me give eat orange me eat orange give me eat orange give me you*). In our discourse analyses of Nim's and Washoe's signing (see below), we suggest mechanisms that can lengthen an ape's utterance but that do not presuppose an increase in semantic or syntactic competence.

Semantic relationships expressed in Nim's two-sign combinations. Semantic distributions, unlike the lexical ones we discussed above, cannot be constructed directly from a corpus. In order to derive a semantic distribution, observers have to make judgments as to what each combination means. Procedures for making such judgments, introduced by Bloom (*19, 20*) and Schlesinger (*42*), are known as the method of "rich interpretation" (*21-23, 42*). An observer relates the utterance's immediate context to its contents. Supporting evidence for semantic judgments includes the following observations. The child's choice of word order is usually the same as it would be if the idea were being expressed in the canonical adult form. As the child's MLU increases, semantic relationships identified by a rich interpretation develop in an orderly fashion (*20, 22, 43*). The relationships expressed in two-word combinations are the first ones to appear in the three- and four-word combinations. Many longer utterances appear to be composites of the semantic relationships expressed in shorter utterances (*20, 22*).

Studies of an ape's ability to express semantic relationships in combinations of signs have yet to advance beyond the stage of unvalidated interpretation. The Gardners (*44*) and Patterson (*11*) concluded that a substantial portion of Washoe's and Koko's two-sign combinations were interpretable in categories similar to those used to describe two-word utterances of children (78 and 95 percent, respectively). No data are available as to the reliability of the interpretations that the Gardners and Patterson have advanced.

A widely cited example of Washoe's ability to create new meanings through novel combinations of her signs is her utterance, *water bird*. Fouts (*45*) reported that Washoe signed *water bird* in the presence of a swan when she was asked *what that*? Washoe's answer seems meaningful and creative in that it juxtaposes two appropriate signs in a manner consistent with English word order. Nevertheless, there is no basis for concluding that Washoe was characterizing the swan as a "bird that inhabits water." Washoe had a long history of being asked *what that*? in the presence of objects such as birds and bodies of water. In this instance, Washoe may have simply been answering the question, *what that*?, by identifying correctly a body of water and a bird, in that order. Before concluding that Washoe was relating the sign *water* to the sign *bird*, one must know whether she regularly placed an adjective (*water*) before, or after, a noun

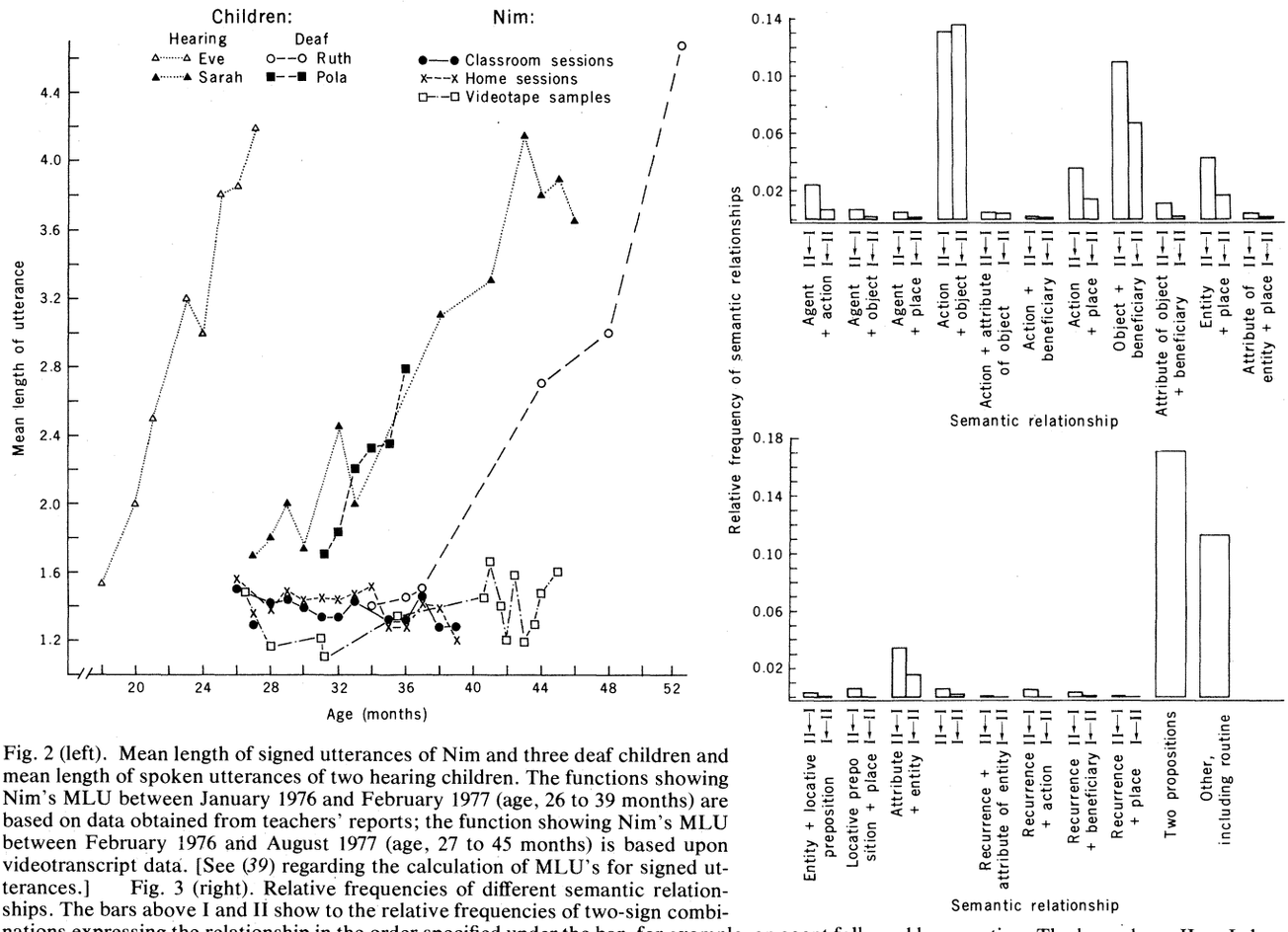

Fig. 2 (left). Mean length of signed utterances of Nim and three deaf children and mean length of spoken utterances of two hearing children. The functions showing Nim's MLU between January 1976 and February 1977 (age, 26 to 39 months) are based on data obtained from teachers' reports; the function showing Nim's MLU between February 1976 and August 1977 (age, 27 to 45 months) is based upon videotranscript data. [See (*39*) regarding the calculation of MLU's for signed utterances.] Fig. 3 (right). Relative frequencies of different semantic relationships. The bars above I and II show to the relative frequencies of two-sign combinations expressing the relationship in the order specified under the bar, for example, an agent followed by an action. The bars above II → I show the relative frequencies of two-sign combinations expressing the same relationship in the reverse order, for example, action followed by an agent.

