Children's Language

VOLUME 2.

Edited by

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,.GARDNER PRESS, INC., NEW YORK

Distributed by Halsted Press
Division of John Wiley & Sons, Inc.

NEW YORK LONDON SYDNEY TORONTO

ON THE GRAMMATICAL CAPACITY OF APES'

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INTRODUCTION

The innovative studies of the Gardners (1969, 1975a, 1975b) and Premack (1970, 1971, 1976) show that a chimpanzee *(Pan troglodytes)* can learn substantial vocabularies of visually differentiated "words." The Gardners taught Washoe, an infant female chimpanzee, American Sign Language'. Premack taught Sarah, a juvenile female, an "artificial" language of plastic chips of different colors and shapes, in a related study, Rumbaugh (1977) taught Lana, also a juvenile chimpanzee, to use an artificial visual language called "Yerkish." These and other studies show that the shift from vocal to visual symbols can compensate effectively for the chimpanzee's inability to articulate many sounds. That inability alone might account for earlier failures to teach chimpanzees to communicate via a spoken language (cf. Hayes, 195 ! ; Hayes & Hayes, 1951; Kellogg, 1968; Kellogg & Kellogg, 1933; Khouts, 1935).

Washoe, Sarah, and Lana each acquired vocabularies of more than 100 symbols in their respective languages. The psychologists who trained these chimpanzees interpreted the words of their subjects' vocabularies just as they would the corresponding words of human languages: as names of people and objects, actions, attributes, and various relationships. In subsequent studies, other chimpanzees acquired similar vocabularies, although of smaller size (Fours, 1972; Gardner & Gardner, 1975b; Premack, 1976; Temerlin, 1975). A current study reports that an infant female gorilla (Koko) has acquired a vocabulary of more than 400 signs in American Sign Language (Patterson, 1978).

The words taught to each of these apes were symbolically arbitrary in the sense that it was not generally possible to infer their referents from their form. In Sarah's language, for example, the word *apple* was a triangular piece of blue plastic. In Yerkish, the word *apple* is a nonsense geometric form on a red background'. In American Sign Language (ASL), *apple* is made by pressing the knuckle of the index finger into the cheek and twisting forward. The signs of ASL may not be as arbitrary in form as spoken words. It is nevertheless difficult and usually impossible for a naive ~b-server to guess the meanings of signs (cf. Beilugi & Klima, 1976; Hoemann, 1975b).

Human language makes use of two easily isolable levels of structure: the *word* and the *sentence.* The meaning of a word is flexible and arbitrary across languages and dialects. This characteristic of words stands in contrast to the immutability of signals in animal communication. Many bird species, for example, sing one song when in distress, another song when courting mate, and still another when asserting their territory. As far as we know, birds are unable to produce other songs in these situations. Such rigidity is true of other genera; for example, bees communicating about the location and quality of food and sticklebacks engaging in courtship behavior (cf. Thorpe, 1961; Frisch, 1954; Tinbergen, 1951).

Human language is most obviously distinctive because of a structural level which subsumes the word: the sentence. It suffices here to note that 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, and object (see Bevel Katz, & Langenden, 1975; Burt, 1971; Chomsky, 1965; Gross, Halle, & Schutzenberger, 1973; Katz & Postal, 1964; Lakoff, 1972; and McCawley, 1968, **for** additional discussion). Unlike words, whose meanings can be learned one by one, most sentences are not learned individually. Instead, children master grammatical rules that allow new meanings to be created by arranging, rearranging or inflecting a set of words or by substituting other appropriate words (for example, *John hit Bill* vs. *Bill hit John; the owner's cat* vs. *the cat's owner, John ate the apple; Bill chased the cat; John, who ate the al~-pie, chased the cat's owner).*

Psychologists, psycholinguists, and linguists are in general agreement that knowing a human language entails knowing a grammar. How else can one account for the child's ultimate ability to create an indeterminately large number of meaningful sentences from a finite number of words? There less agreement, however, on the nature of the grammatical systems that humans use to speak and understand sequences of words. It is still unclear to what extent grammars are learned (cf. Jenkins & Palermo, 1964; Skinner, 1957; Staats, 1968) and to what extent they are the specific expression of an "innate language acquisition device" (Chomsky, 1965). It is also unclear

whether a child's first sentences are best characterized by semantic (Bowerman, 1973b) or by syntactic rules (Bloom, 1970, 1973; Brown, 1973). These controversies provide the background for a simpler but equally controversial question about human language. Is the ability to create and understand sentences uniquely human? Chimpanzees and gorillas can communicate with humans via arbitrary "words," an ability denied them prior to the studies of the Gardners and Premack (e.g., Lenneberg, 1971; Bronowski & Bellugi, 1970). It is therefore natural to ask whether apes can produce and understand *sequences* of words whose structure is governed by a grammar.

The Gardners (1975b), Premack (1976), Rumbaugh (1977), and Patterson (1978) have each claimed that the symbol sequences produced and understood by their pongid subjects were governed by grammatical rules. The evidence consists of the production of different sequences of words (for example, *Washoe more eat, Mary give Sarah apple)* and specific behaviors which follow an instruction presented as a sequence of words (for example, putting an apple in a pail following the instruction: *Sarah applepail insert).* In each case, these sequences of words were regarded as sentences.

If an ape can truly create a sentence, there would be a strong basis for asserting, as Patterson (1978, p. 95) has, that "language is no longer the exclusive domain of man." The purpose of this chapter is to summarize a large body of data we have collected concerning a chimpanzee's ability to create sentences in ASL. A major segment of these data is a corpus of multisign utterances, the first such corpus to be obtained from an ape. Superficially, many of these utterances seem like sentences. However, careful analyses of our data, as well as of those extracted from 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 simpler nonlinguistic processes.

After presenting the results of our study, we will review briefly the results of other recent studies that claim to demonstrate that an ape has the ability to create sentences. At this point we simply note an important limitation of the Gardners' analyses of Washoe's sign combinations which makes it impossible to examine their structure. That limitation is symptomatic of much research in this area and serves as the point of departure of our study.

With but a few exceptions, the Gardners' publications do not distinguish explicitly between Washoe's multisign combinations which contained the same signs in diffe/'ent orders (Gardner & Gardner, 1974a, 1974b, 1978). For example, the relative frequencies of *more tickle* and *tickle more* were not reported. Thus, the Gardners' published data provide an quate basis for deciding whether Washoe's multisign combinations obeyed rules of sign order. Nor in our view do the Gardners provide compelling evidence that Washoe understood how the signs of her sequences were related tO one another. One could conclude that Washoe had learned that both

more and *tickle* were appropriate ways of requesting another bout of tickling and that she signed both signs because of her prior training to sign each sign separately.

A widely cited example of Washoe's ability to create new meanings through novel combinations of her signs is her utterance, *water bird.* Fours (1975) reported that Washoe signed *water bird* in the presence of a swan when she was asked *what that?* Washoe's answer may seem creative in that it names a new referent by juxtaposing two signs from her vocabulary. English word order notwithstanding, it is risky to conclude 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 before or after a noun. Accessible, systematic observations are needed rather than anecdotes, no matter how compelling those anecdotes may seem to an English-speaking observer. The same qualification applies[1] to other acts of creativity attributed to Washoe (e.g., *cry hurt food* for radish) and to Koko (e.g., *cookie rock* for a stale sweet roll and *eye hat* for a mask).

Word order is but one of a number of ways in which sentences can encode different meanings. In a language of specific hand configurations,t body movements, and facial expressions such as ASL, spatial organization and nuances of movement provide additional devices for encoding meaning'. Thus sign order per se is not the only way to demonstrate that sequences of signs were generated by a grammatical rule. When, however, regularities of sign order can be demonstrated, it does provide strong evidence for the existence of grammatical structure. (Even regularities of sign order would not be a conclusive demonstration unless evidence of appropriate semantic structure were provided. 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.)

PROJECT NIM

The purpose of the present study is to analyze the multisign sequences of a chimpanzee from an objective point of view. A basic goal was to amass a large enough corpus of a chimpanzee's utterances to determine if its multisign utterances are regularly ordered. Our subject was a male chimpanzee, Neam Chimpsky ("Nim" for short). From the age of two weeks, Nim was~

raised in a home environment by human surrogate parents and teachers who communicated with him and among themselves in ASL (see note 2). During his waking hours, Nim was always in the company of at least one project member.

Some observers have claimed that natural languages are "ill-defined" (Premack, 1976). We nevertheless chose to teach our chimpanzee ASL because ordinarily, language is a concommitant of an infant's socialization--as "ill-defined~' as such socialization may be. More so than an artificial language, a natural language makes it possible to interact with an infant chimpanzee the way that parents interact with a child. Clearly, the complex nature of socializing an infant makes it difficult to specify all of the variables that bear on language development. It is also difficult to say just how different Nim's socialization was from that experienced by children. Our purpose, however, was not to delineate *how* Nim learned sign language, but to see what features of a natural language he could master. It was also our belief that intensive socialization would increase Nim's motivation to please. If Nim tried to please by signing, his motivation for using language would be considerably more diverse than the motivation of cage-reared subjects whose only obvious reason to use language is to acquire objects they can ingest or play with.

History and Socialization

Nim was born on November 21, 1973, at the Institute for Primate Studies in Norman, Oklahoma'.

On December 3, 1972, Nim was flown to New York accompanied by Mrs. Staphanie LaFarge who, along with her family, raised Nim in their home on New York's West Side6. Between August 15, 1975, and September 25, 1977, Nim lived in a large house (Delafield) with private grounds in Riverdale, N.Y. At Delafield, Nim was cared for by four undergraduate students who had spent long periods of time with Nim at the LaFarge house. As a result, the move from the LaFarge house to Delafield occurred smoothly and without any sign of emotional stress on Nim's part. At Delafield, the living space was separated into two areas which overlapped only in the kitchen. In Nim's area, there were rooms for sleeping, eating, and recreation. The remainder of the living area at Delafield was used by the human residents and was off limits to Nim.

Nim formed particularly close attachments with certain members of the project. The first author 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, Stephanie LaFarge was the most central person in Nim's life. Following his move to Delafield, Nim became closely attached to the second author, who supervised his care both at Delafield and

in a special classroom built for Nim in the psychology department of Columbia University. After the second author left the project (when Nim was 34 months old), Nim became closely attached to two resident teachers at Delafield, Bill Tynan and Joyce Butler. An extensive account of Nim's socialization is provided elsewhere (Terrace, 1979b).

From the time Nim was two months Old, he was visited regularly by volunteers recruited mainly from Columbia University and Barnard College. These volunteers, all of whom had some training in ASL, tried to teach Nim to sign through various activities such as looking at pictures, playing with dolls and mirrors, preparing meals, and so on. The volunteers also signed to Nim and tried to mold (cf. Fours & Goodin, 1974; Gardner & Gardner, 1969) his hands into the configurations of different signs. From September 1974 until August 1977, Nim was driven to his classroom at Columbia three to five times a week. The classroom was a small, bare room approximately eight feet square. One wall of the classroom contained a large one-way mirror which allowed observers in an adjacent room to observe Nim without being seen. Beneath the one-way mirror was a portal which could house various cameras used to photograph Nim's signing. Across from the classroom and the observation room was another small area in which Nim was allowed to recreate during breaks from the classroom.

During a typical day, Nim was taught by a number of different teachers. All teachers were encouraged to emphasize those activities and objects which were conducive to signing and which maintained Nim's attention. At Delafield, Nim's caretakers (who also taught in the Columbia classroom) involved him regularly in such everyday activities as food preparation, eating, laundry, and cleaning. Nim also ate all of his meals with one or more of his companions. These activities provided opportunities for lengthy exchanges in ASL.

In the classroom Nim was given intensive instruction in both the expression and the comprehension Of signs. Nim was also taught regularly at Delafield, albeit 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 below.

During the 46 months in which he lived in New York, Nim was taught by 60 nonpermanent volunteer teachers. As he grew older, it became increasingly difficult to arrange for the kind of overlap between new and old personnel which had been possible when the responsibility for supervising Nim's day-to-day existence transferred from Stephanie LaFarge's family to the resident teachers at Delafield. Because of Nim's emotional reactions to some of those changes it also became increasingly difficult for new teachers to command Nim's attention (Terrace, 1979b). 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 September 25, 1977, Nim was flown back to his birthplace in Oklahoma.

Training Methods

Nim was trained to sign by an eclectic method. His teachers were familiarized with a small number of techniques and then encouraged to use whatever technique(s) they found most comfortable to work with. Our basic method was unodeled after the "molding" and "guidance" techniques developed on other projects (cf. Gardner & Gardner, 1969; Fouts & Goodin, 1974); the trainer physically molded Nim's hands into the appropriate configuration. In most instances, we molded the sign in an appropriate context. Some signs, especially those which required fine and complex movements, were taught by first molding the new sign out of context. Teaching the sign out of context was especially important in situations in which Nim's attempt to reach for the desired referent interfered with our efforts to mold his hands (for example, the signs *book, shoe,* and *apple).*

Typically, Nim reached for something he might want to play with, eat, or inspect. The teacher withheld the item, molded the object's name sign, and then asked Nim to sign for the object. Signs such as *give. me.* and *Nim,* while appropriate, were deemed unacceptable when we were trying to teach Nim a new sign. Since the age of 18 months, Nim often offered his hands to his teacher in an apparent request for the teacher to mold the new sign that the teacher wanted him to use.

Nim's signs were classified in three mutually exclusive categories. An *imitative* sign is one which repeated the teacher's immediately prior utterance. A *spontaneous* sign is one which did not occur in the teacher's immediately prior utterance. A *prompted* sign was a sign of the teacher's immediately prior utterance that used only part of the sign's configuration, movement, or location. For example the sign *Nim* (first and second fingers drawn down the temple) might be prompted by the teacher's extending those two fingers from a fist held in front of the signer or by touching the signer's temple with a finger. By age 30 months, Nim began to learn new signs by imitation. In the context of the desired object, such as a baby doll, the teacher withheld the object, pointed to it, and then signed *baby.* Nim responded by imitating the teachers sign; often Nim made the new sign spontaneously.

Nim was given food and drink objects only when he was being taught a sign about a particular food or drink. Other signs were rewarded by praise (for example, the teacher signed *good* or *correct),* by social reinforcers (such

as a smile or a hug from the teacher), by access to an object (such as a book or a cat), or by the opportunity to carry out an action (such as running or jumping). Even when Nim signed about a particular food or drink, he was not necessarily rewarded with a sample of what he signed about. Often Nim was asked only about the color of a food or a drink or about its similarity to other food and drink objects which the teacher presented. After noting Nim's response, the teacher simply shifted to another activity. During picture-labeling sessions, Nim signed regularly about pictures of food and drink objects, with little apparent interest in obtaining these objects. His only reward for signing about such pictures was occasional praise from his teacher. Nim was also observed to sign about pictures when looking at them on his own, without attempting to involve the teacher.

Data Collection

In many respects our methods of data collection paralleled those used in sludies of the development of language in children (cf. Brown, 1973). The main goal was to obtain an extensive corpus of Nim's utterances that would allow one to go beyond anecdotal examples of an ape's apparent linguistic ability.

During each session, Nim's teacher whispered into a miniature cassette recorder the pertinent details of Nim's signing. As soon as possible after their sessions. Nim's teachers transcribed their tapes and wrote detailed reports about the signs Nim made, the context in which they occurred, and other aspects of Nim's behavior. Our transcription forms included sections covering developmental data, unusual sign exchanges or sign configurations, and a record of dialogues between Nim and his teacher. The sign record was supplemented by notations on context, references, and so on to aid in subsequent in[~fpretation.

In recording Nim's signs, his teachers distinguished among signs which were spontaneous, imitated, prompted, molded, or approximations of the correct sign. Occasional reliability checks were made by comparing teachers' reports with those of independent observers who watched Nim and his teacher through the one-way window of the classroom. The reliability of teachers' reports was also assessed by comparing transcripts of videotapes with a teacher's transcript of the same session. In some instances, transcripts were prepared by professional interpreters of ASL~who had aever seen Nim sign prior to their viewing of the videotapes.

Agreement between a teacher's report and the transcript of indepenct-ent observers and videotapes ranged between 77 percent and 94 percent. There was almost perfect agreement between the teacher's and the independent observers' interpretation of each recorded sign. Typically disagreements between a teacher's report and the independent assessments occurred when the teacher failed to record a sign. This often happened when the~

teacher was busy preparing an activity, when Nim was signing too quickly, or when the teacher was signing to Nim. At worst, the teachers' reports underestimated the extent to which Nim signed. There was, however, no evidence that the omissions of the teacher were systematic. Thus, teachers' reports appear to provide an objective sample of Nim's signing, with the qualification that they underestimate slightly the frequency of his signs'.

Vocabulary

Expressive vocabulary

As of September 25, 1977, Nim had acquired 125 signs. Nim satisfied our criterion of acquiring a sign when, (a) on different occasions, three independent observers reported its spontaneous occurrence, and (b) it occurred spontaneously on each of five successive days.