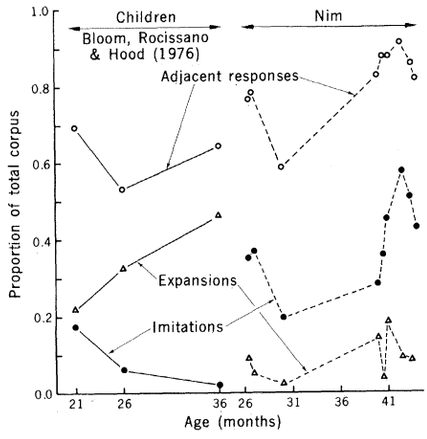

Fig. 4. Proportion of utterances emitted by children (left-hand function) and by Nim (right-hand functions) that are adjacent to, imitative of, or expansions of an adult's prior utterance.

(*bird*). That cannot be decided on the basis of a single anecdote, no matter how compelling that anecdote may seem to an English-speaking observer.

Without prejudging whether Nim actually expressed semantic relationships in his combinations, we analyzed, by the method of rich interpretation, 1262 of his two-sign combinations, which occurred between the ages of 25 to 31 months (*46*). The results of our semantic analysis are shown in Fig. 3. Twenty categories of semantic relationships account for 895 (85 percent) of the 957 interpretable two-sign combinations. Brown (*47*) found that there were 11 semantic relationships that account for about 75 percent of all combinations of the children he studied. Similar categories of semantic relationships were used by the Gardners and by Patterson (*48*).

Figure 3 shows several instances of significant preferences for placing signs expressing a particular semantic role in either the first or the second positions. Agent, attribute, and recurrence (*more*) were expressed most frequently in the first position, while place and beneficiary roles were expressed most frequently by second-position signs (*49*).

At first glance, the results of our semantic analysis appear to be consistent with the observations of the Gardners and Patterson. But even though our judgments were reliable, several features of our results suggest that our analysis, and that of others, may exaggerate Nim's semantic competence. One problem is the subjective nature of semantic interpretations. That problem can be remedied only to the extent that evidence corroborating the psychological reality of our interpretations is available. Neither our semantic analyses of an ape's two-sign combinations nor those of any other studies have produced such evidence. In some cases, utterances were inherently equivocal in our records. Accordingly, somewhat arbitrary rules were used to interpret these utterances. Consider, for example, combinations of *Nim* and *me* with an object name (for example, *Nim banana*). These occurred when the teacher held up an object that the teacher was about to give to Nim who, in turn, would ingest it. We had no clear basis for distinguishing between the following semantic interpretations of combinations containing *Nim* or *me* and an object name: agent-object, beneficiary-object, and possessor-possessed object.

An equally serious problem is posed by the very small number of lexical items used to express particular semantic roles. Only when a semantic role is represented by a large variety of signs is it reasonable to attribute position preferences to semantic rules rather than to lexical position habits. For example, the role of recurrence was presented exclusively by *more*. In combinations presumed to relate an agent and an object or an object and a beneficiary, one would expect agents and beneficiaries to be expressed by a broad range of agents and beneficiaries, for example: *Nim*, *me*, *you*, and names of other animate beings. However, 99 percent (N = 297) of the beneficiaries in utterances judged to be object-beneficiary combinations were *Nim* and *me*, and 76 percent (N = 35) of the agents in utterances judged to be agent-object combinations were *you*. From these and other examples, it is difficult to decide whether the positional regularities favoring agent-object and object-beneficiary constructions (Fig. 3) are expressions of semantic relationships or idiosyncratic lexical position habits. Such isolated effects could also be expected to appear from statistically random variation.

Discourse analysis. An analysis of video transcripts revealed yet another contribution to the semantic look of Nim's combinations; his utterances were often initiated by his teacher's signing and they were often full or partial imitations of his teachers' preceding utterance. Since full or partial imitations were included in the corpus, it is possible that the semantic relationships and position preferences we observed are, to some extent, reflections of teachers' signing habits. Those that were imitated cannot be regarded as comparable to a child's nonimitative constructions.

Table 6. Discourse between Washoe (W) and B. Gardner (B.G.). See Fig. 5. This is a transcript of a tape shown on television.

Time	Frame		
00.00	7	B.G:/*what*	
1.46	8	*time*	
1.96	9		W: /*time*
2.25	10	*now?*/	*eat*/
4.50	11		/*time*/
4.84	12		*eat*/
		---------splice---------	

There has been increasing interest in the way parents speak to their children (*50*) and in the ways children adjust their speech to aspects of the prior verbal context (*51*). Fillmore (*52*) has likened adult conversations to a game in which two participants take turns moving a topic along. Children learn quite early that conversation is such a turn-taking game (*53*). However, our discourse analysis revealed a fundamentally different relationship between Nim's and his teacher's utterances.

The corpus we analyzed was derived from transcripts of 3½ hours of videotapes from nine sessions recorded between the ages of 26 to 44 months (*54*). A comparison of Nim's discourse with his teachers and children's discourse with adults, characterized by Bloom *et al.* (*51*), is shown in Fig. 4. *Adjacent* utterances are those that follow an adult utterance without a definitive pause (*51*). At 21 months (MLU = 1.3), the most appropriate stage of development with which to compare Nim, the average proportion of a child's utterances that are adjacent is 69.2 percent (range, 53 to 78 percent). A somewhat higher percentage (87 percent) of Nim's utterances were classified as adjacent (range: 58.7 to 90.9 percent).

Adjacent utterances can be classified in four categories. (i) Imitations are those utterances that contain all of the lexical items of the adult's utterances, and nothing else; (ii) reductions are those that contain some of the lexical items of the adult's utterance and nothing else; (iii) expansions are those that contain some of the lexical items of the adult's utterance along with some new lexical items; and (iv) novel utterances are those that contain none of the lexical items of the adult's utterance. Among the children studied by Bloom *et al.* (*51*), imitations and reductions accounted for 18 percent (Fig. 4) of all of the children's utterances at stage 1 (MLU = 1.36). That 18 percent decreased with increasing MLU, accounting for only 2 percent of the children's utterances at stage 5

(MLU = 3.91). In contrast, 39.1 percent of Nim's adjacent utterances (N = 509) were imitations or reductions (range, 19.5 to 57.1 percent).

At stage 1, 21.2 percent of a child's utterances are expansions of the adult's prior utterance (range, 10 to 28 percent). On the average, only 7.3 percent of Nim's utterances were expansions of his teacher's prior utterance (range, 1 to 15 percent). As the child gets older, the proportion of its utterances that are expansions increases. Bloom *et al.* (*51*) noted that many of the child's utterances are systematic expansions of verb relations contained in the adult's prior utterance. No such pattern was discernible in Nim's expansions. Indeed a preliminary analysis of Nim's expansions indicates that aside from the teacher's signs, his utterances contain only a small number of additional signs, such as *me*, *Nim*, *you*, *hug*, and *eat*. Since these signs are not specific to particular contexts, they do not add new information to the teacher's utterance.

By definition, adjacent utterances may include interruptions of a teacher's or an adult's utterance. Such interruptions detract from true conversation since they result in discourse that is simultaneous rather than successive. In 71 percent of the utterances that have been examined (425 out of 585), Nim signed simultaneously with his teacher. Of these overlapping utterances, 70 percent occurred when Nim began an utterance while the teacher was signing. When the teacher interrupted one of Nim's utterances, it was generally the case that Nim had just interrupted the teacher and the teacher was, in effect, asserting his or her right to hold the floor. Nim's interruptions show no evidence that they are in response to the teacher's attempts to take the floor from him. Few data are available concerning the relative frequency or duration of simultaneous utterances that occur in dialogues between children and adults in either spoken or sign language. In the most relevant study we could locate, McIntyre reports that her videotape transcripts of a 13-month deaf child signing with her mother revealed virtually no interruptions of the mother's utterances (*54a*). Bloom (*55*) and Bellugi (*56*) have observed that interruptions are virtually nonexistent in their videotapes of children learning vocal and sign languages (*56a*).

None of Nim's teachers, nor the many expert observers who were fluent in sign language, were aware of either the extent to which the initiation and contents of Nim's signing were dependent on the teacher's signing or the degree to which Nim imitated or interrupted his teachers. That information can be obtained only from film or videotape transcripts. The contrast between the conclusions that might be drawn from our distributional analyses and those that follow from our discourse analysis provides an important methodological lesson. In the absence of a permanent record of an ape's signing, and the context in which that signing occurred, even an objectively assembled corpus of an ape's utterances does not provide a sufficient basis for drawing conclusions about the grammatical regularities of those utterances.

Table 7. Discourse between Washoe (W) and B. Gardner (B.G.).

Time (second)	Frame (see Fig. 5)		
00.00	1	B.G: */eat*	
00.42	2	*/me/*	
02.38	3	*/more*	
02.80	4	*me(mine)/*	
03.34	5	(W feeds B.G)	
07.09	6	/thank you/	
10.92	7	*/what*	
12.38	8	*time*	
12.88	9		W: */time*
13.17	10	*now?/*	*eat/*
15.42	11		*/time*
15.76	12		*eat/*
		---------splice---------	
00.00	13	B.G: */what*	
00.46	14	*now?/*	
00.29	15	*/what*	W: */in*
04.79	16	*now*	*in/*
05.33	17	'	*/me*
05.67	18	'	*eat*
06.17	19	'	*time*
06.38	20	↓ ?/	*eat/*

Unanticipated, but instructive, examples of the influence of the teacher's signing on Nim's signing were noted in photographs such as those shown in Fig. 1 (a series of still photographs taken with a motor-driven camera). Examination of Fig. 1, prompted by the results of our discourse analysis, reveals that Nim's teacher signed *you* while Nim was signing *me*, then later signed *who*? while Nim was signing *cat*. Because these were the only four photographs taken of this discourse, we cannot specify just when the teacher began her signs. It is not clear, for example, whether the teacher signed *you* simultaneously or immediately prior to Nim's *me*. However, it is unlikely that the teacher signed *who*? after Nim signed *cat*.

Comparison of Nim's Discourse with That of Other Signing Apes

Two valuable sources of information that suggest that Nim's discourse with his teachers was not specific to the conditions of our project are a film produced by Nova for television, entitled, *The First Signs of Washoe* (*57*), and a film, produced by the Gardners, *Teaching Sign Language to the Chimpanzee: Washoe* (*58*).

Consider the scene from *First Signs of Washoe* shown in Table 6 and in the left-hand portion of Fig. 5 (*59*). In this conversation, Washoe's utterances either followed or interrupted B. Gardner's utterance. It is also the case that the sign *time* was uttered by B. Gardner just prior to Washoe's utterance *time eat* (*60*).

Teaching Sign Language to the Chimpanzee: Washoe presents a longer ver-

Table 8. Discourse between Washoe (W) and S. Nichols (S.N.).

Time	Frame (see Fig. 6)		
00:00	1	S.N: */that/* (points to cup)	
00:29	2		W:*/baby/*
		(brings cup and doll closer to W; S.N. allows W to touch it; S.N. slowly pulls it away)	
05:37	3	S.N: */that/* (points to cup)	
			W:*/in/* (looks away from S.N.)
		S.N: (brings the cup and doll closer to W)	
			W: (looks back at cup and doll)
08.17	4		W: */baby/*
		S.N: (brings cup closer to W)	
10.58	5		W: */in/*
11.46	6	S.N.: */that/* (points to cup)	W: */my*
11.42	7		*drink/*

sion of the same conversation. As can be seen in Table 7 and Fig. 5 both of Washoe's signs (*time*) and (*eat*) were signed by B. Gardner immediately prior to Washoe's having signed them. *Time eat* cannot be considered a spontaneous utterance for two reasons. It was a response to a request to sign by B. Gardner and it contained signs just signed by her. The significance of a full record of discourse between a chimpanzee and its teacher is also revealed by the segment that follows the splice in the film. Consider Washoe's combination *me eat time eat* in isolation. Without knowledge of the teacher's prior utterances it would be all too easy to interpret Washoe's utterance as one that signifies a description of future behavior and a knowledge of time. Our transcription of the discourse between B. Gardner and Washoe also shows that three out of Washoe's four utterances interrupted B. Gardner's utterances.

Another instructive example of the influence of the teacher on the production of Washoe's signs is provided by the utterance glossed as *baby in my drink* (Fig. 6 and Table 8), a combination of four signs described in both films as a creative use of sign language by Washoe. In this (run-on) sequence, the order of Washoe's signs reflects the order in which the teacher (Susan Nichols) signed to Washoe to sign about a baby doll inserted in a cup. The sequence of the teacher's signs (pointing to the doll and then pointing to the cup) follows the order called for by an English prepositional phrase. Only the last two signs, *my* and *drink* occurred without intervening prompting on the part of the teacher. The sign glossed in film as *my* is configurationally identical to the sign *me* shown in Fig. 5, frame 17. Both signs conform to the specification of *my* in the Gardners' description of Washoe's sign (*1*, p. 264). For these reasons alone, Washoe's actual sequence of signs, *baby in baby in my drink*, cannot be regarded as a spontaneously generated utterance.

Table 9. Discourse between Washoe (W) and S. Nichols (S.N.).