The sequence and the rate at which he learned these signs are shown in Figure 8-1'. Nim acquired his first sign, *drink,* on March 2, 1974, at which time he was four months old. During the next four months, Nim acquired five other signs *(up, sweet, give, more,* and *eat).*

Between the ages of 19 and 34 months, Nim learned new signs at a rate of 1.4 signs per week. If Nim continued to learn new signs at that rate, he would have had a vocabulary of 250 words by the time he was 5 years old. Nevertheless, it seems probable that Nim could acquire signs at an even faster rate. Until Nim's last year in New York, most of his teachers were not highly fluent in sign language'. A more serious problem was the large number of teachers (60 in all) with whom Nim had to contend.

How Nim's rate of sign acquisition can be influenced by the teachers who worked with him can be seen by comparing two time periods (June 1975-September 1976, age 19-34 months; and September 1976-February 1977, age 34-39 months). During the first period; Nim was taught by a relatively stable group of teachers (Walter Benesch, Andrea Liebert, Laura Petitto, and Amy Schacter). When they had to be replaced, Nim's rate of acquisition decreased from 1.4 to 0.3 signs per week. Once Nim adapted to his new teachers, he acquired signs at a rate of 1.0 signs per week. During Nim's last two months in New York, he learned new signs at the rate of 2.0 signs a week. The rate at which Nim acquired new signs seems to reveal as much about his teachers as it does about his actual ability to master new signs.

Usage

Nim's day-to-day usage of signs was determined by his needs, the demands of his teachers, and the situations to which he was exposed. As far as we could tell, the main (and perhaps only) reason for a sign to drop out

of Nim's day-to-day vocabulary was that a situation was not set up in which the sign was likely to occur. For example, once Nim learned to sign *dog,* he would regularly make the sign when he saw a dog or a picture of a dog. If Nim did not come in contact with a dog for several days, the sign did not occur. However, in this and in other instances, it was relatively easy to reestablish the sign simply by restoring the appropriate circumstances that occasioned its occurence.

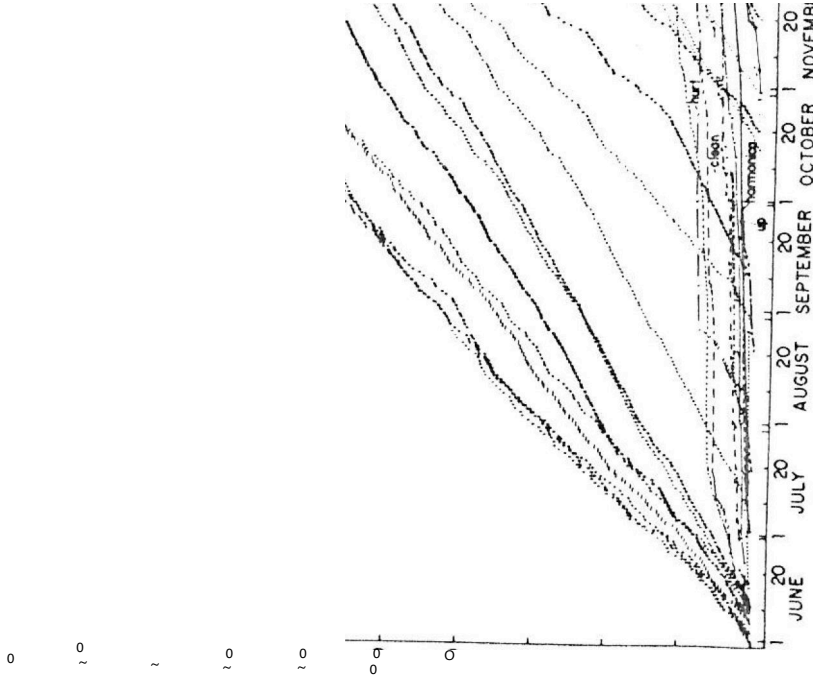
Figure 8-2 shows the number of days on which each sign of his vocabulary was observed to occur during an early phase of the project[10]. Generally, once a sign was acquired, it occurred each day. The few exceptions can be attributed to the absence of a demand that a sign be used (for example, *clean, hurt, ball, harmonica, up). Harmonica* was prevalent during the tenure of a volunteer teacher who worked with Nim for only three months. After that teacher left, the frequency of *harmonica* decreased sharply. *Hurt* was used only when Nim hurt himself or when he noticed a scratch or scar on someone else. As Nim became more mobile, he signed *up* (and *down)* less frequently". During the phase of the project shown in Figure 8-2, *ball* and *clean* were rarely called for in the classroom and only sporadically at home.

As Nim's vocabulary grew, it became increasingly difficult to maintain all of the signs on a daily basis. Accordingly, the relative frequency with which particular words were signed did not remain constant. Table i shows the rank and the absolute frequencies of Nim's most frequent 25 signs during five periods between June 1, 1975 and February 7, 1977. Also shown in Table I are the number of different signs Nim was observed to make during each period.

Comprehension of signs

The task of evaluating what words a child or chimpanzee understands poses problems which, in practice, are seldom encountered in evaluating what words they express. When evaluating expressive ability, it is usually only necessary to observe whether a particular sign occurred and in what context. In evaluating comprehension, however, it is essential to devise behaviorial tasks which show that comprehension is specific to the sign, and not to some other cue that the teacher may be transmitting (cf. Bever, 1970; Brown, 1973; Fodor, Bever, & Garrett, 1974; Macnamara, 1972) If, for example, the teacher signed *book,* Nim may pick up the book, not because he understands *book,* but because the teacher was looking at the book.

In most instances our basis for concluding that Nim could comprehend a sign came from tests performed in the classroom. For example, his teacher would arrange Nim's brush, a bottle of hand cream, a mirror, and other grooming articles on the floor. Nim was positioned beside his teacher,



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equidistant from each item. The teacher signed, *Nim give me hand cream,* deliberately not looking at or pointing at the object in question. Nim reliably walked across the room, got the hand cream, and brought i! to the teacher. If the teacher signed, *Nim give me brush,* Nim walked over, picked up the brush, and placed i1 next to the teacher.

Another variation of this procedure was to present Nim with a closed but familiar book. The teacher then signed,/Vim *where banana?* or *show me banana.* Nim often responded by looking through the book, finding the picture of the banana, and placing the book with he page open to the banana in front of his teacher. He then signed *banana* and pointed to it.

Table I

Twenly-five Most Frequent Signs During Each Period

	Period I 16/1/75- 17./20/75)		Period II 11/5- 2/29/76)		Period III (3/I- 3/29/75)		Period IV 14/5- 714/76)		Period V (7/5/76- 2/7177)	
	Rank Sign Freq.		**Rank Sign I"req.**		**Rank Sign Freq.**		**Rank Sign Freq.**		**Rank Sign Freq.**	
I	eat	360	1 me	169	I play	219	I play	767	I hug	1650
2	tickle	356	2 play	156	2 hug	174	2 eat	515	2 play	1545
3	drink	327	3 hug	]38	3 me	169	3 hug	440	3 finish	1103
4	more	320	4 tea	99	4 eat	137	4 drink	321	4 eat	951
5	open	299	5 more	75	5 give	I01	5 Nim	273	5 dirty	788
6	brush	256	6 drink	73	6 banana	99	6 me	267	6 drink	712
7	hand cream	234	7 eat	65	7 tickle	94	7 Open	211	7 out	615
g	give	229	8 tickle	62	8 drink	87	8 angry	205	8 Nim	613
9	shoe	196	9 Nim	56	9 more	85	9 tickle	186	9 open	554
i 0	play	186	I 0 banana	50	I 0 Nim	81	]0 toothbrush	166	IO tickle	414
I I	me	157	I I nut	39	!1 tea	73	II bite	165	I I bite	407
12	apple	98	12 sorry	38	12 water	58	12 gum	162	12 shoe	405
13	hat	75	13 open	37	13 apple	51	13 banana	145	13 pants	377
14	toothbrush	68	14 give	36	14 hot	50	14 chair	144	14 red	380
15	banana	63	15 water	35	15 jump	41	15 sorry	140	15 sorry	366
16	water	56	16 you	33	16 cracker	38	16 groom	139	16 angry	354
17	hug	50	17 smell	32	17 listen	35	17 red	138	17 me	351
18	ball	40	18 loothbrush	28	19 brush	33	18 book	136	]8 banana	348
19	hurt	33	19 brush	77	19 gum	33	19 water	133	19 nut	323
20	dog	26	20.5 hat	26	19 open	33	20 nut	127	20 down	316
21	down	24	20.5 shoe	26	21 hat	30	21 jump	120	2! toothbrush	302
22	gum	22	22 apple	24	22.5 you	29	22 give	I18	22 change	301
23	Nim	22	23 hand cream	23	22.5 orange	29	23 handcream	I15	23 grape	239
24	orange	20	24 groom	19	24 toothbrush	28	24 tea	III	24 sweet	236
			25.5 in	15						
25	come	18	25.5 sweet	15	25 dog	25	25 Andrea	106	25 apple	228

Total Number of Different Signs Observed in Period 33

While there is no limit to the fineness of tests of comprehension, we felt that our tests adequately demonstrate Nim's responsiveness to specific signs. In each case, his behavior was both appropriate and immediate, in many of our tests, it was possible for alternative modes of behavior to have taken place as, for example, looking for a picture of an object in a picture book. A list of signs that Nim comprehended, as determined by tests administered independently by at least two of his teachers, appears in Table li.

Some anecdotal observations of Nim's use of sign language

The main goal of Project Nim was to collect a corpus of sign combinations which would allow us to assess their structure. While collecting our basic data, we also observed a number of interesting usages of sign ian~ guage. Some have not been reported in other studies of an ape's ability to learn a language; others have been given a different interpretation, in con-~ sidering our observations the reader should keep in mind their anecdotal nature. Even though each usage we will describe was reported independently by at least four of Nim's teachers, these observations were not subjected to experimental manipulation.

Emotional expression. The study of private events in humans poses an obvious problem: how can one establish that a verbal report about an internal state is an expression of that state and not a device to manipulate the listener's behavior (cf. Skinner, 1945)? Through language, one can often query the speaker and thereby obtain additional clues as to the veracity of the speaker's description of an internal state. The listener can also judge from the speaker's bodily expressions and overall behavior whether the speaker's statements about a bodily state are credible.

In attempting to communicate with nonhuman species, a human listener has few options for evaluating utterances about a bodily state. The main source of information is the subject's overall behavior. There's little basis for expecting the subject to reply to queries about its feelings (cf. Terrace & Bever, 1976). With these qualifications in mind let us consider a number of instances in which Nim appeared to use sign language as a means of emotional expression and some instances in which he appeared to misrrepresent certain bodily states.

Nim learned the signs for *bite* and *angry* with the aid of photographs showing an actor making an angry face, and, in a different scene, attempting to bite someone's hand. Without any specific training to do so, Nim began to sign *bite* and *angry* during confrontations with his teachers. In many instances Nim signed *bite* or *angry* while on the verge of attacking his teacher. Before signing *bite* or *angry* he appeared ready to bite or attack: his lips were pulled back over his bare teeth, he ran toward the target of aggression, and his hair was often erect. After signing *bite* Nim appeared to relax and showed no further interest in attacking the target of his anger. On

Table II
Signs Nim Comprehends

afraid	door	light	shoe
airplane	down	listen	sign
alone	draw	little	sit
Andrea	drink	look	sleep
angry	ear	make	smell
apple	easy	Mary	smile
attention	eat	match	sock
baby	egg	me	sorry
bad	eye	mine	spaghetti
ball	fall	mirror	spoon
balloon	false	more	squirrel
banana	finish	mouse	stand up
bell	first	mouth	slay
berry	fish	music	Steve
big	flower	napkin	stop
Bill	fruit	Nim	Susan
bird	give	no	sweet
bite	go	nose	swing
black	good	now	table
blue	goodbye	nut	take out
Bob	grape	on	taste
book	green	one	lea
bowl	groom	open	leer h
box	gum	orange	telephone
bring	gym	out	thirsty
brown	hand cream	paint	throw
brush	handkerchief	pants	tickle
bug	happy	paper	time
butterfly	harmonica	peach	toilet
camera	harness	pear	toothbrush
car	hat	peekaboo	toys
cat	hello	plant	train
chair	help	play	tree
change	Herb	play key	under
clean	here	point	up
climb	hot	pole	wagon
close	house	pool	wait
coat	hug	pour	walk
color	hungry	powder	Walter
come	hurry	pull	want
cookie	hurt	put-in	wash
crayon	ice	quiet	water
cup	i n	raisin	what
cut	Joyce	red	where
diaper	jump	Renee	who
Dick	key	right	window
dirty	kiss	rock	with
dog	later	run	work
don't	Laura	shirt	yellow
	lie down		yes
			you

some occasions, Nim was observed to sign both *bite* and *angry* as a warning. Such warnings were not followed by a full display of aggression or anger.

These observations suggest that the signs *bite* and *angry* may have functioned as substitutes for the chimpanzee's natural expression of aggres. sion. Unfortunately, the evidence that is needed to demonstrate this function of language is not complete. We do know that, unless he was restrained from doing so, Nim would often bite or attack someone when he exhibited an aggressive posture. After signing *bite* or *angry,* Nim's tendency to inflict "physical damage seemed greatly reduced. But we have no way of knowing to what extent Nim would have actually attacked someone he threatened when he didn't sign *bite* and *angry.* Often when a teacher responded to Nim's physical threat by signing *stop* or *careful.* Nim backed down and became quite docile. It may also be the case that *bite* and *angry* were signed during weak states of arousal and that Nim was able to inhibit his impulse to attack without actually signing *bite* or *angry.* Further clarification of this issue requires an experiment which would pose both practical and ethical difficulties. One would want to create a situation in which Nim reliably attacked a person or an object. If Nim refrained from attacking after signing *bite* or *angry* (either spontaneously, or in response to questions such as *what you feel?.),* one could conclude that an arbitrary symbol functioned as a substitute for physical impulse.

Sorry was another "emotional state" that Nim signed about, particularly after misbehaving (e.g., nipping someone's hand, jumping around too much in the classroom, or breaking a toy). Nim was often observed to sign *sorry* before his teacher reacted to his transgression. From Nim's troubled expression (a protruding lower lip and fear vocalizations), it was apparent that Nim's use of *sorry* was motivated by his anticipation of being reprimanded. *(Sorry* also appears in the expressive vocabularies of Washoe and Koko [Gardner & Gardner, 1975b; Patterson, 1978],)

Two of Nim's signs were used to misrepresent bodily states. Once he was toilet trained, Nim learned to sign *dirty* when he wanted to use the toilet (Terrace, 1979b). Nim also learned the sign *sleep* when he wanted to go to bed. Normally, Nim was taken to the bathroom after having signed *dirty,* and allowed to take a nap or go to his bedroom, having signed *sleep.* Having learned to sign *dirty* and *sleep* when appropriate, Nim began to make these signs when they were clearly inappropriate. For example, within minutes of having urinated and/or defecated, Nim often signed *dirty.* Likewise Nim signed *sleep* while showing every sign of being fully alert.

The misuse of *dirty* and *sleep* seemed motivated by a desire to change the situation. For example, when Nim looked bored he was prone to sign *dirty* or *sleep.* Symptoms of Nim's boredom included his looking away from his teacher, running around the classroom, and otherwise resisting his teacher's efforts to focus his attention. The inappropriate use of *dirty* also

occurred when Nim wanted to delay his transfer to a new teacher. At first he resisted the transfer physically. If that effort failed, he signed *dirty* even though he had just used the toilet.

In instances in which Nim may have been misrepresenting his condition, his teachers often signed *you not dirty* or *you not sleepy,* or otherwise indicated that they were not fooled by Nim's sign. Nim's response to this teacher's signing provided additional evidence that Nim was not using *dirty* or *sleepy* appropriately. When challenged by his teacher after signing *dirty* or *sleep* inappropriately, he often backed down and abandoned his effort to be taken to the toilet or to be allowed to lie down. When Nim's expression of his need was genuine, he persisted in his signing even when challenged by his teacher. For example, he might sign *me out, dirty hug, /Vim point, me sleep,* and so on. In addition, his nonlinguistic behavior also revealed a strong motivation to satisfy his needs. Often he would stick out his lips and begin to pout. Following a genuine *dirty* or *sleep* sign that was not honored by his teacher, Nim took his teacher's hand and led the teacher to the potty or his bedroom respectively. Figure 8-3 shows Nim underscoring his need to use the toilet while signing *dirty.* In this instance, he removed his pants after his first *dirty* sign was ignored. In Figure 8-4 Nim is emphasizing his need to use the toilet by signing *dirty* with both hands. (Nim signed with two hands a sign which he normally signed with one hand, in order to emphasize other requests as well. A similar phenomenon has been reported by observers of sign language in deaf children [Klima & Bellugi, 1972]. Figure 8-5 shows Nim signing *apple* with one hand; Figure 8-6 shows him making the same sign with two hands.)