Time (seconds)	Discourse	
00.00	S.N:/ *who stupid?*/	
00.42		W:/ *Susan, Susan*/
05.30	S.N:/ *who stupid?*/	
05.58		W:/ *stupid*/
06.42	S.N/: *who?*/	
06.72		W:/ *Washoe*/
07.04	S.N:/ *Washoe*/	
07.36	S.N:/ (tickles Washoe)/	

In the immediately preceding scene of the film, Susan was shown drilling Washoe extensively about a *baby in shoe* and an *apple in hat* while Washoe was trying to grab the desired objects from the teacher. This suggests that Washoe's sign *my*, in *baby in baby in my drink*, was signed to convey to her teacher that she wanted the doll. Given this type of drill, and the teacher's pointing to the objects to be named in the appropriate sequence, it is gratuitous to characterize the utterance shown in Fig. 6 as a creative juxtaposition of signs that conveyed the meaning "a doll in Washoe's cup."

As a final example of Washoe's dis-

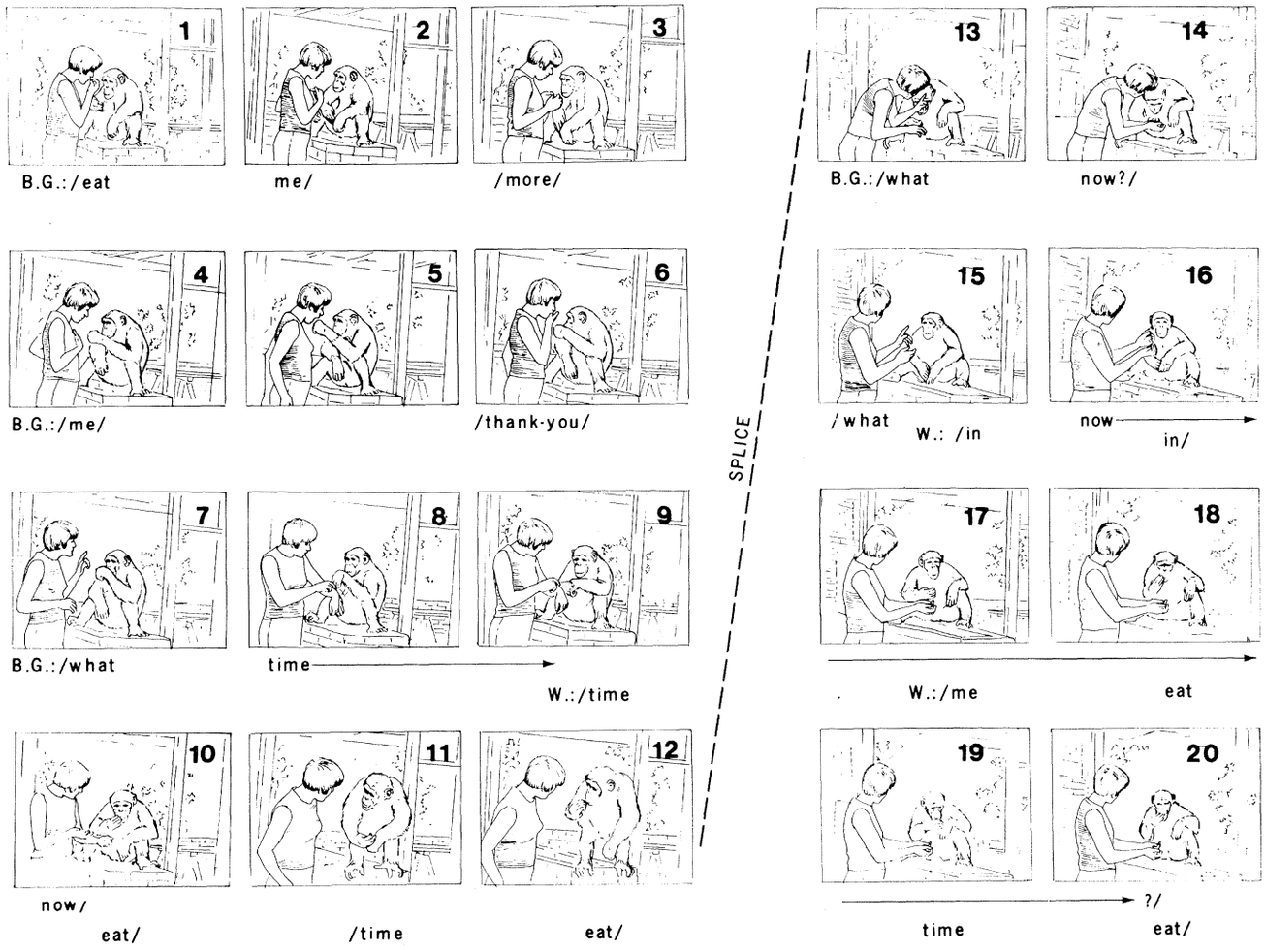

Fig. 5. Tracings (made from a film) of Washoe signing with B. Gardner. See (*59*).

course with her teachers, consider the conversation about Washoe's intelligence shown in Table 9. This sequence also appears to be a drill. The important question it raises, however, is whether Washoe actually understood the meanings of *stupid* (and *smart*). Her usage of *stupid* was clearly imitative of her teacher. The exchange between Washoe and the teacher (Susan Nichols) was also terminated at the point at which the teacher induced Washoe to make the signs *stupid* and *Washoe*. The circumstances under which this sequence of signs occurred raises questions about the Gardners' semantic analysis of combinations such as *Naiomi good* (*44*). That combination was presented as an example of attribution, an interpretation that would be appropriate only in the absence of the kinds of prompting and reward shown in the films of Washoe signing.

The longer of these films, *Teaching Sign Language to the Chimpanzee: Washoe*, showed 155 of Washoe's utterances of which 120 were single-sign utterances. These occurred mainly in vocabulary testing sessions. Each of Washoe's multisign sequences (24 two-sign, 6 three-sign, and 5 four-sign sequences) were preceded by a similar utterance or a prompt from her teacher. Thus, Washoe's utterances were adjacent and imitative of her teacher's utterances. The Nova film, which also shows Ally (Nim's full brother) and Koko, reveals a similar tendency for the teacher to sign before the ape signs. Ninety-two percent of Ally's, and all of Koko's, signs were signed by the teacher immediately before Ally and Koko signed.

The data provided by a few films are admittedly much more limited in scope than data of the type we obtained from our nine videotapes. It seems reasonable to assume, however, that the segments shown in the films, the only ones available of apes signing, present the best examples of Washoe's, Ally's, and Koko's signing. Even more so than our transcripts, these films showed a consistent tendency for the teacher to initiate signing and for the signing of the ape to mirror the immediately prior signing of the teacher.