Development of sign topography from "'baby'" to "mature"form. In the case of some signs we accepted approximations of standard ASL signs which were referred to as "baby signs." Through the concerted efforts of his teachers, Nim was slowly weaned away from the baby configuration toward the adult version of the sign. A similar development has been observed in children who learned sign language as a first language (Schlesinger & Meadow, 1972). Figure 8-7 through 8-9 show Nim signing *more* when he was 2, 2 I/2, and 3 I/2 years old. At first Nim touched only the index fingers of each hand (Figure 8-7). Later he touched the index fingers and the remaining fingers but in separate groups (Figure 8-8). Eventually he learned to sign the standard form of *more* (Figure 8-9). Other signs which went through a similar evolution were *eat, open, come, me, tea, smell* (see Terrace, 1979b, Appendix C for additional detils).

Topographical vs. semantic errors. Another interesting example of systematic variation in Nim's signing can be seen in errors of topography. Our meager data on such errors also point to some interesting similarities between sign language as practiced by humans and by Nim. The nature of these errors is most easily appreciated by considering how humans re-

Figure 8-3. Nim underscoring his need to go to the bathroom by signing *dirty.*

Figure 8-4. Nim signs *dirty* with both hands (Photos by H,S. Terrace).

Figure 8-5. Apple produced with one hand.

Figure 8-6. Apple produced using both hands.

t,

7„:

Figure 8-7. 2 years; *more.*

Figure 88. 2t/2 years; *more.*

7

Figure &g. 31/2 years; *more* (photos by H.S. ***Terrace).***

member a list of unrelated words (e.g, *bad, cat, big* and so on). Typically, the errors that occur in this process are phonetic and not semantic (Conrad, 1964). Words like *pad* are substituted for *bad* instead of words like *rotten* or *wicked; cap* might be *substituted* for *cat* instead *of pet or feline; pig* might be substituted for *big* rather than *large* or *huge,* and so on. Phonetic errors in list learning of spoken words have an analog in the list learning of signs (Bellugi & Klima, 1976, 1979). Signs which are made in a similar fashion are often substituted for one another; for instance, *potato* for *time,* and *vote* for *tea.*

In learning to make the name sign of the senior author, Nim often signed variations of *ca/,* a sign which is topographically similar to *Herb.* Having learned"to sign *Herb,* Nim signed *Herb* while trying to sign *cat* and *cat* while trying to sign *Herb.* Figure 8-13 shows Nim signing *Herb* correctly. A mixture of the signs *cat* and *Herb,* where Nim is trying to sign *cat,* **can** be seen in Figure 8-10. Figure 8-11 shows Nim signing a one-handed *cat* sign while trying to sign *Herb.* Figure 8-12 shows Nim signing *cat* with one hand and *Herb* with the other, when it would have been appropriate to sign only *Herb.* Other pairs of topographically related signs whose components occurred in inappropriate situations were *rock-work, hot-drink, run-berry,* and *Bill-Andrea* (see Terrace, 1979b, Appendix C, for additional details).

Combinations of Signs

The major goal of this study was to determine whether a chimpanzee could create a sentence. To answer that question, we analyzed Nim's multi-sign utterances with an eye toward distributional and semantic regularities.

Figure 8-10. Nim signing a mixture of *Herb* and *cat* (photo by H.S. Terrace).

Figure8-12. Nim signing *Herb* with one hand and incorrectly signing *cat* with the other (photo by S. Kuklln).

Figure 8-11. Nim incorrectly signing *cat while trying to sign Herb* (photo by S. Kuklin).

Figure 8-13. Nim signing *Herb* correctly (photo by S. Kuklin).

Before we could argue that one or more structural rules account for Nim's multisign utterances, it was necessary to demonstrate that regularities of sign order and semantic usage could not be explained by simpler processes such as sampling artifacts, rote learning, or imitation.

A combination of signs was defined as the occurrence of two or more different signs which were not interrupted by the occurence of other behavior or by the return of the hands to a relaxed position (see Stokoe, Casterline, and Croneberg [1965] for a discussion of constituent boundaries in ASL). In ASL, the segmentation of signs into combinations has a function similar to that of the segmentation of speech into clauses in spoken language. Segmentation delineates word sequences which are immediately related to one another (Brown & Miron, 1971; Lane & Grosjean, 1973).

The corpus of combinations we analyzed consisted entirely of sequences of distinct signs which occurred successively. Such sequences accounted for approximately 95 percent of Nim's combinations. It is of interest to consider first two kinds of combinations which were *not* included in the corpus. These were contractions of two or more signs and simultaneous combinations in which two distinct signs occurred at the same time. Even though contractions and simultaneous combinations occur normally in ASL, they were excluded from our corpus because it was impossible to specify the temporal order of the signs they contained.

An example of a contraction can be seen in Figures 8-14 and 8-15,

Figure 8-14. NIm contracting the signs *more* and *drink* (photo by H.S. Terrace).

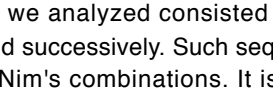

Figure 8-15. Nim signing *drink* (photo by H.S. Terrace).

which show Nim contracting the signs *more* and *drink.* In Figure 8-14, Nim's right hand forms the sign *drink* while his left hand makes a movement similar to the conventional *more* sign. Figure 8-9 above show a conventional *more* sign. In the contraction of *more* and *drink, more* is articulated at the mouth rather than in opposition to the other hand. in Figure 8-16, Nim is shown contracting the elements of two signs: *Nim* and *hug.* These signs are shown as they would occur separately in Figures 8-17 *(Nim)* and 8-18 *(hug).*

Examples of simultaneous signing can be seen in Figures 8-19 and 8-20. Figure 8-19 shows Nim signing *me* and *hat* simultaneously. Both *me* and *hat* were signed as they would be signed if signed separately. Figure 8-20 shows Nim signing three signs, *me, point,* and *hug. Me* and *point,* however, were signed simultaneously. In signing two distinct signs simultaneously, Nim has also been observed to maintain a particular sign with one hand while signing other signs with his other hand. Consider the following example from a video transcript made while Nim was asking for a grape and a sip of tea on January 17, 1977 (adapted from a transcript prepared by W. J. Tynan).

time(sec): 0 I 2 3 4 5 6 7 8 9 10 I I

I--I--I--[--I--I--I--I--I--I-- I--I

left hand: *drink Nim Nim eat ~ grape*

right hand: *me drink Nim tea*

Figure 8-16. NIm contracting the signs *Nim* and *hug* (teacher: Bill Tynan).

Figure 8-17. Nim signed in its normal form (teacher: Susan Quinby).

Figure 8-18. Hug signed in its normal form (Teacher: Bill Tynan). (Figures 8-16, 8-17, and 8-18 photographed in the Columbia classroom by H.S. Terrace.)

Figure 8-19. Nim signed *me* and *hat* simultan. eously in the classroom with the first author (photo by LA. Petitto).

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N I W

. . _ . . . . _

Figure 8-20. Left-hand panel: Nim signing *me* and *point* simultaneously. Right-hand panel: Nim completes utterance by signing *hug.* (Not visible is the cat Nim was trying to obtain.) Bill Tynan, the teacher, is dictating what Nim is signing. (Photographed at Delafield by H.S. Terrace.)

In this relatively simple example of simultaneous signing, Nim maintained the sign *eat* with his left hand while signing *me drink* with his right hand.

In each of the foregoing examples it should be clear that there is no basis for referring to the sequential nature of a particular combination. The contraction *more* and *drink,* and *Nim* and *hug,* could just as well have been referred to as *drink* and *more,* or *hug* and *Nim.* Likewise, there is nothing in Figures 8-10 through 8-15 which suggests that *me hat* or *mepoint* are more appropriate descriptions of what Nim is signing than *hat me* or *point me.*

Figure 8-21 shows a combination, me hug cat, in which there is no temporal overlap between any of the signs. This is the typical manner in which Nim combined signs. The corpus we will describe below consists exclusively of such linear combinations.

Nim's first documented combinations *(more drink* and *more eat)* occurred on March 3, 1975, at age 16 months. Since that time, he has made numerous combinations, some containing as many as 16 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. We must, of course, recognize that Nim's teachers exerted some influence on Nim's combinations.

Typically, they signed to him in stereotyped orders that were modeled after English usage. It may also be the case that some of Nim's teachers unwittingly gave 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 2-sign utterances: did Nim place particular signs in the first or the second position of 2-sign combinations? Having established that iexical regularities did exist in 2-sign combinations, we then examined these regularities for semantic relationships. The existence of semantic relationships was explored in a smaller corpus of 2-sign combinations for which we had comprehensive notes about the context of each combination. The results of these analyses were equivocal. Our final analysis, a "discourse" analysis, sought to relate Nim's signing to his teachers' signing. For that purpose we assembled a third corpus from video-ti-~th++cripts which provided reliable records of both Nim's and his teachers' signing.

In order to minimize the contribution of signs which were repeated successively, two rules were used to tabulate combinations containing successive repetitions of the same signs. The motivation for using these rules was to insure the shortest possible description of a particular combination. In "homogeneous combinations," if all signs in a sequence were the same (e.g., *eat eat eat),* the sequence was treated as a single sign utterance *(eat).* Homogeneous sequences of signs were not tabulated as combinations. In "heterogeneous sequences," if a particular sign repeated itself successively, in a heterogeneous sequence of signs, 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 5 signs, this combination was entered as a 3-sign sequence. We carried out this procedure to insure that we did not overestimate the length of Nim's utterances. In general the sign Y, repeated in succession n times, was counted as a single occurrence of Y, independently of the value of n. This same rule was applied in decidingt whether a sequence was a new type of sequence. Consider the sequence X, (Y)n, Z. This would be reduced to X, Y, Z. Accordingly X, Y, Z would be tallied as a new type of sequence only if the sequence X, Y, Z had not been observed previously. For example, if *banana me me me eat* (which is entered into the corpus as *banana me eat)* had been observed previously, the combination *banana me me me me eat* would not be considered as an instance of a new *type* of combination. In tabulating *tokens* of multisign sequences, *banana (me)n eat* would be counted as an instance of a 3-sign sequence' 3.

Corpus and distributional regularities

A corpus of linear combinations assembled through the application of the above rules consisted of 5,235 types of 19213 tokens of combinations of 2, 3, 4, 5, or more signs. This corpus included all linear combinations entered in teachers' reports between June l, 1975, and February 7, 1977 (ages 18-38 months). An overall view of Nim's production of combinations during this period is shown in Figures 8-22 and 8-23. These figures show the cumulative frequencies of tokens (Figure 8-22) and types (Figure 8-23) of combinations of 2, 3, 4, 5, or more signs. Different sequences of the same sign were regarded as different types (for example, *banana eat vs. eat banana).* The functions shown in Figures 8-22 and 8-23 are based upon the number of types and tokens of Nim's linear combinations we observed before using the reduction rules employed to minimize the contribution of repeated signs. The appendix shows a complete listing of all combinations of 2, 3, 4, 5, or more *signs following* application of the reduction rules.

The length of an utterance was related inversely to its frequency. This was true both in the case of types and tokens. As of April 1976, the frequency of new types of 3-sign combinations exceeded that of 2-sign combinations, and as of June 1976, the frequency of combinations of 5 or more signs exceeded that of 4-sign combinations. The reasons for **the** crossing of these functions was, however, different in each case. The frequency of 5-sign combinations per se was consistently lower than that of 4-sign combinations, but Nim began to make combinations longer than 5 signs with increased frequency. In the case of the 2- and 3-sign functions, the frequency of 3-sign types did in fact exceed that of 2-sign types. This could be a consequence of Nim's elaborating what he learned to say with two signs by adding a third sign; for example, *Joyce tickle me* rather than *tickle me,* or a consequence of adding a relevant, but redundant, sign for emphasis (see the later section, "Relationship between Nim's 2-, 3-, and 4-sign combinations").

The sheet variety of Nim's combinations and the fact that he was not required to combine signs suffices to show that Nim's combinations were not learned by rote. Considering only Nim's 2- and 3-sign combinations, the occurrence of more than 2,700 types of combinations would strain the capacity of any known estimate of a chimpanzee's memory. As 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 most parsimonious explanation of Nim's utterances is that they are unstructured combinations of signs, in which each sign is appropriate to the situation at hand.

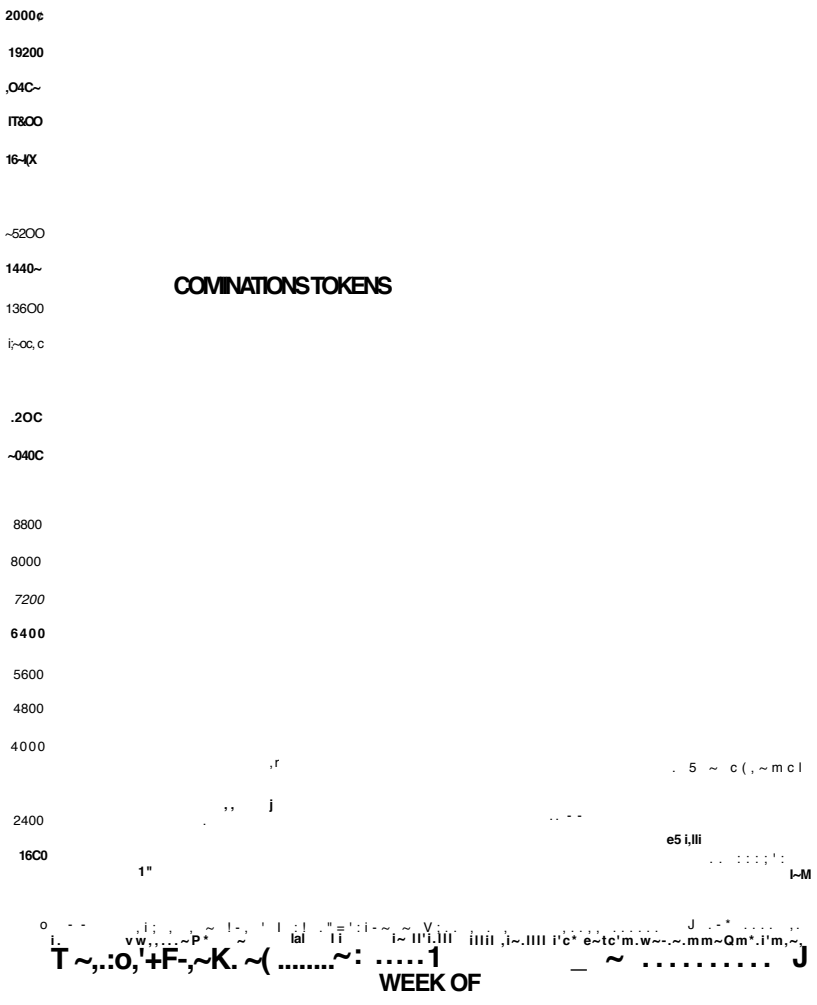

Figure 8-22. Cumulative number of tokens of linear combinations during the period June 16, 1975-February 7, 1977.

Nevertheless, the regularity and the variety of Nim's 2-sign combina-, ,ions suggest that some structural rules may be needed to account for their construction. Table Il 1 shows all 2-sign combinations of the corpus containing *more.* There were considerably more types and tokens containing *more* in the first position than in the second position, irrespective of whether *more* was combined with signs designating objects (e.g., *banana)* or actions (e.g., *tickle).* A similar state of affairs can be seen in Table IV, which sho~s all 2-sign combinations containing *give.* Here again there is a strong ten-

dency for *give* to occur in the first position The regularities shown in Tables III and IV (as well as in Tables V-VII below) were apparent through each of the five time-periods during which these data were obtained

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

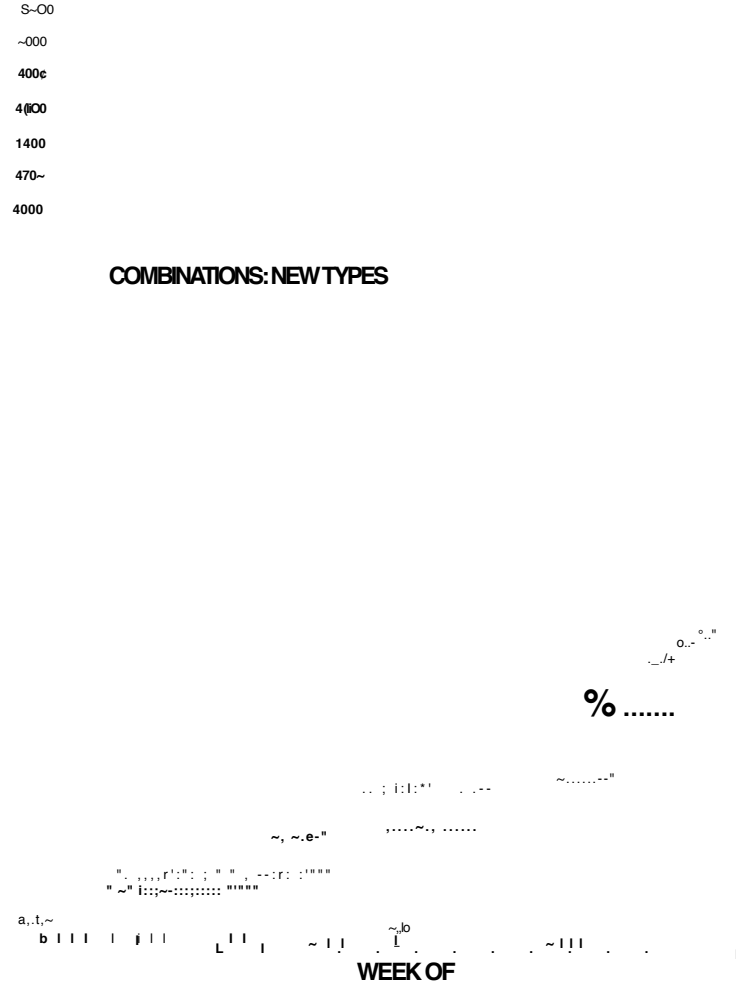

Figure 8-23. Cumulative number of types of linear combinations during the period June 16, 1975-February 7, 1977.