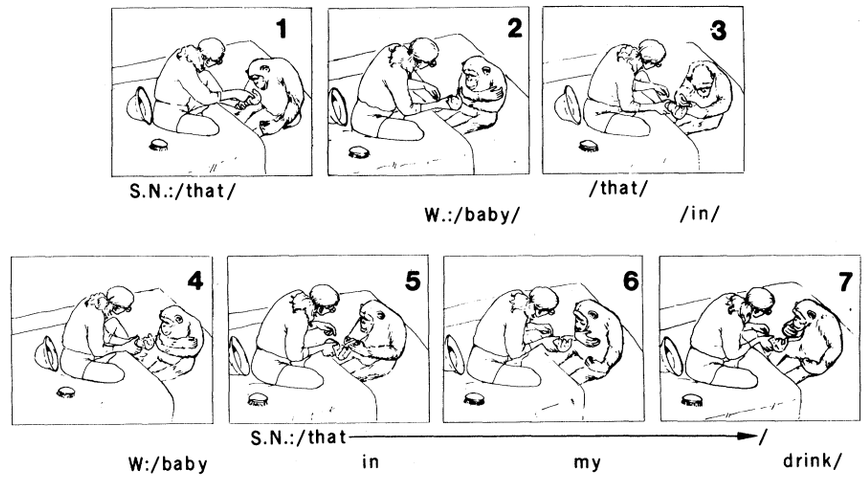

Fig. 6. Tracings of Washoe (made from a film) signing with S. Nichols. See (*59*).

Other Evidence Bearing on an Ape's Grammatical Competence

In evaluating the claim that apes can produce and understand sentences it is important to keep in mind the lack of a single decisive test to indicate whether a particular sequence of words qualifies as a sentence or whether a particular performance qualifies as an instance of grammatically guided sentence comprehension. It has been observed widely that the early sequences of words uttered by a child do not necessarily qualify as sentences (*19, 24*). If, indeed, the only evidence that children could create and understand sentences were their initial utterances, and their responses to their parents' utterances, there would be little reason to conclude that a child's production and comprehension of words are governed by a grammar.

A rich interpretation of a young child's early utterances assumes that they are constrained by structural rules (*20, 22*). It is difficult, however, to exclude simpler accounts of such utterances. A child's isolated utterance of a sequence of words could be a haphazard concatenation of words that bear no structural relationship to one another (*22*) or routines that the child learns by rote as imitations of its parent's speech (*24*). However, as children get older, the variety and complexity of their utterances gradually increase (*21, 61*). Especially telling is the observation that children pass through phases in which they produce systematically incorrect classes of utterance. During these phases, the child apparently "tries out" different sets of rules before arriving at the correct grammar. Children are also able to discriminate grammatically correct from incorrect sentences (*62*). Accordingly, explanations of their utterances that are not based upon some kind of grammar become too unwieldy to defend.

Production of sequences. Before regarding a sequence of words as sentences, it is necessary to demonstrate the insufficiency of simpler interpretations. Consider some examples of sequence production on the part of Sarah and Lana. As a result of rote training, both Sarah and Lana learned to produce specific sequences of words, for example, *please machine give apple* (*9*), or *Mary give chocolate Sarah* (*6*). Subsequently, both Sarah and Lana learned to substitute certain new words in order to obtain other incentives from the same or from other agents (for example, *Randy give Sarah apple*, *please machine give drink*, or *please machine show slide*). The last sequence was presented as evidence that Lana learned to use different "verbs" (*give* and *show*) in conjunction with a different category of incentives, *slide*, *window*, and *music* (*9*).

Sarah's and Lana's multisign utterances are interpretable as rotely learned sequences of symbols arranged in particular orders; for example, *Mary give Sarah apple*, or *please machine give apple*. There is virtually no evidence that Lana and Sarah understood the meaning of *all* of the "words" in the sequences they produced. Except for the names of the objects they requested, Sarah and Lana were unable to substitute other symbols in each of the remaining positions of the sequences they learned. Accordingly, it seems more prudent to regard the sequences of symbols glossed as *please*, *machine*, *Mary*, *Sarah*, and *give* as sequences of nonsense symbols (*63*).

Consider comparable performance by pigeons that were trained to peck arrays of four colors in a particular sequence, A→B→C→D, regardless of the physical position of the colors (*64*). In these experiments, all colors were presented simultaneously and there was no step-by-step feedback after each response. Evidence that the subjects learned the overall sequence, and not simply the specific responses required by the training arrays

was provided by performance that was considerably better than chance on novel arrays. It has yet to be shown that pigeons can master ABC*X* problems (where X1 could refer to one type of grain, X2 to a different type of grain, X3 to water, X4 to the opportunity to see or to attack another pigeon, and so on). If a pigeon can learn such sequences (a not unlikely outcome) one wonders what is to be gained by assigning "names" to each member of the sequence, for example, referring to the sequence, green→white→red→blue, as *machine give R-42 grain*.

Sequences of symbols produced by an ape may seem grammatically related to one another in the eyes of human observers. It does not, however, follow that the chimpanzee had any knowledge of the relationships that a human observer may infer (*65*). As difficult as it may be to train an ape, or any organism, to produce a sequence of arbitrary responses that may look like a sentence, it is even more difficult to show that those sequences have the structural properties of human sentences (*63*).

Comprehension of multiword sequences. An inherent difficulty in using apparent comprehension as an indicator of a child's syntactic competence is the frequent presence of nonsyntactic cues to meaning (*22, 23*). This can be controlled if sentence comprehension experiments are designed to exclude semantic and extralinguistic cues. However, many purported examples of sentence comprehension by chimpanzees can be explained as nonsyntactic problem-solving behavior. Even complex problems, which seem to require an understanding of the syntactic structure of the instruction (for example, conditional instructions and instructions presented in hierarchical form), could be solved by applying nonsyntactic rules (*63*).

Demonstrations by Premack, Rumbaugh, and the Gardners that their chimpanzees can answer *wh*-questions correctly is evidence of the memory capacity of a chimpanzee. There is little reason, however, to conclude that these chimpanzees comprehended *wh*-questions. In each case, the chimpanzees were drilled extensively on the correct answers to questions such as *color that?*, *what that?*, and only a limited choice of answers (usually two) were available. The constant setting in which repeated problems of the same nature were administered provided ideal conditions for the establishment of learning sets and the use of nonsyntactic strategies in solving these problems. Without a greater variety of problems and a greater range of possible answers, the results of such studies cannot be interpreted as "linguistic" demonstrations of the interpretation of *wh*-questions (*64*).

In their effort to demonstrate comprehension of *wh*-questions, the Gardners accepted as correct *any* response they designated as lexically appropriate. For example, if Washoe signed *blue* in answer to *what color?* when she was shown a red ball, *blue* was considered "correct" because it was a color. The significant correlation that the Gardners report between question forms and response forms shows that Washoe learned to respond to category questions with signs from the appropriate category: colors, trainers' names, actions, and so on. However, many of her specific answers were clearly inappropriate. The Gardners nevertheless concluded that Washoe's performance is comparable to that of a child at stage 3 in Brown's scheme for describing the development of language in children (*22*). At this stage, children are not only able to produce correct answers to simple *wh*-questions, but they are also able to produce a variety of constructions whose mean length exceeds 2.75 morphemes. The significance of analyzing child language in terms of stages derives largely from the structural complexities that a child masters, in a cumulative fashion, at each point of its development. The Gardners' conclusion does not take into account these aspects of a child's language at stage 3.