Table I!!
Two-Sign Combinations Containing *more*

	more + X		*X +more*		
Types		**Tokens** Types			**Tokens**
more	apple	12	apple	more	
			baby	more	
more	ball	2			
more	banana	62	banana	more	
more	berry	2			
more	bill	I			
more	bile	2			
more	brush	5			
more	chair	19	chair	more	**r3**
more	drink	99	drink	more	**14**
more	eal	287	eat	more	**58**
more	fruit	2			
more	give	!	give	more	
more	g o	7	g o	more	
more	grape	I I	grape	more	
more	groom	4			
more	gum	29	gum	more	
more	hand cream	23	hand cream	more	
			hat	more	
more	hug	16	hug	more	
more	hurry	1	hurry	more	
more	i n	!			
more	jump	I			
more	key	1			
more	lislen	I			
more	me	42	me	more	
more	Nim	24	Nim	more	
more	nut	I !	nut	more	
more	open	!			
more	orange	6			
more	paint	I			
more	peach	2			
more	pair	13			
more	play	4I	play	more	
more	pole	9	pole	more	
more	raisin	I	raisin	more	
			red	more	
more	shoe	2	shoe	more	
more	smell	3			
more	spoon	2			
more	sweet	14	sweet	more	5
more	swing	I			
more	tea	23	lea	more	**8**
more	tickle	136	tickle	more	23
more	toothbrush	3	toothbrush	more	**23**
more	up	I			
more	water	10	water	more	**I**
more	what	6			
more	yogurt	5	yogurt	more	2
Tot als:	47	974		27	

fable IV
Two-Sign Combinations Containing *give*

	give +X		*X +Rive*	
Types		**Tokens** Types		**Tokens**
give +	apple	9	apple +give	
	baby	I	baby	
	ball	14	ball	
	bananna	**7**		
	black	I		
	blue	2		
	brown	I		
	brush	3	brush	
	bug	2		
	clean	I		
			come	
			cracker	
	crayon	2		
	dog	I		
	drink	15	drink	7
	eat	54	eal	12
	finish	I	finish	3
	flower	2		
	grape	3	grape	I
	gum	4	gum	3
	hand cream	14	hand cream	3
	harmonica	2		
	here	I		
	hug	3	hug	I
	hungry	2		
	hurry	2		
	jump	2		
	key	I		
	kiss	1		
	light	2	lighl	2
	listen	I		
	point	6	poinl	2
	me	41	me	11
	more	3		
	Nim	23	Nim	4
	nut	2	nul	2
	open	2	open	2
	orange	3		
	oul "	!		
	pear	2	pear	2
	play	I	play	3
	raisin	2	raisin	2
	red	2		
	rock	I		

(continued)

Table IV **(Continued)**
Two-Sign Combinations Containing *give*

give + X			*X + give*	
Types		**Tokens**	**Types**	**TokeM**
			shoe	I
	smell	I		
	spoon	I		
	sweet	6		
	tea	**I**		
	that	**4**		
	tickle	I		
	toothbrush	4		
	water	9	water	4
	what	I		
Totals: 51		271	24	77

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 *give + X.* Nim began signing *give + X* reliably long before his teachers asked Nim to give them objects by signing *give + S.*

Two other interesting examples of regularities in Nim's 2-sign combinations can be seen in his use of transitive verbs and in his reference to himself as *me* or *Nim.* Table V shows Nim's 2-sign sequences in which transitive verbs such as *hug, open,* or *tickle* were combined either with *me* or *Nim.* The number of tokens with the verb in the first position far exceeds the reverse construction.

On some occasions, Nim's teachers queried Nim with questions such as *tickle you?* in order to prompt him to sign before tickling him. In these instances simple imitation of the teacher's signing could explain Nim's preference for signing the verb in the first position of the sequence types shown in Table V. Nim, however, was signing *tickle me* quite regularly, long before his teachers asked Nim to tickle them by signing *tickle + teacher's-name-sign.* Furthermore, the argument that Nim was imitating his teachers' questions does not apply in the case of other transitive verbs shown in Table V (e.g., *finish).* Nim was not asked questions in which these signs could have served as models.

Table V also shows that Nim combined transitive verbs as readily with *Nim* as with *me.* The number of types of sequences containing *Nim* and *me* are essentially the same. That there are more tokens of 2-sign combinations containing *me* than *Nim* is perhaps best explained by the fact that Nim

learned the sign *me* before he learned the sign Nim. During Period V (July 5, 1976-February 7, 1977 ages 33-39 months), the frequencies with which */Vim* and *me* were combined with transitive verbs was essentially the same.

Nim's preference for using *me* and *Nim* in the second position of 2-sign combinations can also be seen in requests for items of food and drink. Table VI shows all 2-sign combinations containing *me* and *Nim* as combined with either food or drink nouns. The signs *me* and *Nim* tend to follow food and drink nouns in 2-sign combinations. A somewhat smaller preference for the location of the signs *me* and *Nim* is apparent in the case of 2-sign combinations in which these signs were combined with nonfood/-drink nouns (cf. Table VII).

The proportion of tokens in which *me* and *Nim* appears in the second position was highest when those signs were combined with transitive verbs (0.83), next highest when combined with food and drink nouns (0.75), and lowest when combined with nonfood and nondrink nouns (0.65). Why the different frequencies of combining the signs *me* and *Nim* with these categories of signs? One explanation is that when Nim combined transitive

Table V
Two-Sign Combinations Containing *me* or *Nim*
and Transitive Verbs (Viii)

V(t) *+me*			V(I) *+Nim*		*me* +V(I)		*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		brush	4
clean	me	2	clean	Nim I	me clean			
			draw	Nim I	me cook			
finish	me	I	finish	Nim 7			Nim finish	
give	me	41	give	Nim 23	me give	11	Nim give	
							Nim go	
groom	me	21	groom	Nim 6			Nim groom	
help	me	6	help	Nim 4	me help	2		
hug	me	74	hug	Nim 106	me hug	40	Nim hug	
kiss	me	I	kiss	Nim 6	me kiss	I	Nim kiss	
open	me	13	open	Nim 6	me open	10	Nim open	
			pull	Nim I				
'tickle	me	316	tickle	Nim 107	me tickle		20 Nim tickle	
Totals: 12		515		13 283		**10 98**		**9**

Total Types: 25
Total Tokens: 788

Total Types: 19
Total Tokens: 158

Table **V!**
Two-Sign Combinations of Nim +Noun or Me +Noun (food/drink)

Noun +Nim			Noun +me			Nim + Noun			me +Noun		
Types		Tokens	Types		Tokens	Types		Tokens	Types		Tokens t
apple	Nim	65	apple	me	27	Nim	apple	25	me	apple	17
banana	Nim	73	banana	me	97	Nim	banana	18	me	banana	34
berry	Nim	I	berry	me	2						
cracker	Nim	21	cracker	me	3	Nim	cracker	3	me	cracker	I
egg	Nim	2	egg	me	2						
Irul!	Nim	II	fruit	me	I	Nim	fruit	6			
grape	Nim	21	grape	me	12	Nim	grape	5	me	grape	2
gum	Nim	47	gum	me	19	Nim	gum	21	me	gum	43
nut	Nim	71	nut	me	16	Nim	nut	9	me	nut	4
orange	Nim	4									
pancake	Nim	2	pancake	me	2						
peach	Nim	3				Nim	peach	1	me	peach	I
pear	Nim	20	pear	me	4	Nim	pear	4			
raisin	Nim	23	raisin	me	5	Nim	raisin	6	me	raisin	4
sweet	Nim	85	sweet	me	23	Nim	sweet	13	me	sweet	8
tea	Nim	14	tea	me	17	Nim	tea	7	me	tea	13
water	Nim	10	water	me	13	Nim	water	2	me	water	5!
yogurt	Nim	.57	yogurt	me	2	Nim	yogurt	8	me	yogurt	1
Totals: 18		530		14	245		14	28		12	133
Total Types: 34											
Total Tokens: 775											
Total Types: 26											
Total Tokens: 261											

verbs with food or drink nouns, he was using the signs *me* and *Nim* mainly as what would be an indirect object in a sentence. However, when Nim signed about objects that were neither edible nor drinkable, he may have signed *me* and *Nim* to indicate possession on some occasions, and to refer to himself as an indirect object on other occasions. For example, when Nim signed *hat me,* he may have been asking his teacher to give him the hat. BUt ' when he signed *me hat,* he may have been saying that he regarded the hat as his. These and other interpretations of Nim's signing will be considered below in our semantic analysis of Nim's 2-sign combinations.

The fact that certain categories tend to appear more frequently in the first position (for instance, transitive verbs and *more)* and certain ones in the second position (for example, *me* and *Nim)* indicates that Nim differentiated between the first and the second positions of 2-sign sequences. Further, the absence of a universal pattern with which *me* or *Nim* is combined with other types of signs suggests that Nim was not using simple position habits to form combinations. However, different frequency patterns, such as those shown in Tables III-VII, are not sufficient to demonstrate

Table Vii
Two-Sign Combination of Nim +Noun or me +Noun (nonfood/drink)

Noun +Nim			Noun +me			Nim +Noon			me *Noun		
Types		Tokens	Types		Tokens	Types		Tokens	Types		Token~
baby	Nim	20	baby	me	2	Nim	baby	6			
ball	Nim	6	ball	mc	7				me	ball	10
						Nim	bird	I			
book	Nim	2				Nim	book	I	m e	book	3
brush	Nim	13	brush	me	35	Nim	brush	4	me	brush	9
bug	Nim	I				Nim	bug	I			
			cat	me	I						
chair	Nim	2	chair	me	]	Nim	chair	2			
						Nim	color	2			
			dog	me	2						
hand-			hand-						me	flower	I
cream	Nim	6	cream	me	4	Nim	hand-		me	hand.	
harmon-			harmon-				cream	7		cream	3
ica	Nim	I	ica	me	I						
hat	Nim	3	hat	me	20	Nim	hat	8	me	hat	26
ice	Nim	2									
key	Nim	I	key	me	3	Nim	key	1			
						Nim	music	I			
pants	Nim	2	pants	me	4	Nim	pants	I	me	pants	2
						Nim	paper	I			
pole	Nim	i	pole	me	2				me	pole	1
shoe	Nim	3	shoe	me	4	Nim	shoe	I	me	shoe	I
smell	Nim	2	smell	me	1				me	smell	I
socks	Nim	I									
spoon	Nim	3	spoon	me	I						
			time	me	I						
tooth-			tooth-			**Nim**	tooth-		me	tooth.	
brush	Nim	17	brush	me	6		brush	4		brush	
	Nim	17									
Totals: 18		86						41			
Total Types: 35								Total Types: 26			
Total Tokens: 181								Total Types: 99			

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 which 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 + /Vim,* from the relative frequency of their constituents in the initial and final positions.

The accuracy of such predictions was tested as follows. First, each sign of a 2-sign sequence was assigned to a lexical category. These categories, and the relative frequency of their occurrence in the first and second positions, are shown in Table VIII. In some instances, specific signs were given as lexical types because they were the only examples of a particular kind of sign (for example, *me* was the only personal pronoun) or because their status as a particular lexical type was ambiguous (for instance, it was not always clear when *eat* and *drink* were used as nouns or verbs).

The relative frequencies shown in Table VIII were used to predict the probabilities of 2-sign lexical types which occurred'at least l0 times. The predicted value of the probability of a particular sequence was calculated by multiplying the probabilities of the relevant lexical types appearing in the

Table VIII
Frequencies of Lexical Types by Position in 2-Sign Combinations (types whose frequencies ≥ 10)

	Firs! Position Frequency		Second Position Frequency	
LexJcal Type	Absolute	Relative	Absolute	Relative
Noun (animate--human)	59	0.0066	149	0.0164
Noun (animate--nonhuman)	33	0.0037	29	0.0032
Noun (inanimate--food)	1453	0.1616	999	0.1100
Noun (inanimate--non food)	430	0.0478	477	0.0525
Adjective (personal)	353	0.0393	160	0.0176
Adjective (nonpersonal)	89	0.0099	100	0.01 l0
Verb (transitive)	1371	0.1525	1243	0.1368
Verb (intransitive)	729	0.0811	269	0.0296
point	283	0.0315	368	0.0405
drink	376	0.0418	461	0.0508
eat	924	0.1028	1358	0.1495
give	238	0.0265	42	0.0046
me	1088	0.1210	1530	0.1684
more	931	0.1036	156	0.0171
Nim	634	0.0705	1743	0.1919

first and second positions respectively. In predicting the probability of *me eat,* for example, the *probability of me* in the first position (0.121) was multiplied by the probability *of eat* in the second position (0.149). This yielded a predicted relative frequency of 0.016. The observed relative frequency of *me eat* was 0.024. in the case of some lexical types, the agreement between the observed and predicted probabilities is quite good; as, for example, noun (animate', food) + *me.* There were, however, many discrepancies between predicted and observed probabilities.

A comparison of the predicted and observed probabilities of the lexical sequences generated by combining the lexical categories shown in Table VII! does not provide strong support for an independent position model. The correlation between 124 pairs of predicted and observed probabilities was 0.0036. The average predicted probability was 0.015; the average value of the absolute deviation between predicted and observed relative frequencies was 0.007. Since the average predicted probability did not differ substantially from the average value of the absolute deviation between predicted and observed relative frequencies, and since the correlation between these probabilities was essentially zero, it seems reasonable *to* conclude that overall, Nim's 2-sign sequences are not formed by independent position habits for each item. The same conclusion would follow if we relaxed our conservative rule of considering only reliable two-sign lexical types.

A similar analysis was performed on reliable 3-sign utterances (frequency ≥ 5). Table IX shows the probability of a particular lexical category appearing in each position of a 3-sign sequence. The average value of the predicted relative frequencies of the 66 lexical types we considered was 0.0011; the average value of the absolute deviation between observed and predicted values was 0.0012. The correlation between the 66 pairs of predicted and observed probabilities was 0.05. Similar results obtained when all 3-sign combinations were considered. As in the case of 2-sign combinations, it is not possible to predict the observed relative frequencies of lexical types of 3-sign combinations from the relative frequencies of their constituents in a particular serial position.

Relationship between Nim's 2-, 3-, and 4-sign combinations

As children's utterances grow in length, it is possible to discern how their initially short utterances are elaborated so as to provide additional information about some topic (Bloom, 1973; Brown, 1973). 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 which were mastered separately. Longer utterances are not, however, unstructured concatenations of short utterances. In making longer utterances, the child combines words in short utterances in just one order; he de-

letes repeated elements and he treats shorter utterances as units when they are used to expand what was expressed previously by a single word.

Our corpus of Nim's combinations allowed us to evaluate the lexical similarity between Nim's 2- and 3-sign combinations. The 25 most frequent 2- and 3-sign combination types and their absolute frequencies are shown in Table X. A comparison of these combinations reveals that, from a lexical point of view, the topic of Nim's 3-sign combinations overlapped considerably with the topic of his 2-sign combinations. Eighteen of Nim's 25 most frequent 2-sign combination types can be seen in his 25 most frequent 3-sign combination types, in virtually the same order in which they appear in his 2-sign combinations. A striking similarity emerges between Nim's 2- and 3-sign combinations if one considers only the signs that appeared in 2-sign combinations (and not their order of occurrence). All but 5 signs which appear in Nim's 25 most frequent 2~ign combinations appear in his 25 most frequent 3-sign combinations. The 5 exceptions are *gum, tea, sorry, in,* and *pants.* (The combination *in pants* was the least frequent 2-sign combination shown in Table X. It 0ccurred mainly during dressing and after trips to the toilet.)

With the few exceptions noted, it appears as if the topic of Nim's signing remained the same whether he produced a 3-sign or a 2-sign combination. We did not have enough contextual information to perform a semantic analysis of all of Nim's 2- and 3-sign combinations. However, Nim's teachers' reports indicate that the individual signs of his combinations were appropriate to their context and that equivalent 2- and 3-sign combinations occurred in the same context.

Table iX
Frequency of Lexical Types by Position in 3-sign Combinations (types whose frequency ≥ 10)

	First position		Second Position		Third Position		
Le~ical Type	Aba.	Rel.	AM.	Rel.	Abs.	Rel.	Total
Adjective	91	0.3105	70	0.0239	84	0.0287	245
Noun (inanimate)	780	0.2662	342	0.1167	494	0.1686	1616
Noun (animate)	60	0.0205	50	0.0171	73	0.0249	183
verb	504	0.1720	257	0.0877	363	0.1239	!124
drink	13	0.0471	127	0.0433	133	0.0454	398
eat	363	0.1239	499	0.1703	559	0.1908	142!
me	29"/	0.1014	735	0.2509	267	0.0911	1299
more	178	0.0608	108	0.0386	65	0.0222	351
Nim	225	0.0768	623	0.2126	718	0.2451	1566
wh-	13	0.0044	6	0.0020	7	0.0024	26
you	36	0.0123	6	0.0020	28	0.0096	70
give	14"/	0.0502	37	0.0126	33	0.0113	217
other	16	0.0055	11	0.0038	7	0.0024	34
point	45	0.1534	44	0.0150	80	0.0273	!~9

Table X
Twenty-five Most Frequent 2- and 3-sign Combination Types

2-Sign Comb.		Frequency	3-Sign Comb.			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	28"/	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	eal	22
more	tickle	136	me	Nim	eat	21
sorry	hug	123	hug	me	Nim	20
tickle	Nim	107	yogurt	Nim	cat	20
hug	Nim	106	me	more	eat	19
more	drink	99	more	eat	Nim	19
eat	drink	98	finish	hug	Nim	18
banana	mg	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
gum	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	Nim	hug	14
in	pants	70	play	me	play	14
			sweet	Nim	sweet	14

Though lexically related to 2-sign combinations, the 3-sign combinations shown in Table X do not appear to be informative elaborations of 2-sign combinations. Rather they seem to be redundant with 2-sign utterances. Consider, for example, Nim's most frequent 2- and 3-sign combinations: *play me* and *play me Nim.* Adding/Vim to *play me* to produce the 3-sign combination *play me Nim,* adds a reclundant proper noun to a personal pronoun. A further complication is revealed when one considers an alternative derivation of the 3-sign combination *play me Nim. It* could have occurred by adding the single sign, *play,* to Nim's second most frequent 2-sign combination, *me/Vim.* Even when one takes into account the relative frequencies of single signs (cf. Table I), there is no obvious way to choose

between the two derivations *of play me]Vim* suggested by Table X: *play me +]Vim* and *play + me ?Vim.* Similar alternatives present themselves when trying to derive the other 3-sign combinations shown in Table X.

Another aspect of Nim's 3-sign combinations which suggests that they are not informative elaborations of 2-sign combinations is the occurrence of combinations in which the same sign is repeated; for example, *eat Nim eat, nut Nim nut,* and so on. Ten of the most frequent combination types contain *me* and *Nim;* 8 contain a repetition of the same sign. Of the 2,925 tokens of 3-sign combinations, 460 (16 percent) contain *Nim* and *me,* and 591 (20 percent) contain the repetition of a sign (cf. Appendix). In producing a 3-sign combination, it appears as if Nim is adding emphasis rather than new information.

Nim's 4-sign combinations reveal a similar picture. Table XI shows all 4-sign combinations whose frequency is equal to or greater than three. Fifteen of the 21 types of signs shown in Table XI contain repetitions of some signs; for example, *eat banana Nim eat* and *grape eat Nim eat.* If *me* and *]Vim* are equated on the grounds that they have the same referent, 20 of the 21 combinations shown in Table X! repeat the same sign. That leaves but one combinalion type, *me eat drink more,* which contains 4 distinctly different signs. Seven of the 21 combinations shown in Table XI repeat 2-sign combinations in the same order; for example, *drink Nim drink Nim* and *me gum me gum.* Similar generalizations hold for the remainder of all of Nim's combinations containing 4, 5, or more signs (cf. Appendix). Of the 708 tokens of 4-sign combinations, 123 (17 percent) contain *)Vim* and *me,* and 379 (54 percent) contain a repetition of the same sign. Of the 309 tokens of combinations containing 5 or more signs, 116 (37 percent) contain *Nim* and *me,* and 165 (54 percent) contain a repetition of the same sign. If combinations containing/Vim andree and repetitions of the same sign are considered redundant, there is a clear increase in redundancy as Nim's combinations grow in length: 35 percent of 3-sign combinations, 71 percent of 4-sign combinations, and 91 percent of combinations containing 5 or more signs were redundant.

Differences Between Nim's and a Child's Utterances

Instead of adding new information when producing combinations of 3, 4, or 5 or more signs, Nim seems to be simply repeating or emphasizing what he signed in shorter combinations. The absence of a difference between the semantic and syntactic complexities of Nim's short and long utterances is but one of a number of differences between the initial multiword utterances of Nim and a child. As far as we can tell from published reports describing children's utterances, the repetition in an utterance of a word or

Table X!

Twenty.one Most Frequent 4-Sign Combination Types

4-Sign Comb.	Frequency
eat drink eal drink	
eat Nim eat Nim	**15**
banana Nim banana Nim	7
drink Nim drink Nim	5
banana eat me Nim	5
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	**4**
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
	3

sequence of words that were not considered to be examples of stuttering, is a rather rare event (Colburn, 1979). It is rather the case that each additional word of a child's.utterance tends to provide information which is integrated semantically and syntactically into existing structures.

Other differences between Nim's signing and that of a child are elaborated below. The many differences indicate that Nim's general use of combinations bears only a superficial similarity to the early utterances of children. 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 dala 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 (Newport & Ashbrook, 1977; Hoffmeister, 1972; Kiima & Bellugi, 1972).

The mean length of Nim's utterances

Recent studies of language acquisition in children suggest certain universal patterns of language development. One important observation is the orderly increase in the mean length of a child's utterances (MLU) which is accompanied by a progressive increase in their complexity (Bloom, 1973; Brown, 1973). In English, for example, subject-verb and verb-object construction merge into subject-verb-object constructions. As evidenced by Nim's longer utterances, length per se does not imply an increase in grammatical complexity. An increase in MLU is, however, a necessary condition for the production of the many types of construction that demonstrate a knowledge of grammar.

In calculating a child's MLU, certain conventions are followed which cannot be applied directly to sequences of signs. A spoken utterance, for example, is broken down into morphemes rather than words: *running* and *run there* would each be regarded as a 2-morpheme utterance. In sign language, the utterance *run there* can be expressed by a single sign". Despite these and other difficulties in measuring MLU in a sign language, it serves as a rough measure of a child's linguistic development.

Figure 8-24 shows Nim's MLU (the mean number of signs in each utterance) between the ages of 26 and 45 months. The method used to calculate Nim's MLU differed somewhat from the one that is generally followed in child language studies (Brown, 1973). Nim's MLU was calculated as follows: (1) All intelligible single sign utterances were counted. Excluded were ambiguous single-sign utterances or movements that were approximations of signs. (2) Repetitions of signs in multisign utterances were first collapsed; i.e., wherever the same sign occurred successively, only one occurrence of that sign was counted. Thus an utterance such as *Nim eat eat apple apple,* which contains 5 signs with 2 successive repetitions, was counted as a 3-sign utterance. Approximations were included in combinations. (3) Instances of nonlinear signing, such as contractions and simultaneous signs, were not included. (4) An utterance was not adjusted in any way to account for its relationship to the teacher's prior utterance. This is in contrast to Bloom (1973), who does not count words in a child's utterance which have appeared in any of the adults' 5 prior utterances. (5) The entire sign record from beginning to end was used regardless of the length of the transcript. (6) The total number of signs in the utterances that were counted was divided by the number of utterances to yield the MLU.

. The functions showing Nim's MLU between January 1976 and February 1977 (age 26-39 months) are based on data obtained from teachers reports; the function showing Nim's MLU between February 1976 and August 1977 (ages 27-45 months) is based upon video-transcript data. The most striking aspect of these functions is the lack of growth of Nim's MLU during a 19-month period.

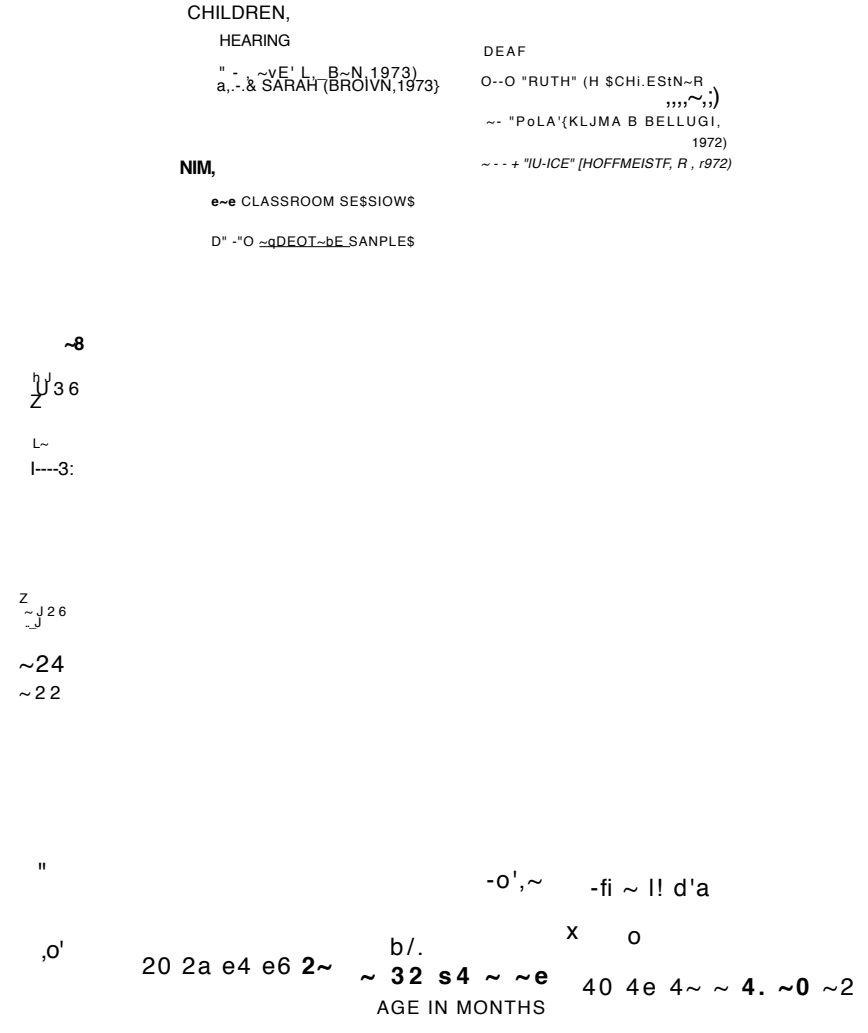

Figure 8-24. Mean length of signed utteranc6~, of Nim and three deaf children, and mean length of spoken utterances of two hearing children. See note 68 regarding the calculation of MLU's for signed utterances.

Figure 8-24 also shows comparable MLU functions obtained from hearing (speaking) anddeaf (signing) children. The function based upon Sarah's utterances shows the longest delay in the growth of MLU that we could locate in the literature on language development in speaking children; the MLU function from the other speaking child (Eve) begins to rise at a much younger age. The 3 remaining functions (based upon Ruth's, Pola's, and Alice's utterances) show the MLU of deaf children learning sign language (Klima & BeUugi, 1972; Schlesinger, personal communication 1975; Hoffmeister, 1972). All children start at an MLU similar to Nim's at 26 months. But unlike Nim's flat MLU functions, the functions obtained from children all show increases in MLU.

The lack of growth of Nim's MLU defines a major difference between the development of language in young apes and children. Another difference 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" (Brown, personal communication, 1978). Nim, however, made utterances containing as many as 16 signs (e.g., *give orange me give eat orange me eat orange give me eat orange give me you)* with an MLU that never exceeded 1.6. This is at variance with the relationship between the upper bound of the MLU distribution and a child's MLU. We have already noted that Nim's longer utterances were neither semantic or syntactic elaborations of his shorter utterances. In our discourse analyses of Nim's and Washoe's signing (see the following sections, "Discourse Analysis" and "Comparisons of Nim's Discourse With That of Other Signing Apes"), we will suggest other mechanisms which lengthen an ape's utterance but do not presuppose an increase in semantic or syntactic competence.

Semantic relationships expressed in Nim's 2-sign combinations

The regularities we observed in our distributional analysis of Nim's 2-sign combinations are lexicah certain lexical categories occur in the initial or in the final position when combined with other signs, These regularities provide no direct information about the intended meaning of Nim's combinations, nor do they reveal whether they express a limited set of semantic relationships. Unlike lexical distributions, semantic distributions 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 (1970) and Schlesinger (1971), are known as the method of "rich interpretation" (Bloom, 1970, 1973; Brown, 1973). An observer relates certain aspects of the utterance's immediate context to its contents. By considering the meanings of the individual words and the roles played by their referents

it is often possible to infer a particular semantic interpretation of the relationships between the words of a child's utterance.

The challenge of the method of rich interpretation is not only to make specific judgments but to demonstrate their validity as well. Bloom's (1970, 1973) important insight concerning semantic interpretations was to specify how the validity of such interpretations could be evaluated by independent evidence from the corpus, Supporting evidence 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. 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 (Bloom, 1973; Bowerman, 1973a; Brown, 1973). As the child's MLU increases, semantic relationships identified by a rich interpretation develop in an orderly fashion. The relationships expressed in 2-word combinations are the first ones to appear in the 3- and 4-word combinations. Many longer utterances appear to be composites of the semantic relationships expressed in shorter utterances. For example, action-object, agent-action, and agent-object relationships merge into an agent-action-object relationship. New semantic relationships are first expressed in short utterances. These are often imitations and reductions of the adult's prior utterance. The initial difficulty of expressing new semantic relationships apparently results in their expression in utterances that are the least taxing for the child (Bloom, 1973; Brown, 1973).

Studies of an ape's ability to express semantic relationships in combinations of two or more signs have yet to advance beyond the stage of unvalidated interpretation. The Gardners interpreted 294 types of Washoe's 2-sign combinations and concluded that 78 percent of these combinations were interpretable in categories similar to those used to describe 2-word utterances of children (Gardner & Gardner, 1971). A similar analysis was performed by Patterson (1978) on 2-sign combinations emitted by the gorilla Koko. No data are available as to the reliability of the interpretations that the Gardners and Patterson have advanced. Because of the paucity of combinations of 3 or more signs it has not been possible to observe, in combinations of more than 2 signs, the elaboration of semantic relationships used to describe Washoe's and Koko's 2-sign combinations.

Without prejudging whether Nim actually expressed semantic relationships in his combinations, 1,262 of his more recent 2-sign combinations were analyzed by the method of rich interpretation. Three of Nim's teachers examined the 2-sign combinations which they recorded in their session reports between mid-December 1976, when Nim was 25 months old, and early June 1977, when Nim was 31 months old (Joyce Butler, 48 reports; Dick Sanders, 58 reports; Bill Tynan, 48 reports). 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). Disagreements resulted as frequently from different judgments about whether an utterance could be interpreted at all (and, if so, interpreted unambiguously) as from different semantic judgements per se. The disagreements resulted in part (23 percent) because of differences in semantic interpretations and in part (20 percent) because of differences in judgments regarding the interpretability of an utterance. An attempt was made to resolve disagreements through discussions between the two relevant teachers and reference to their records. If a disagreement could not be resolved, the utterance was considered ambiguous and disregarded. Contextual notes in the teachers' records included sufficient information for the teachers to agree as to the interpretation of 967 2-sign combinations (77 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 which could not be disambiguated (N = 35). it should be noted, however, that none of our conclusions would be altered if we used either of the interpretations of the 35 combinations which could not be resolved.

Table XII contains 20 categories of semantic relationships which account for 895 (93 percent) of the 967 interpretable 2-sign combinations. Brown (1970) found that there were eleven semantic relationships which account for about 75 percent of all combinations of the children he studied. Similarly, the Gardners (1971) reported that nine categories account for 78 percent of a sample of Washoe's 2-sign combinations, and Patterson (1978) reported that eleven categories accounted for 75 percent of Koko's 2-sign combinations. Table XII compares our semantic categories with those used by Brown, the Gardners, and Patterson. It should be apparent that the number of categories used for interpreting a child's or an ape's early combinations is arbitrary. Our twenty categories could be collapsed roughly into seven in Brown's, with two left over; into eight in the Gardners' system, with two left over; and into eleven in Patterson's system, with one left over.

The results of our semantic analysis are shown in Figure 8-25. In several instances there were 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 by signs in the first position in 80 percent, 67 percent, and 84 percent of the respective 2-sign combinations in which they occurred. Place and beneficiary roles were expressed by second-position signs in 73 percent and 64 percent of the respective 2-sign combinations in which they occurred.

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 shown to be reliable, there are several features of our

Table XII
Semantic Categories

Brown	*Patterson*	*Gardners*	*Terrace el al.*
Nomination Notice	Nomination	--	_
Recurrence	Recurrence	Appeal-object	Recurrence-entity Recurrence-attribute of entity Recurrence-action Recurrence-benefici. ary Recurrence-place
Nonexistence	Nonexistence		
Attribute-entit y	Attribute-entity Attribute-person-state	Object-attribute Agent-attribute	Attribute-entity
Possessive	Genitive	Agent-object Object-attribute	
Locative: N + N		(not applicable)	Agent-place Entity-place Attribute of entity-place
Locative: N&V	Locative	Action-location Action-object Object-location	Action-place Locative prep.-place Entity-locative prep.
	Dative		Action-beneficiary Object-beneficiary Attribute of object-beneficiary
Agent-action	Agent-action	Agent-action	Agent-action

/continued)

Table XIII *(Continued)*
Semantic Categories

Brown	*Patterson*	*Gardners*	*Terrace el el.*
Action-object	Action~9bject	Action-object	Action-object Acdon-attribute of object
Agenl-object	Agent-object	Agenl-object	Agent-object
-	Appeal	Appeal-action Appeal-object	(Various)
--	--	--	Two propositions

results which suggest that our analysis may exaggerate the level of semantic competence (as may the analyses of the Gardners and Patterson). Our results also call into question the validity of a rich interpretation of the semantic contents of an ape's 2-sign combinations.