Conclusions

Projects devoted to teaching chimpanzees and gorillas to use language have shown that these apes can learn vocabularies of visual symbols. There is no evidence, however, that apes can combine such symbols in order to create new meanings. The function of the symbols of an ape's vocabulary appears to be not so much to identify things or to convey information [as, for example, Skinner's concept of "tacts" (*66*)] as it is to satisfy a demand that it use that symbol in order to obtain some reward [Skinner's concept of "mands" (*66*)].

In our study more than 20,000 combinations of two or more signs, produced by Nim, an infant chimpanzee, were examined for evidence of syntactic and semantic structure. Lexical regularities, in which particular signs tended to occur in particular positions, were observed in the case of two-sign combinations. It is impossible to explain these regularities as overall position habits or the memorization of many individual sequences. As such, these regularities provide superficial evidence that Nim's two-sign combinations followed rules of sign order. However, other aspects of Nim's use of sign language suggest that it is unwarranted to conclude that his combinations were primitive "sentences."

The mean length of Nim's combinations fluctuated between 1.1 and 1.6 during the last 19 months of the project. During that time, the size of his vocabulary more than doubled (from 42 to 125 signs). Nim's three-sign combinations showed no evidence of lexical regularities, nor did they elaborate or qualify what he signed when he produced a two-sign combination.

Our semantic analysis of Nim's two-sign combinations showed that 85 percent of these combinations could be assigned unambiguously to one of 20 semantic categories. Going beyond the results of other studies, we demonstrated the reliability of our semantic judgments and also observed that certain semantic roles were expressed in particular orders of signs. However, our data also suggest that it is premature to apply the method of "rich interpretation" to the utterances of an ape. Not only did the number of lexical examples of each semantic role seem too few to justify the designation of order regularities as semantic (rather than lexical), but there were also too many idiosyncratic order regularities in combinations of particular signs. Thus, the evidence necessary to demonstrate a knowledge of categorical semantic rules is insufficient.

A discourse analysis of Nim's use of sign language, which related Nim's utterances to his teacher's immediately prior use of sign language, produced further evidence that Nim's use of language differed fundamentally from that of a child. Nim imitated and interrupted his teachers' utterances to a much larger extent than a child imitates and interrupts an adult's speech. This suggests that Nim was less creative than a child in producing utterances and that he had not learned the give-and-take aspect of conversation that is evident in a child's early use of language. Analyses of films of other apes signing with their teachers revealed a similar lack of creativity in other apes' utterances, and a similar dependence of these utterances on the prior signing of their teachers.

In sum, evidence that apes create sentences can, in each case, be explained by reference to simpler nonlinguistic processes. Sequences of signs, produced by Nim and by other apes, may resemble superficially the first multiword sequences produced by children. But un-

less alternative explanations of an ape's combinations of signs are eliminated, in particular the habit of partially imitating teachers' recent utterances, there is no reason to regard an ape's multisign utterance as a sentence.

Our results make clear that any new study of an ape's ability to use language must collect a large corpus of utterances, in contexts that can be readily documented by reference to a permanent visual record (*67*). With such data one would be left with an incomplete basis for comparing an ape's and a child's use of language.

For the moment, our detailed investigation suggests that an ape's language learning is severely restricted. Apes can learn many isolated symbols (as can dogs, horses, and other nonhuman species), but they show no unequivocal evidence of mastering the conversational, semantic, or syntactic organization of language.

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16. Nim was born on 21 November 1973 at the Institute for Primate Studies in Norman, Okla. On 3 December 1973, Nim was flown to New York accompanied by Mrs. Stephanie LaFarge, who, along with her family, raised Nim in their home on New York's West Side for 21 months. Between 15 August 1975 and 25 September 1977, Nim lived on a university-owned estate (Delafield) in Riverdale, N.Y., in a large house with private grounds where he was cared for by four to five resident trainers. Nim formed particularly close attachments with certain members of the project. H. S. Terrace was the only project member who maintained a strong and a continuous bond with Nim throughout the project. During the first 18 months of the project, Mrs. LaFarge was the most central person in Nim's life. After he was moved to Delafield, Nim became closely attached to L. A. Petitto, who supervised his care both at Delafield and in a special classroom built for Nim in the Psychology Department of Columbia University. After Petitto left the project (when Nim was 34 months old), Nim became closely attached to two resident teachers at Delafield, W. Tynan and J. Butler. From September 1974 until August 1977, Nim was driven to his classroom at Columbia three to five times a week where he was given intensive instruction in both the expression and the comprehension of signs and where he could also be observed, photographed, and videotaped by other teachers with a minimum of distraction (through a one-way window). Nim was also taught regularly at Delafield, although in a less formal manner. Extensive analyses of his signing at Delafield and in the Columbia classroom revealed no systematic differences in any of the aspects of Nim's signing reported in this study. During the 46 months in which he lived in New York, Nim was taught by 60 nonpermanent volunteer teachers. As he grew older, Nim's emotional reactions to changes in personnel intensified, and it became increasingly difficult for new teachers to command Nim's attention. By September 1977, it was clear that we did not have the resources necessary to hire a staff of qualified permanent teachers who could advance the scientific aspects of the project. Our choice was to provide "babysitters" who could look after Nim, but who were not uniformly qualified to further Nim's understanding of sign language, or to terminate the project. With great reluctance, we decided on the latter course of action. On 25 September 1977, Nim was flown back to his birthplace in Oklahoma. A full description of Nim's history and socialization can be found in (*17*).
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24. M. Braine, *Monogr. Soc. Res. Child Dev.* **41** (1), Serial No. 164 (1976).
25. An imitative sign is one which repeats the teacher's immediately prior utterance. A spontaneous sign is one that has not occurred in the teacher's immediately prior utterance. A *prompted* sign follows a teacher's prompt. A prompt uses only part of the proper sign's configuration, movement, or location. For example, the teacher might prompt *Nim* (first and second fingers drawn down the temple) by extending those two fingers from a fist. Agreement between teachers' reports and transcripts of an independent observer (who either watched Nim and his teacher through the one-way window of his Columbia classroom or who transcribed videotapes) ranged between 77 and 94 percent. Virtually all of the disagreements occurred when the teacher failed to record a sign, when, for example, the teacher was busy preparing an activity, when Nim was signing too quickly, or when the teacher was signing to Nim. There was no evidence that the omissions of the teacher were systematic. At worst, the teachers' reports underestimated the extent to which Nim signed.
26. A complete listing of Nim's vocabulary, including the topography of each sign and context in which it occurred, can be found in (*17*, Appendix C).
27. B. T. Gardner and R. A. Gardner, *Bull Psychon. Soc.* **4** (No. 4a), 264 (1974); *Minn. Symp. Child Psychol.* **8**, 3 (1974).
28. Word order is but one of a number of ways in which a language can encode different meanings. When, however, regularities of sign order can be demonstrated, it does provide strong evidence for the existence of grammatical structure. Given the difficulty of documenting other aspects of an ape's signing, regularities of sign order may provide the simplest way of demonstrating that an ape's utterances are grammatical [U. Bellugi and E. S. Klima, *The Signs of Language* (Harvard Univ. Press, Cambridge, Mass., 1979); H. W. Hoemann, *The American Sign Language: Lexical and Grammatical Notes with Translation Exercises* (National Association of the Deaf, Silver Spring, Md., 1975); E. S. Klima and U. Bellugi, *Ann. N.Y. Acad. Sci.* **263**, 255 (1975); H. Lane, P. Boyes-Braem, U. Bellugi, *Cog. Psychol.* **8**, 262 (1976)].
29. In ASL, the segmentation of combinations into signs has a function similar to that of the segmentation of phrases into words in spoken language: segmentation delineates sign sequences that are immediately related to one another. Other segmentation devices as well are used in ASL. In addition to the relaxation of the hands, specific head and body shifts, and specific facial expressions signal constituent boundaries [Stokoe *et al.* (*8*); E. Brown and S. Miron, *J. Verbal Learn. Verbal Behav.* **10**, 658 (1971); H. Lane and F. Grosjean, *J. Exp. Psychol.* **97**, 141 (1973)].
30. Two rules were used in combinations containing signs which were repeated successively. These rules ensured the shortest possible description of a particular combination. For homogeneous combinations, if all signs in a sequence were the same (*eat eat eat*), the sequence was treated as a single sign utterance (*eat*). Homogeneous sequences of signs were not tabulated as combinations. For heterogeneous sequences, if a particular sign was repeated, immediate repetitions of that sign were not counted. For the purpose of tabulation within the corpus, a sequence such as *banana me me me eat* was reduced to *banana me eat*. Whereas the original sequence contained five signs, this combination was entered as a three-sign sequence. In general, the sign Y, repeated in succession n times, was counted as a single occurrence of Y, independently of the value of n. The entries shown in Table 1 represent the number of types and tokens of Nim's linear combinations observed to occur *before* the reduction rules were used. A complete listing of Nim's combinations that resulted from the application of the reduction rules can be found in Terrace *et al.* (*31*). In ASL, repetitions of a sign convey particular meanings. One type of contrast between repeated and nonrepeated signs is exemplified by the contrast between the forms of certain nouns and verbs. Many verbs (*sweep, fly, drive*) are made with a single motion. Related nouns (*broom, airplane, car*) are made by repeating a sign twice (the so-called double bounce form; see T. Suppala and E. Newport, personal communication). None of Nim's teachers could distinguish between the meanings of utterances that did and did not contain signs that were repeated successively. Emphasis appears to be their sole function. Overall, less than 15 percent of the linear utterances we observed contained successively repeated signs. As far as we could tell, the outcomes of our analyses would be unchanged if we included utterances containing signs that were repeated successively.
31. H. S. Terrace, L. A. Petitto, R. J. Sanders, T. Bever, in *Children's Language*, K. Nelson, Ed. (Gardner Press, New York, in press), vol. 2.
32. Other complete listings of the regularities of Nim's two-sign combinations can be found in (*17*).
33. That there are more tokens of two-sign combinations containing *me* than containing *Nim* is perhaps best explained by the fact that Nim learned the sign *me* before he learned the sign *Nim*. Subsequently the frequencies with which *Nim* and *me* were combined with transitive verbs was es-