One problem rests on 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 (Brown, 1973; Fodor, Bever, & Garrett, 1974; Macnamara, 1972). Neither our study, nor any of the other studies which present "semantic" analyses of an ape's 2-sign combinations, have produced such corroborative 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 instance, *Nim banana).* These occurred when the teacher held up an object that he or she 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 additional complication was that in many of these cases, *Nim* or *me* was combined with *eat* or *drink.* Not only was it impossible to determine whether Nim was an agent, beneficiary, or possessor in these cases, but it was also impossible to determine whether *eat* and *drink* referred to consumable objects or to actions. An arbitrary decision was made to assign these cases to the object-beneficiary category, a category which showed a preferred sign order in the clear instances and which also accounted for eighteen percent of the utterances shown in Figure 8-25. This decision may have also contributed to the absence of genitive relationships in our data.

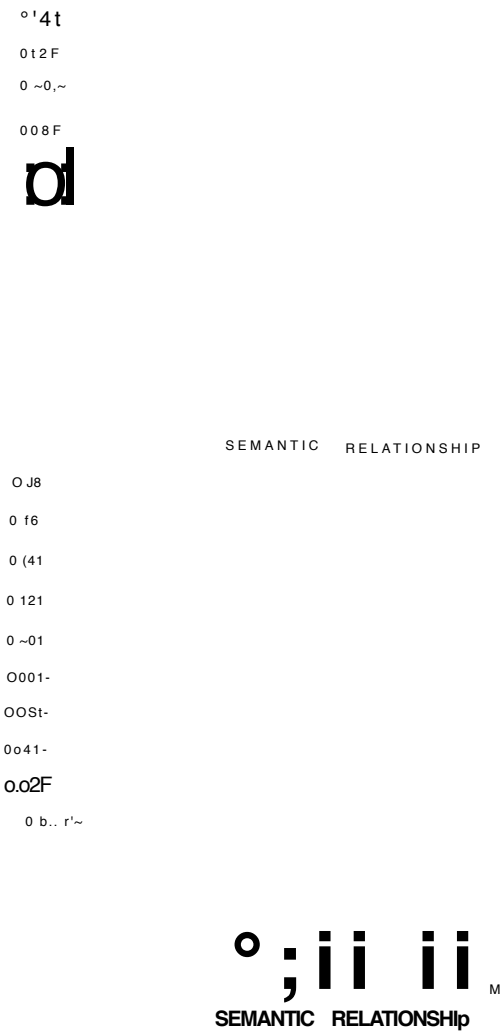

Figure 8-25. Relative frequencies of different semantic relationships. The bars above ! ~ II show the relative frequencies of 2-sign combinations expressing the relationship in the order specified under the bar; e.g. an agent followed by an action. The bars above II ~ I show the relative frequencies of 2-sign combinations expressing the same relationship in the reverse order, an action followed by an agent.

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. Ninety percent of the combinations interpreted as an expression of location contained only one exemplar of that semantic role: the sign *point* (including *up* and *down;* see note 9 for details). A similar state of affairs exists in the case of combinations interpreted as expressions of recurrence. That role was represented 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.* In both agent-object and object-beneficiary combinations, *Nim* and *me* occurred predominantly. !n the second position (in 64 percent and 68 percent of these combinations, respectively). Accordingly, it is difficult to decide whether the positional regularities favoring agent-object and object-beneficiary constructions (cf. Figure 8-25) are expressions of semantic relationships or idiosyncratic lexical position habits.

In contrast with those cases, combinations describing an action and an object contained a considerable variety of terms in both semantic roles. Even though overall position effects were not found in the case of combinations describing an action and an object, idiosyncratic order effects involving particular signs were noted". *Tickle* was in the first position in all 11 utterances containing *tickle* that were judged as action-object combinations; *play* was in the first position in all but one of the 10 such combinations containing *play. Me* occurred in the second position on 12 occasions, and never in the first position. *Nim,* on the other hand, was in the first position in 16 of the 21 action-object combinations containing *Nim. Drink* and *hug* were in the first position in ! i out of 15 cases and 13 out of 16 cases respectively, while *out* occurred in the second position in 17 out of 23 cases. Even though the number of combinations in these examples is not large, many of the regularities we observed are statistically significant. It is also of interest that similar idiosyncratic orders involving particular signs were apparent in the large corpus we collected in order to perform our distributional analysis. For example, in 313 combinations of the signs *eat* and *me, me* occurred in the second position in 76 percent of the cases, while *Nim* occurred in the second position in about half (59 percent) of the 511 combinations of *eat* and *Nim.* In the 186 combinations of *drink* and *Nim, Nim* occurred in the second position 77 percent of the time, while *me* occurred in the second position with *drink* in about half (44 percent) of 116 cases. In combinations

of eat and *drink* and food nouns, there were no overall position preferences. There were, however, individual cases showing strong position preferences: *gum* occurred in the first position with *eat* in 83 percent of the 95 cases, and *tea* occurred in the first position with *drink* in all of the 77 cases. As far as we can tell, there is no common thread running through these apparently idiosyncratic patterns that would justify their description by semantic rules rather than by lexical position habits.

In addition to the relational combinations we observed (cf. Table X), 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 have not been reported in previous ape studies. In children, the development of two proposition elements does not occur generally until the MLU passes 2.0, when clauses begin to appear. Prior to that, what appear to be two propositions are actually chained single utterances occurring within the same speech event (Bloom & Lahey, 1977; also see Bloom, Lightbown, & Hood, 1975).

An analysis of video transcripts revealed yet another spurious source of the semantic look of Nim's combinations: the extent to which Nim's utterances were initiated by his teacher's signing and were imitations of his teacher's preceding utterance. An utterance can be considered to be imitative if it contains some or all of the signs of the teacher's prior utterance. In many cases, Nim's teachers were able to judge whether a combination was spontaneous or an imitation of an immediately prior teacher's utterance. Nevertheless, *all* 2-sign combinations were included in the semantic analysis. Since 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 that were imitated, in full or in part, by Nim. Those that were imitated should not be regarded as comparable to a child's nonimitative constructions. In order to provide a general picture of the relationship between Nim's utterances and those of his teacher, we analyzed a corpus of Nim's utterances recorded on videotape, for which we could specify the linguistic as well as the nonlinguistic context.

Painstaking transcriptions of our videotapes revealed certain aspects of Nim's signing that were not apparent to his teachers in the course of normal observation. None of Nim's teachers, nor the many expert observers who were fluent in sign language, detected either the extent to which the initiation and contents of Nim's signing were dependent upon the teacher's signing or the degree to which Nim interrupted his teachers. Having convinced ourselves that Nim's signing was not *simple* imitation, our limited powers of attention were directed more to the contents of his signing and its nonverbal context than to the precise relationship between the teacher's input and Nim's output of signs. The contrast between the conclusions that might be drawn from our distributional analyses and those that follow from our dis-

course analysis poses an important methodological lesson. In the absence of a permanent record of an ape's signing, and the context in which that signing occurred, an objectively assembled corpus of the ape's utterances does not provide a sufficient basis for drawing conclusions about the grammatical regularities of those utterances.

Discourse analysis

During recent years there has been increasing interest in the way parents speak to their children (Newport, 1976; Snow, 1972) and in the ways children adjust their speech to aspects of the prior verbal context (Bloom, Rocissano, & Hood, 1976). In its early discourse, a child relates to its parents' speech by often relying on imitation and on contextually obvious topics. That type of discourse appears to be the crucible in which the child's knowledge of pragmatics, semantics, and syntax of its language is formed.

Fillmore (1973) 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 (Stern, Jaffee, Beebe, & Bennett 1975). Our discourse analysis reveals that the relationship between Nim's and his teacher's utterances is fundamentally different from the one that obtains between a child's utterances and those of its parents. All of the available data concerning Washoe's discourse with her teachers (which will be described below) reveal a similar difference between a chimpanzee's and a child's conversations with their adult teachers.

In our initial analysis of some of the ways in which the signs used by Nim are related to the prior verbal context, we transcribed and analyzed three-and-one-half hours' of videotapes from nine sessions recorded befween February 1976 and' 'Juiy 1977, when Nim was between 26 and 44 months old=L Each tape was transcribed by the teacher who worked with Nim. Only single signs and linear combinations were used in our discourse analysis. They accounted for 95 percent of the transcribed utterances. An initial check of the remaining 5 percent of the utterances (simultaneous combinations and contraction) indicated that the results of our discourse analysis 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 most conservative analysis of reliability we performed included all of the following categories: (1) Unambiguous signs: Both transcribers perceive a clearly interpretable sign and agree as to its designation. (2) Equivocal signs: Transcriber **1** cannot decide between the sign specified by transcriber 2 and one other sign. (3) Nonverbal gestures: These include hand movements that are part of the chimpanzee's

natural repertoire of movements. The topographies of these movements overlap with certain signs; for example, scratching the head (similar to *Nim),* pointing (similar to *point),* or waving an arm (similar to *hurry).* (4) "X" signs: These are gestures which look like signs but which are not part of Nim's otherwise attested expressive vocabulary. (5) Molded signs: These are molded by the teacher. (6) Not visible: The transcriber believes a sign occurred but Nim was not sufficiently visible to allow a clear interpretation of it. (7) Nonreport of a sign: One transcriber fails to perceive a sign which the other transcriber reported. (8) Nonreport of a repeated sign: This is the same as (7), but the sign in question was an immediate repetition of a sign about which both transcribers agreed.

In his transcripts, transcriber 1 made 231 entries that Nim had signed. The transcript of transcriber 2 agreed with that of transcriber 1, 104 times, or in 71 percent of the cases in which both transcribers stated that a sign occurred. Transcriber 2 made 209 entries of signs in his transcript. Transcriber ! agreed with transcriber 2's entries of signs 104 times, or in 78 percent of the cases in which both transcribers stated that a sign occurred. The average of these values, 74.5 percent, underestimates the degree of agreement concerning the data used in our discourse analysis. Molded signs, "X" signs, and nonverbal gestures did not enter into our discourse analysis. The failure to detect a repetition of an immediately preceding sign also did not alter the outcome of our discourse analysis. A final correction of our estimate of reliability has to do with the status of entries in the "equivocal" category as sources of disagreement, in these cases, one transcriber reported sign X and the other transcriber reported sign X or sign Y. It was not the case, however, that each of the transcribers reported different signs. Accordingly, it is reasonable to assign a weight of 0.75 to the entries in the "equivocal" category [0.5 for transcriber 1, who reported only X, plus 0.25 for transcriber 2, who reported Xor Y. The above corrections of the reliability estimate yielded a transcriber I-transcriber 2 agreement of 80.4 percent (176 agreements/219 observations) and a transcriber 2-transcriber I agreement of 81.3 percent (165 agreements/203 observations)]. The average agreement between the two transcribers was 81 percent.

A comparison of Nim's discourse with his teachers and children's discourse with adults (cf. Bloom, Rocissano, & Hood, 1976) is shown in Figure 8-26. Adjacent utterances are those which follow an adult utterance without a definitive pause. The most appropriate stage of development for comparing Nim's and a child's utterances is when their MLU's are the same. At 21 months (MLU = 1.4), the average proportion of a child's utterances that are adjacent is 69.2 percent (range 53-78 percent). A somewhat higher percentage (87 percent) of Nim's utterances were classified as adjacent (range 58.7-90.9 percent).

Adjacent utterances were assigned to one of four mutually exclusive

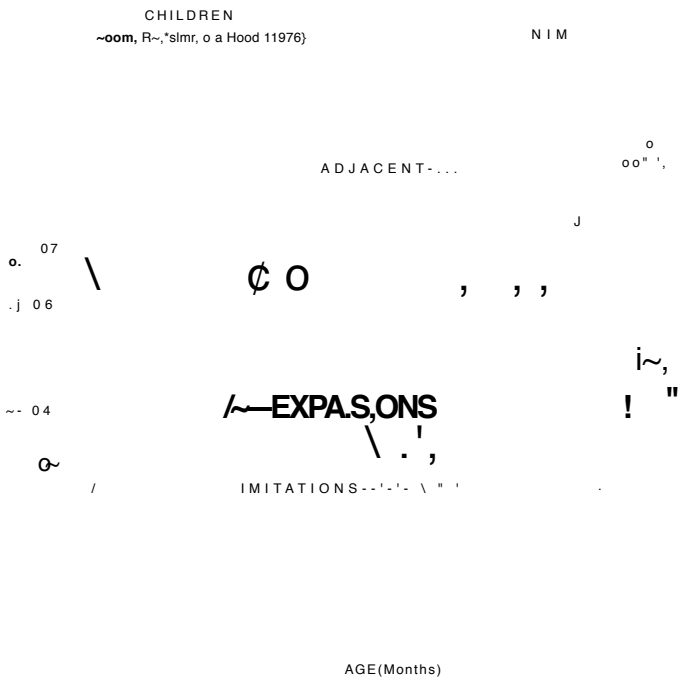

Figure 8-26. Proportion of utterances emitted by children (left-hand functions) and by Nim (right-hand functions) which are adjacent to. imitative of, or expansions of, an adult's prior utterance.

categories: (I) *imitations* were those utterances which contained all of the lexical items of the adult's utterances, and nothing else; (2) *reductions* were those utterances which contained some of the lexical items of the adult's utterance and nothing else; (3) *expansions* were those utterancs which contained some of the lexical items of the adult's utterance along with some new lexical items; and (4) *novel utterances* were those utterances which contained none of the lexical items of the adult's utterance.

How do Nim's responses to an immediately prior teacher's utterance, on the 509 occasions when.he produced an adjacent utterance, compare with the adjacent utterances of children? Among the children studied by Bloom and her colleagues, imitations and reductions accounted for 18 percent (cf. Figure 8-26) of all of the children's utterances at Stage ! (MLU = 1.3). That figure decreased with increasing MLU, accounting for only 2 percent of the children's utterances at Stage V (MLU = 3.9). On the average,

39.1 percent adjacent utterances of Nim's adjacent utterances were imitations or reductions (range 19.5-57.1 percent).

At Stage I, 21.2 percent of a child's utterances were expansions of the adult's prior utterance (range 10-28 percent). On the average, only 7.3 percent of Nim's utterances were expansions of his teacher's prior utterance (range 1-15 percent). As the child gets older, the proportion of its utterances that are expansions increases. Bloom and her colleagues (1976) noted that many of the child's utterances were systematic expansions of verb relations contained in the adult's prior utterance. No such pattern was discernable 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; e.g., *me, /Vim, you, hug,* and *eat.* In the sense that Nim's signs are not specific to particular contexts, these signs do not add new information to the teacher's utterance. In fact, the sole function of the teacher's signs seems to be to provide a model which tells Nim what signs are appropriate for particular requests. Unlike the adjacency of children's utterances, the adjacency of Nim's signs to his teacher's signs does not appear to result in informative communication between Nim and his teacher.

Adjacent utterances which follow a prior adult utterance would constitute evidence of turn-taking in discourse. On the other hand, a child who interrupts by beginning to talk during a parent's utterance would provide evidence against an understanding of the principle that the speaker and the listener alternate their messages to one another.

By definition, adjacent utterances may include interruptions of a teacher's or an adult's utterance. Such interruptions detract from true discourse since they result in utterances which are simultaneous rather than successive. We know of no data on the relative frequency or duration of simultaneous utterances that occur in dialogues between children and adults in either spoken or sign language. However, both Bloom (1977) and Bellugi (1977) have reported that interruptions are virtually nonexistent in their videotapes of children learning vocal and sign languages.

Simultaneous signing by Nim and his teacher occurred in 71 percent of the utterances which have been examined (425 out of 585). Seventy percent of these simultaneous utterances 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 t~acher was, in effect, asserting his or her right to hold the floor. Nim's interruptions showed no evidence that they were in response to the teacher's attempts to take the floor from him.

Our analysis of Nim's discourse with his teachers has revealed that the vast majority of Nim's utterances were occasioned by the teacher's signing and that many of Nim's signs were identical with those of his teacher's most

recent utterance(s). Nim imitated what his teacher signed more than twice as frequently as a Stage-I child would in similar circumstances. Nim interrupted his teacher's signing quite frequently and thereby deviated from the pattern of give and take which characterizes discourse between a child and its parents. It is also the case that as a child gains experience in discourse, its frequency of imitation decreases. No such trend was observed in Nim's discourse.