sentially the same. In the case of combinations containing *more*, it might be argued that Nim modeled the construction *more* + *X* after his teachers' utterances. Often a teacher would sign to Nim, *more* + *X*?, to see if Nim would sign *more* or *X* in reply. On this view, Nim learned to sign *more* + *X* by first imitating a few instances of *more* + *X* and then generalizing this construction to new objects and actions. Such generalization would be necessary because Nim produced most of the first tokens of each type of *more* + *X* combination without any modeling by the teacher. This type of explanation seems less cogent in the case of other classes of combinations, for example, those containing transitive verbs shown in Table 2, because Nim was not asked questions with these signs that could serve as models.

34. N. Colburn, thesis, Teachers College, Columbia University (1979).
35. Most of the comparisons we will make draw upon data obtained from studies of the acquisition of spoken language by hearing children of hearing parents. Nim was taught by hearing teachers who were not uniformly fluent signers. Accordingly, studies describing the acquisition of sign language by deaf children of hearing parents would provide the most relevant point of reference for evaluating the data we obtained from Nim. However, to the extent that data are available from deaf children (of either deaf or hearing parents) there is no evidence that any major differences exist between the general features of language acquisition by deaf and hearing children. For further details see (*36*–*38*).
36. E. F. Ashbrook, "Development of semantic relations in the acquisition of American Sign Language" (working paper, Salk Institute, June 1975).
37. R. S. Hoffmeister, *Proceedings of the First National Symposium on Sign-Language Research and Teaching*, Chicago, 1977.
38. E. S. Klima and U. Bellugi, in *Communication and Affect: A Comparative Approach*, T. Alloway, L. Krames, P. Pliner, Eds. (Academic Press, New York, 1972), p. 67.
39. In calculating a child's MLU, certain conventions are followed that cannot be applied directly to sequences of signs. A spoken utterance, for example, is often broken down into morphemes rather than words: *running*, and *run there* would each be regarded as a two-morpheme utterance. In sign language, the utterance, *run there*, can be expressed by a single sign [E. S. Klima and U. Bellugi (*38*)]. While the MLU of utterances in sign language has yet to be calibrated as a measure of linguistic development, it is nevertheless of interest to ask how the mean length of Nim's combinations varied during the time in which we recorded his utterances. The rules used to calculate Nim's MLU resulted from a conservative adaptation of those followed by Brown (*22*). See Terrace *et al*. (*31*) for further details.
40. As far as we can determine, the only MLU functions that have been described for deaf children acquiring sign language are those described by E. S. Klima and U. Bellugi (*38*); H. S. Schlesinger, in preparation; R. J. Hoffmeister (*37*). One explanation for the apparent delay in the growth of MLU in deaf children has to do with the property of sign language that allows one to encode a number of morphemes within a single sign [see E. S. Klima and U. Bellugi (*38*), p. 85].
41. R. Brown, personal communication.
42. I. M. Schlesinger, in *Ontogenesis of Grammar*, D. I. Slobin, Ed. (Academic Press, New York, 1971), p 63.
43. In some cases, word order is also used contrastively, and in at least one child, intonational differences were observed that were associated with differences in meaning [L. Bloom (*20*); M. Bowerman, *Early Syntactic Development: A Cross-Linguistic Study with Special Reference to Finnish* (Cambridge Univ. Press, London, 1973)].
44. B. T. Gardner and R. A. Gardner, in *Behavior of Nonhuman Primates: Modern Research Trends*, A. M. Schrier and F. Stollnitz, Eds. (Academic Press, New York, 1971), vol. 4, pp. 117–184.
45. R. S. Fouts, in *Society and Psychology of Primates*, R. H. Tuttle, Ed. (Mouton, The Hague, 1975), pp. 371–390.
46. The semantic corpus covered data from roughly 5.5 months for each teacher. Data were based on 48 reports of J. Butler, 58 of R. Sanders, and 41 of W. Tynan. After interpreting the utterances of their own sessions, each teacher interpreted the utterances of one of the other two teachers. They agreed in their interpretations of 717 utterances (57 percent of the original corpus). If a disagreement could not be resolved, the utterance in question was considered ambiguous and disregarded. Contextual notes in the teachers' records included sufficient information for the teachers to agree as to the interpretation of the 967 two-sign combinations (76 percent of the original corpus). In the remaining cases (N = 295), no interpretation could be made (N = 260), or two or more equally reasonable interpretations were made that could not be disambiguated (N = 35). These combinations were not included in our analysis. None of our conclusions would be altered if we used either of the interpretations of the combinations that were not distinguishable.
47. R. Brown, *Psycholinguistics; Selected Papers by Roger Brown* (Free Press, New York, 1970).
48. The number of categories used for interpreting a child's or an ape's early combinations is arbitrary. Our 20 categories could be collapsed into seven in Brown's with two left over; into eight in the Gardners' system, with two left over; and into 11 in Patterson's system, with one left over.
49. In addition to the relational combinations we observed (Fig. 3), 166 combinations were assigned nonrelational interpretations, apparently expressing the conjunction of elements from two propositions, for example, *tickle hug, dirty run, apple nut*, and *in play*. Such expressions are rare in children's speech and have not been reported in previous studies on training apes to learn sign language [L. Bloom, P. Lightbown, L. Hood, *Monogr. Soc. Res. Child Dev.* **40** (2), Serial No. 160 (1975).
50. E. Newport, in *Cognitive Theory*, N. J. Caselan, D. B. Pisoni, G. R. Potts, Eds. (Lawrence Erlbaum Associates, Hillsdale, N.J., 19 → C. Snow, *Child Dev.* **43**, 549 (1972).
51. L. Bloom, L. Rocissano, L. Hood, *Cog. Psychol.* **8**, 521 (1976).
52. C. Fillmore, *On Deixis* (Indiana Linguistics Club, Bloomington, 1973), vol. 9, p. 269.
53. D. Stern, J. Jaffee, B. Beebe, S. Bennett, *Ann. N.Y. Acad. Sci.* **263**, 89 (1975).
54. These analyses were performed by R. J. Sanders. Each tape was transcribed by the teacher who worked with Nim (L. Petitto, four tapes; R. Sanders, four tapes; J. Butler, one tape; W. Tynan, one tape). Only single signs and linear combinations were used in our discourse analysis. They accounted for 95 percent of the transcribed utterances. An informal check of the remaining 5 percent (simultaneous combinations and contractions) indicated that the results would remain the same if all of Nim's utterances were included in the analysis. In order to check the reliability of our transcripts, short segments of five tapes were transcribed by two independent transcribers, both of whom were teachers from the project. The average agreement between the two transcribers was 81.8 percent.

54a. M. McIntyre "Learning to take your turn in ASL," unpublished manuscript.

55. L. Bloom, personal communication.
56. U. Bellugi, personal communication.

56a. C. Baker [in *On the Other Hand: New Perspectives on American Sign Language*, L. A. Friedman, Ed. (Academic Press, New York, 1977)] notes that, in some instances the "speaker's" sign overlaps with the "addressee's" sign, for example, the last sign of a question is held momentarily. However, Baker (personal communication) observes that this kind of overlap is not regarded as an interruption and that interruptions in dyadic signing pairs are as infrequent as interruptions in dyadic oral pairs.

57. *The First Signs of Washoe*, WGBH Time-Life, Nova (Time-Life Films, New York, 1976).
58. *Teaching Sign Language to the Chimpanzee: Washoe*, produced by R. A. Gardner and B. T. Gardner (Psychological Cinema Register, University Park, Pa., 1973), No. 16802.
59. The transcripts of Washoe signing with her teachers (Tables 6 to 9) were prepared by L. A. Petitto and verified by H. S. Terrace. In preparing our transcripts we followed the practice of psychologists and linguists studying sign language acquisition by deaf children, reviewing each utterance in normal and in slow motion. It should be clear that static descriptions of isolated signs (Tables 6 to 9 and Figs. 5 and 6) cannot convey information about movement. Such information would be crucial, for example, in distinguishing between signs where repetition influences their meaning ["double bounce" signs described in (*30*)]. Our reviews of both films of Washoe yielded no instance in which the addition of information about movement would alter the interpretation of Washoe's or her teachers' signing. With the one exception noted in Table 7 and Fig. 5, the segments we analyzed were unedited. Our transcripts and tracings show all of the teacher's and Washoe's signs, at the earliest time at which they were discriminable during the segments we selected. Since the films we analyzed consisted of edited segments, it was not possible to establish a single temporal reference for the occurrence of each sign. In transcripts, the time of occurrence of each sign was specified with respect to the first sign of that portion of the transcript (arbitrarily designated 00:00). Time was measured by counting the number of frames between the beginning of each scene. The frame numbers in the transcript refer to the frames of the figure in this text that show a tracing of the sign. In Tables 6 to 9, the beginning and the end of each utterance is marked by back slashes. Other behavior is described in parentheses. Tracings were prepared by L. Roberts.
60. The Gardners have not presented evidence that Washoe understood the meaning of the sign *time*. In this and in other examples of its usage, it seems as if Washoe learned that it was an appropriate response when requesting food or some other incentive [the Gardners' description of the usage of time (*1*, p. 266)].
61. P. S. Dale, *Language Development, Structure and Function* (Holt Rinehart & Winston, New York, 1976).
62. T. G. Bever, in *Georgetown University Round Table on Languages and Linguistics*, D. P. Dato, Ed. (Georgetown Univ. Press, Washington, D.C., 1975), pp. 63–75.
63. H. S. Terrace, *J. Exp. Anal. Behav.* **31**, 161 (1979).
64. ———, *Bull. Psychon. Soc.* **9**, 269 (1977); R. O. Straub, M. S. Seidenberg, T. G. Bever, H. S. Terrace, *J. Exp. Anal. Behav.* **32**, 137 (1979); R. O. Straub, thesis, Columbia University (1979).
65. J. Limber, *Am. Psychol.* **32** (No. 4), 280 (1977); → G. Mounin, *Curr. Anthropol.* **17** (No. 1), 1 (1976); M. S. Seidenberg and L. A. Petitto, *Cognition* **7**, 177 (1979).
66. B. F. Skinner, *Verbal Behavior* (Appleton-Century-Crofts, New York, 1957).
67. Our experience also suggests that in attempting to extend the mastery of sign language beyond that which we observed in Nim, it is important to guarantee that the subject of this type of study be raised and taught by a small and stable group of teachers [see (*17*)].

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