An unanticipated, but instructive, example of the influence of the teacher's signing on Nim's signing can be seen in Figure 8-21, which presents a series of still photographs (taken with a motor-driven camera) of Nim signing *me hug cat.* A careful examination of Figure 8-21 (which was prompted by the results of our discourse analysis) reveals that Nim's teacher signed *you* while Nim was signing *me;* and *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.* It is, however, unlikely that the teacher signed *who?* after Nim signed tat. Inspection of Figures 8-9, 8-17, 8-18, and 8-19 also reveal similar patterns of discourse between Nim and his teachers. In Figure 8-9, Nim's teacher is signing *no* in response to Nim's prior utterance, a poorly formed *more* sign (not shown). In Figure 8-17, Nim is signing Nim in response to his teacher's query *who?* In Figure 8-18, Nim is signing *hug* in response to his teachers's prompting of that sign. In Figure 8-19, Nim is signing *me* in response to his teacher's signing *mine.* At the very least, these photographs demonstrate the importance of discourse analysis for revealing the extent to which Nim's utterances were influenced by his teacher's signing.

Comparison of Nim's discourse with that of other signing apes

One valuable source of information which suggests that Nim's discourse with his teachers was not specific to the conditions of our project is a 59-minute film produced by Nova, entitled, *The First Signs of Washoe'L* This film, which is mainly about Washoe's signing, also presents brief scenes showing Ally (Nim's full brother) signing with Fouts at the Oklahoma Primate Center, and Koko signing with Patterson in Koko's trailer home. Another film, *Teaching Sign Language to the Chimpanzee: Washoe* (Gardner & Gardner, 1973), which was produced by the Gardners, shows somewhat longer versions of a number of conversations presented in the Nova film. Both films provide good examples of discourse between Washoe and her teachers. A comparison of the longer and the shorter versions of the same conversation provides an instructive example of the importance of capturing as much of the teacher's prior utterance as possible in performing a discourse analysis.

In one scene of the Nova film, Washoe is shown signing *time eat* to B. Gardner. The discourse between Washoe and B. Gardner is presented in the transcript that follows below. Since the films we analyzed were edited, it was not possible to establish a fixed temporal point of reference for the occurrence of each sign. in this and in ensuing 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 in the film was measured by counting the number of frames from the beginning of each scene." The beginning and the end of each utterance are marked by slashes. Other behavior is described in parentheses.

Consider the following complete scene from *First Signs of Washoe:* 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.* (In passing, we should note that the Gardners have yet to present detailed 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.)

Teaching Sign Language to the Chimpanzee." Washoe presents a longer version of the same conversation:

Time (Seconds)						
00.00	**BG.:**	*/eat*				
00.42		*me/*				
02.38		*/more*				
02.80		*me*	*(mine)/*			
03.34		*(W*	feeds	BG)		
07.09		/thank		you/		
10.92		*/what*				
12.38		*trine~*				
12.88					*W:*	*/time*
13.17						*eat/*
15.42						*/t i m e*
15.76						*eat~*
. . . . . splice						
00.00	BG:	*/what*				
00.46		*now?/*				
00.29		*/what*			W:	*/in*
04.79		*now*				*in/*
05.33						*/me*
05.67						*eat*
06.17						*time*
06.38						*eat/*

The film reveals that both signs of Washoe's utterance *time 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 imitated some of the 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 which follows the splice. Suppose that one considered 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 analysis of discourse between B. Gardner and Washoe also shows that three out of Washoc'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, *baby in my drink, a* combination of four signs described in both films as a creative use of sign language by Washoe. In this sequence, the order of Washoe's signs reflect the order in which the teacher first signed about the referents of Washoe's signs. The actual exchange between Washoe and her teacher, Susan Nichols, is shown below:

Time (Seconds)			
00:00	*/that/* (points to cup)		
00:29	(brings cup and doll closer to W. SN allows W to Iouch it; SN slowly pulls it away)	W:	*/baby/*
	/that/ (points to cup) (Brings the cup and doll closer to W)	W:	*/in/* (looks away from SN)
		W:	(looks back at cup and doll)
	SN: (Brings cup closer to W)	W:	*/baby/*
10.58		W:	***/in/***
11.46	SN: */that/(points* to cup)	W:	*/my drink/*
I1.42			

In this example of what was actually a "run-on" sequence, two of Washoe's four signs were prompted. It is important to note that the sequence of the promptings (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. For these reasons alone, Washoc's actual sequence of signs, *baby in* (pause) *baby in my drink,* cannot be regarded as a clear instance of a spontaneously generated utterance.

In the immediate preceding scene of the film, Susan was shown drilling Washoe extensively about a *baby in shoe* and an *apple in hat.* In both cases Washoe was trying to grab the desired object 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 seems unwarranted to claim that the utterance is a creative, spontaneous juxtaposition of signs that conveyed the meaning "a doll in Washoc's cup."

As a final example of Washoe's discourse with her teachers, consider the following conversation about Washoe's intelligence:

Time (Seconds)			
00.00	SN:	*who stupid?*	
00.42			**W:** *Susan, Susan*
05.30	SN:	*who stupid?*	
05.58			W: *stupid*
06.42	SN:	*who?*	
06.72			*W: Washoe*
07.04	SN:	*Waghoe*	
07:36		(tickles Washoe)	

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 prompted by the teacher. The exchange between Washoe and Susan also terminated at the point at which the teacher got Washoe to make the signs *stupid* and *Washoe.* The circumstances under which this sequence of signs occurred raises questions about the validity of the Gardner's semantic analysis of combinations such as *Naiomi good* (Gardner and Gardner, 1971). That combination was presented as an example of attribution, an interpretation which would be appropriate only in the absence of the kinds of prompting and reward shown in the films of Washoe signing.

This film *(The First Signs of Washoe)* shows 156 of Washoe's utterances. One hundred and twenty are single-sign utterances. These occurr mainly in vocabulary testing sessions. Each of Washoe's multisign sequences (24 2-sign, 6 3-sign, and 5 4-sign sequences) are preceded by a similar utterance or prompting from her teacher. Thus, Washoe's utterances often are adjacent to and imitative of her teachers'.

The ~hort segments of the Nova film showing Ally and Koko signing reveals a similar relationship between the ape's and the teacher's signing. In each case, the teacher signed first to initiate the "conversation." Ninety-two percent of Ally's, and all of Koko's, signs are imitations of the teacher's prior sign.

The data provided by a single film are admittedly much more limited in scope than data we obtained from our nine videotapes. It seems reasonable to assume, however, that the segments shown in these films, the only films publicly available of apes signing, present some of the best examples of Washoe's, Ally's, and Koko's signing at the time when the films were made. Even more so than our transcripts, these films showed a consistent tendency for the teacher to initiafd'~igning and for the signing of the ape to mirror the teacher's signs.

OTHER EVIDENCE BEARING ON AN APE'S GRAMMATICAL CAPACITY

Our evaluation of an ape's grammatical capacity has focused exclusively on the production of sequences of signs. We have yet to consider other evidence which has been used to substantiate the claim that apes can produce and understand sentences, in evaluating this evidence 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 (Bloom, 1973; Brown, 1973).

It has been widely observed that the early sequences of words uttered by a child do not necessarily qualify as sentences (Bloom & Lahey, 1977; Braine, 1976; Brown, 1973). Indeed, if a child's initial utterances and his responses to his parents' utterances constituted the only evidence of his linguistic ability, there would be little reason to conclude that a child's production and comprehension of words are governed by a grammar (Bloom, 1973). A "rich interpretation" of a child's early utterances assumes that they are constrained by structural rules (Bowerman, 1973b; Bloom, 1970, 1973; Brown, 1973). 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 which bear no structural relationship to one another (Brown, 1973). Even frequently occurring sequences of words may be interpreted as routines that the child learned by rote as imitations of his parents' speech (Braine, 1976).

As children get older, the variety and complexity of their utterances increase gradually. Especially telling is the observation that children pass through phases in which they produce systematically incorrect classes of utterance. During these phrases the child "tries out" different sets of rules before arriving at the correct grammar. Children are also able to discriminate grammatically correct from incorrect sentences (Bever, 1975). Accordingly, explanations of their utterances which are not based upon a grammar become too unwieldy to defend (Blbom & Lahey, 1977).

Production of Sequences

As is the case with a child, the mere occurrence of a sequence of words uttered by a chimpanzee does not warrant its designation as a sentence. Before regarding such utterances as sentences, it is necessary to discredit 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* (Rumbaugh, 1977), or *Mary give Sarah chocolate* (Premack, 1976). 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 sho w slide).* In the last sequence, Lana showed evidence that she could use a different "verb" *(show)* in conjunction with a different category of incentives. These incentives were *slide, window,* and *music* (Rumbaugh, 1977).

Sarah's and Lana's multisign utterances are interpretable as rotely learned sequences of arbitrary symbols arranged in particular orders; for instance, *Mary give Sarah apple,* or *please machine give apple.* There is good reason to doubt whether 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 showed little evidence of being able to substitute other symbols in each of the remaining positions of the sequences they learned (Terrace, 1979a). Accordingly it seems more prudent to regard the sequences of lexigrams glossed as *please, machine,* and *give* or plastic chips glossed as *Mary, Sarah,* and *give* as sequences of nonsense symbols rather than as sequences of words.

Consider comparable responding to nonsense symbols in a fixed order by a pigeon. Terrace, Straub, Bever & Seidenberg (1977) and Straub, Seidenberg, Bever, & Terrace (1979) have shown that pigeons can learn to peck arrays of four colors in a particular sequence: green -- white -- red -- blue, irrespective of the physical position of the colors. In this experiment, all of the colors were presented simultaneously and there was no step-by-step feedback following each response. Evidence that the subjects learned the overall sequence, and not simply the specific responses required by the 15 training arrays, was provided by performance which was considerably better than chance on four novel arrays. Such performance demonstrates that pigeons can master serial learning tasks comparable to those mastered by Sarah and Lana. It has yet to be shown that pigeons can master ABCX

problems (where X 1 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 inferred by a human observer (Limber, 1977; Mounin, 1976; Seidenberg & Petitto, 1979b). As difficult as it may be to train an ape, or any organism, to produce a sequence of arbitrary responses which may look like a sentence, it is even more difficult to show that those sequences have the structural properties of human sentences (Bloom & Lahey, 1977; Dale, 1976).

Comprehension of Multisymbol 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 (Beret, 1970; Brown, 1973; Fodor, Bayer, & Garrett, 1974; Macnamara, 1972). 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. For example, when Sarah was given two pieces of colored paper, she learned to arrange them in response to instructions such as *color I on color 2.* Premack (1976) interpreted this behavior as evidence that Sarah comprehended the preposition *on.* Two extra-linguistic cues render this interpretation questionable. As was generally true, *all* of the problems of the relevant training and testing sessions focused on one feature of language, in this case, *on.* During each trial, Sarah was required to put one piece of paper on the other. She could have learned to solve this problem simply by attending to the symbol, *color 1.* That color *wasalways* to be placed on top of the other color. This rather simple strategy requires no understanding of the relationship between the symbol glossed as *on* and the symbols for the other two colors. When three choices of color were available, the problem was somewhat more difficult because Sarah had to attend to both color names. The context, however, still sufficed to define the task of putting one piece of paper on another. Similar considerations reveal that more complex problems, which seem to require an understanding of the syntactic structure of the ins/ruction (for example, conditional instructions and instructions presented in hierarchical form), could be solved by applying nonsyntactic rules , (Terrace, 1979a).

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 comprehend wh-questions. In each case, the chimpanzees were drilled extensively on the correct answers to questions such as *color that? what that?,* and so on (Gardner & Gardner, 1975b). The only alternatives present when Sarah was asked *color that?* were the symbols designating various colors (Premack, 1976). For most tests, only two alternative color names were provided. On similar problems, alternating questions were presented to Lana which asked her first to identify the color and then the name of certain objects. Even though this type of problem was slightly more complex than those posed to Sarah, correct performance does not imply an understanding of the interrogative. Lana simply had to match the lexigram shown to her *(name of vs. coloroJ)* with the appropriate subset of alternatives available on her console, I f, for example, *name* of was presented, she had to restrict her choice to object names, a task on which she had been drilled extensively in earlier problem sets.

Each example of Sarah's and Lana's purported use of language was obtained in a constant setting with repeated problems of the same nature and with a restricted number and variety of answers. These conditions were ideal 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 should not be interpreted as "linguistic" (Limber, 1977; Mounin, 1976; Seidenberg & Petitto, 1979b; Terrace, 1979a).

In their effort to demonstrate comprehension of wh-questions, the Gardners accepted as correct *any* response they designated as being lexically appropriate response. 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 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 III in Brown's scheme for describing the development of language in children.

At Stage ill, 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 which a child masters, in a cumulative fashion, at each point of its development. The Gardners' conclusion ignores these aspects of a child's language development.

SUMMARY AND CONCLUSIONS

Taken together, the available data indicate that apes can learn extensive vocabularies of symbols; that is, they can learn that particular symbols are appropriate to particular situations (e.g., *Nim, hug, cat, me* in the presence of a cat). In studies using artificial "languages," chimpanzees are required to solve comprehension or production problems by using certain elements of those languages in order to obtain a reward. Those problems can be solved, however, without an understanding of the semantic relationships which a *human* observer can perceive between the relevant symbols. There is no evidence that apes can *combine* the symbols they learn in order to create new meanings or that they organize semantic relationships between symbols. The function of the symbols of an ape's vocabulary appears to be not so much to identify things or to convey information (cf. Skinner's [1957] concept of "tacts") as it is to satisfy a demand that it use that symbol (cf. Skinner's concept of "mands").

In the present 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 2-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 2-sign combinations followed rules of sign order. However, other aspects of Nim's use of sign language suggest that it is erroneous to conclude that his combinations were primitive "sentences."

The mean length of Nim's combinations fluctuated unsystematically between l.l and 1.6 du~ing the last 19 months of the project. During that time the size of his vocabulary approximately tripled (from 42 to 125 signs). Nim's combinations of three or more signs showed no evidence of lexical regularities, nor did they elaborate or qualify what he signed when he produced a 2-sign combination.

As has been the practice of other studies of sign language in apes, we performed a "semantic" analysis of Nim's 2-sign combinations. Ninety-three percent of these combinations could be assigned unambiguously to one of 20 semantic categories. Expanding on the results of other studies, we demonstrated the reliability of our semantic judgments and that certain semantic roles were expressed (statistically) in particular orders of signs. In the case of children's utterances, position preferences analyzed by the method of "rich interpretation" can serve as evidence that the children use order rules to express semantic relationships. Certain aspects of our data suggest that it is premature to apply the method of rich interpretation to Nim's utterances. Not only were there too few lexical examples of each semantic role to justify the designation of order regularities as semantic (rather than lexical); there were also too many idiosyncratic order regularities in combinations of particular signs. It would be gratuitous to explain these by categorical semantic rules.

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. Our discourse analysis revealed that 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 which is evident in a child's early use of language, instead of conversing, Nim appears to have complied with his teacher's request that he sign when he was unable to acquire a desired object by reaching or grabbing for it, or unable to persuade the teacher to engage in some desirable activity (e.g., a game of chase or tickle) by using a nonverbal gesture. The more rapidly Nim satisfied his teacher's demand to sign, the more rapidly he was rewarded. Accordingly, it is not surprising that Nim's signs often interrupted his teacher's signs.

In general, the teacher's signing appeared to function as a cue informing Nim that only if he signed, would he be rewarded by a desired object or activity. Having learned that many of the signs used by the teacher are acceptable responses, Nim used some of them along with certain generally appropriate signs (e.g.,/Vim, *me, you).* Analyses of films of other apes signing with their teachers revealed a similar lack of creativity in the apes' utterances, a similar tendency to interrupt and a similar dependence of these utterances on the prior signing of their teachers.

In sum, evidence that an ape can create a sentence can, in each case, be explained by reference to simpler nonlinguistic processes. Sequences of signs produced by Nim and by other apes may bare superficial similarities with the first multiword sequences produced by children in the eyes of a human beholder. But unless alternative explanations of an ape's combinations of signs are eliminatedmin particular, the habit of imitating teachers' utterancesmthere is no reason to regard an ape's muhisign utterance as a sentence.

At the level of individual signs, anecdotal evidence suggests that Nim may have learned to use certain signs to express emotional states, and in some instances to use these signs as alternatives to physical action. He also seems to have learned to use certain signs to manipulate the behavior of his teachers by misrepresenting certain body states.

The results of our study are negative in the sense that we have shown that Nim's utterances are not sentences. That is, they do not express well-formed semantic propositions in structured sequences. Our results, how-

ever, are positive in that they reveal the strategy that Nim and other apes follow in producing utterances which contain certain superficial properties of sentences.

We are, of course, aware that our results cannot be considered definitely negative concerning an ape's capacity to master the basic features of a natural human language. Even though Nim was subjected to an intensive program of socialization and instruction in sign language, that program was marred by the large number of teachers with which he had to cope. His emotional reactions to the steady replacement of volunteer teachers suggests that his use of sign language may have been limited as much by motivational as by intellectual factors (Terrace, 1979b). As far as we can determine, however, there is no reason to assume that Nim's motivation to sign was affected more adversely by the many teachers he experienced than was Washoe's. Both chimpanzees were taught by a small nucleus of long-term caretakers who were assisted by a larger group of less permanent teachers; both achieved essentially the same level of mastery of sign language.

Our experience 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 exclusively by a small and stable group of teachers. Our results also show that it is important to have a sufficiently large corpus of utterances, in contexts which can be accurately documented.

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.

NOTES

'This research was supported in par; by grants from the W.T. Grant Foundation, the Harry Frank Guggcnheim Foundation, and NIMH (R01MH29293). We thank Lois Bloom and Roger Brown for their helpful comments on an earlier draft of this manuscript. Stephanie LaFarge for the conscientious care with which she raised Nim during his first lg months. Drs. B. Stark. S. Lerman, and T. Blumenfeld for their supervision of Nim's medical care. and G.A. Tare for his assistance in producing photographs of Nim. We also wish to thank the more than 100 volunteers who assisted in working with Nim and on data analysis. Particular thanks are extended to Walter Benesch, Ilene Brady, Joyce Butler, Bob Johnson, Susan Quinby, Amy Schachter, and Bill Tynan.

:It is often assumed ¢rr~c~ously that all forms of manual-visual communication are American Sign Language. However, sign languages vary along a continuum. At one extreme is ASL, which possesses a unique grammar, expressive devices, and morphology. It is the natural language of North American deaf people which is learned as a first language by many deaf people, especially the deaf children of deaf parents. At the opposite extreme is Signed English; a code for expressing English in a manual-visual mode. In Signed English--but not in ASL--signs are used in English word order with signed equivalents of morphemes such as -ed and -ly. Pidgin Sign uses ASL signs and some of its expressive devices in English word order without the grammatical morphemes of English. Thus it is derivative of both ASL and Signed English. Hearing persons rarely achieve native-like control over the complex structure and grammar of ASL; their signing skills typically fall somewhere within the Pidgin to Signed English end of the continuum. Pidgin Sign, nol ASL, was used in this and all other studies of signing behavior in apes. It is misleading Io lerm their signing "ASL" since it does not exhibit the grammatical structure of that language (see Bornstein. 1900 and Stoko¢. Casterine, & Cronberg, 1965).

tYerkish symbols were chosen so Io have "no semantic *significance* at all" (Rumbaugh. 1977, p. 93). In fact. however, the symbols are not semantically arbitrary. Each symbol is composed of one or more of nine design elements, and this symbol appears on one of seven background colors. These colors designate general semantic types; e.g., red for ingestables, blue for activities, green for parts of the body, blue-gray for states and conditions, and so on. Two colors, while and yellow, were used as senlential modifiers; they could occur only at the beginning of a sequence.

"The basic structure of a sign is defined by four parameters: location, orientation, hand configuration, and movement. Signs do not inflec! in the same manner as words in spoken language; i.e.. by adding affixes in a *linear* manner. Rather, ASL accomplishes these same functions *bysimullaneously* superimposing the "inflection" on the basic form of the sign. This is generally done by systematically modulating the movement, repetition, and/or spatial parameters of Ihe sign. The structured use of the signing space is an important device for signaling grammatical changes in ASL, particularly pronominal reference in the language. Furthermore, the systematic use of facial expressions, body shifts, and eye gaze are integral parts of the grammar of the language. For these reasons, ASL should be considered as a natural language whose phonology, morphology, syntax, and semantic structure is independenl of that of spoken languages, For additional details see Hoemann (1975a).

'The son of Pan and Carolyn, both long-term residents at the Institute, Nim is Carolyn's eighth offspring and the fourth to be taught sign language. Ally (a full brother), Tania (a full sister), Onan (a half brother), and Bruno (a half brother), have been subjects of sign language studies conducted at the Institute by Dr. Roger S. Fouls.

'Stephanie's household included seven other people: her husband WER; three of Stephanic's children from an earlier marriag. Heather, Jennie. and Joshua Lee (aged 15, 14, and I l. respectively); and on many occasions. WER's four children from an earlier marriage: Louisa, Annik. Albert, and Mathilda (aged 16, 14,] l, and 8, respectively). Another fulhime resident of the house was Marika Moosbrugger, a 2g-year-old schoolteacher and close friend of the family. Only Stephanie, Jennie, and Marika could be regarded as proficient in sign language. The other members of the LaFarg¢ household knew a vocabulary of basic signs but had not had formal training in sign language.

'Checks of sign order, as opposed to the actual occurrence of signs, were made in too few instances to provide a good estimate of the reliability of sign order. However. two indirect checks of sign order suggested thai there were no systematic errors in the teachers' reports: agreement between teachers' reports as to sign order and data from video transcripts.

'Two signs originally included in Nim's acquired vocabulary were subsequently deleted. A review of our data suggested that Nim did not understand the meaning of *lime* and *what,* and that these signs served as routine event markers: they always appeared in combination with another sign, and were always in the first position. A complete description of the topography of each of Nim's signs and their contexts can be found in Terrace, 1979b, Appendix C.

"During the first three years of the project. Nim's teachers varied widely in their sign

language proficiency, At any time, only three or four could be classified as skilled signers. During the final year several factors increased *the* proficiency of old and new teachers: weekly classes conducted by a native deaf (ASL) signer (Alb Boerwick); weekly informal sessions with skilled Signed English signer (Ronnie Miller), who was the daughter of deaf parents; the addition to *the* project of an R.I.T.-trained sign-language interpreter (Renee Falitz) and a hard-of-hearing person (Mary Wambach), who was skilled in both Signed English and ASL.

'°Niun's signing was analyzed during each of the five data periods: Period I, **6/I/75** -12/20/75 (ages 18-25 monthsl; Period 2, I/5/76-2/28/76 (ages 26-28 months); Period 3, 3/l/76-4/4/76 (ages 29-30 months); Period 4, 4/5/76-7/4/76 (ages 30-33 months); and Period 5, 7/5/76-2/7/77 (ages 33-39 months). These periods were arbitrary and not intended to rellect qualitative changes in Nim's signing. The time of each period was determined by factors such as the availabilily of voh0nteers for analyzing data and deadlines for submitting grant proposals.

"Initially, when Nim pointed at an object or locations, the point was coded in terms of the interpreted meaning of the point; e.g., *up* if Nim pointed vertically into the air. Eventually it became clear that the majority of points were not easily classifiable, and thus signs Ihat could be glossed such as *up, down. there,* and *that, were* referred to as a single "sign" *point.* Two important exceptions were the signs *me* and *you.* In these instances the contexts justified designation of separate signs. See Hoffmeister 0972) for a discussion of *point* as used by deaf children.

'~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 (e.g., *sweep, fly,* and *drive)* are made with a single motion. Related nouns (e.g., *broom, airplane,* and car) are made by repeating a sign twice (the so-called "double bounce" form, (cf. T. Suppala & E. Newport, 1978). None of Nim's teachers could distinguish between the meanings of utterances which did and did not contain signs that were repeated successively. Emphasis appears to be their sole function. We saw no evidence that repeated signs were "'disfluent," and as is often the case with children who stutter (Colburn, 1979). Overall, less than 5 percent of the linear utterances we observed contained successively repeated signs.

"Run there, is signed by moving the *run* sign from the signer to a real or previously established location in the signing space. This has been termed "inflecting for location" in ASL and is a regular grammatical device in sign language. Deaf children acquire this process progressively (of. Seidenberg and Petitto, 1979a). In calculating the child's MLU, however, researchers have labeled constructions such as *run there* as a single sign. Even though a 2-sign count may be warranted, they have counted only I sign in order to avoid exaggerating a deaf child's grammatical competence. In addition, *invented signs* and *mimetic depictions* are generally not counted by researchers studying the deaf child's acquisition processes, thus deflating the MLU count even further (Klima & Bellugi, 1972). Accordingly, the deaf child's MLU count might erroneously appear somewhat deflated in comparison with the hearing child's data.

"Such isolated effects may be nothing more than what one would expect from statistically random variation. That is, in a certain proportion of the many cases we examined in our semantic analysis (the product of the level at statistical significance and the number of comparisons), we should expect to find statistical evidence of *apparent* structure.

"These analyses were performed by the third author as part of his dissertation research.]"he teachers and Ihe date~ on which they were videotaped arc Laura Petitto: February 5, 1976, March 18. 1976, and June 24, 1976; Dick Sanders: March 20, 1977, July I.'t and 19, 1977; Joyce Butler: April 19, 1977, June 6, 1977; Bill Tynan: April II, 1977.

"The First Signs of Washoe, WGBH Nova fihn, 1976.

"Tracings of selected film frames would have been published, but no agreement on film copyright releases was reached with the Gardners. Tracings of signs shown in *transcripts* below can be seen in Terrace *et aL,* 1979.

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APPENDIX: EXHAUSTIVE LISTING OF NIM'S COMBINATIONS OF 2 OR MORE SIGNS

Two-Sign Sequences

Sequence Type		*Tokens*
Alex	locative/point	I
Andrea	angry	I
	banana	I
	Bill	5
	cracker	2
	eat	4
	hug	2
	Laura	I
	lOcative/point	2
	me	I
	Nim	6
	peach	I
	peat	]
	play	I
	red	I
	what	I
	you	I
angry	had	3

Sequence Type		*Toketts*
	ball	I
	bite	4
	cat	1
	dirty	2
	handcream	2
	hug	14
	Laura	I
	me	6
	Nim	4
	open	1
	shoe	1
	sorry	8
Anna	eat	I
	you	1
apple	Andrea	3
	baby	]
	bite	I
	bowl	I

(Continued)

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
apple *(conl.)*	cracker	*I*
	dirty	*I*
	drink	*6*
	eat	37
	fruit	2
	give	3
	gum	3
	hug	2
	in	I
	jump	I
	locative/point	2
	me	27
	lilt)re	5
	Ninz	65
	orange	4
	Oul	2
	play	
	please	
	raisin	
	red	
	smell	
	lea	
	yogurt	
baby	chair	
	clean	
	drink	
	eat	
	give	
	hug	
	me	
	more	
	Nim	
	out	
	sit	
	tickle	
	angry	
	bite	
	dirty	
	hug	
	me	
	Nim	
	sorry	
ball	give	
	gum	
	in	
	locative/point	
	me	
	Nim	

Sequence Type		*70kens*
	play	
	red	
	tickle	
banana	apple	
	Bill	
	come	
	cracker	
	drink	4
	eat	69
	fruit	1
	hug	4
	locative/point	4
	me	97
	more	5
	Nim	73
	play	2
	same	I
	sorry	I
	tea	I
	toothbrush	I
	what	I
bed	time	2
berry	eat	3
	grape	I
	me	2
	Nim	I
Bill	Andrea	5
	apple	1
	come	I
	groom	I
	gum	I
	hug	I
	Nim	5
	play	I
	shoe	I
bile	apple	2
	angry	6
	bad	I
	down	I
	hug	I0
	Joyce	I
	me	3
	Nim	2
	no	2
	out	I
	pear	1
	peach	2
	play	4

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
	please	*I*
	,sorry	*7*
	Susan	*I*
	tickle	*2*
black	paper	I
blue	hug	I
	in	I
	pants	2
	sock	I
book	Nim	2
	open	3
bowl	apple	1
bracelet	locative/point	I
	open	I
break	hug	2
	IRe	2
brown	color "	2
	eal	2
	IOcative/poInt	I
	Nim	2
	shoe	I
	sweet	I
brush	baby	2
	give	2
	me	
	Nim	13
	orange	I
	play	I
	smell	1
	toolhbrush	I
	whal	I
	you	I"
bug	drink	2
	locative/point	I
	Nim	I
	same	I
	smell	I
cat	apple	I
	book	2
	chair	I
	come	I
	eal	2
	localive/point	I
	me	I
chair	finish	I
	gum	2
	hug	I
	locative/poinl	6

Sequence Type		*Tokens*
	me	*I*
	more	*3*
	Nim	*2*
	play	*I*
clean	angry	*I*
	brush	*I*
	bowl	*1*
	dirly	*2*
	hug	*3*
	in	*I*
	locative/point	*I*
	me	*2*
	Nim	*I*
	open	*I*
	toothbrush	*I*
	walcr	*3*
close	light	*I*
cold	in	*I*
color	black	*4*
	blue	*5*
	brown	*2*
	cat	*2*
	hat	*I*
	Nim	*5*
	orange	*I*
	red	*7*
	yellow	*I*
come	apple	*I*
	Bill	*5*
	bug	*2*
	give	*3*
	hug	14
	jump	I
	kiss	I
	me	5
	Nim	2
	open	3
	play	6
	tickle	3
cookie	cat	I
	liut	I
cracker	eat	10
	give	2
	locative/point	I
	me	3
	Nim	21
	Sweet	2
	what	I

Two-Sign Sequences *(cont.)*

Sequence Type		Tokens
crayon	red	*1*
cup	in	*1*
	drink	*2*
diaper	dirty	*1*
Dick	bite	*1*
dirty	chair	*2*
	down	*1*
	eat	*2*
	finish	12
	hug	56
	in	1
	locative/point	5
	me	3
	Nim	7
	orange	3
	out	5
	pants	1
	red	1
	smell	
	sorry	
	sweet	
	toothbrush	
	water	
dog	come	
	me	
	play	
	yogurt	
down	come	
	Nim	
	yogurt	
draw	black	
	eat	
	finish	
	['lower	
	Nim	
	open	
	paper	
	red	6
	tree	**1**
drink	apple	6
	Bill	**1**
	bite	**1**
	cracker	**1**
	down	3
	eat	64
	finish	2
	flower	**1**
	give	7

Sequence Type		Tokens
	grape	*2*
	groom	***1***
	gum	*1*
	hat	*1*
	hot	*1*
	hug	*6*
	hungry	*1*
	hurry	*1*
	in	*3*
	kiss	*1*
	I.aura	*2*
	locative/point	*5*
	me	*51*
	more	14
	Nim	143
	nut	1
	open	2
	orange	8
	red	1
	smell	2
	sweet	12
	tea	44
	toothbrush	5
	up	6
	water	7
	what	1
	you	1
	angry	2
	apple	56
	baby	3
	banana	38
	berry	4
	bite	1
	blue	2
	black	2
	brown	3
	bug	2
	cat	1
	clean	1
	cold	1
	come	3
	cracker	6
	drink	98
	finish	2
	fruit	7
	give	12
	glass	1
	grape	38

Two-Sign Sequences *(cont.)*

Sequence Type		Tokens
	green	*2*
	groom	*3*
	gum	16
	hug	15
	hungry	13
	in	2
	kiss	2
	point	16
	me	76
	locative/point	16
	Niul	302
	nut	36
	open	2
	orange	10
	out	**1**
	peach	5
	pear	10
	play	**1**
	please	2
	raisin	24
	red	5
	shoȼ	**1**
	sleep	**1**
	smell	2
	sorry	**1**
	spoon	**1**
	Susan	**1**
	swat	26
	tea	9
	tickle ,.	**1**
	time	6
	toothbrush	**4**
	what	12
	work	3
	yellow	**1**
	yogurt	2]
	banana	**1**
clean		**1**
eal		3
me		2
Nim		2
out		2
pull		**1**
finish	baby	**1**
	banana	**1**
	bite	**!**
	cat	**1**
	chair	2

Sequence Type		Tokens
	clean	*1*
	dirty	*7*
	down	*1*
	drink	*2*
	eat	*7*
	give	*3*
	hug	187
	me	**1**
	Nim	7
	out	4
	play	**1**
	Rcnee	**8**
	shoe	**1**
	sorry	7
	toot hbrush	5
	yogurt	2
flower	angry	2
	point	**1**
	smell	**1**
fruit	eat	**8**
	me	**1**
	Nim	11
	nut	**1**
	open	**1**
gimme	drink	**1**
	eat	2
	handcream	2
	sweet	**1**
	toothbrush	**1**
	water	2
give	apple	9
	baby	**1**
	ball	14
	banana	7
	black	**1**
	blue	2
	brown	**1**
	brush	3
	bug	2
	clean	**1**
	crayon	2
	dog	**1**
	drink	15
	eat	54
	finish	**1**
	flower	2
	grape	3
	gum	4

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
give *(cont.)*	handcream	14
	harmonica	2
	hal	4
	here	I
	hug	3
	hungry	2
	hurry	2
	jump	2
	key	I
	kiss	I
	light	2
	listen	I
	locative/point	6
	me	41
	more	3
	Nim	23
	nut	2
	open	2
	orange	3
	out	1
	pear	2
	play	I
	raisin	2
	red	2
	rock	I
	smell	I
	spoon	I
	sweet	6
	tea	I
	that	4
	tickle	i
	toothbrush	4
	water	9
	wha!	I
glass	eat	I
g o	Bill	I
	eat	]
	more	2
	open	I
good	banana	I
good-bye	cat	I
	drink	I
grape	eat	74
	gimme	I
	give	I
	grOom	1
	hug	1
	in	2

Sequence Type		*Tokens*
	locative/point	*2*
	me	12
	more	2
	Nim	21
	open	2
	out	3
	time	**I**
	up	**I**
green	apple	**I**
	sock	**I**
groom	baby	2
	grape	**I**
	handcream	**I**
	me	21
	Nim	6
	peach	**I**
	you	2
gum	apple	**4**
	Bill	3
	bite	**4**
	drink	3
	eat	79
	gimme	2
	give	3
	hug	I
	me	19
	more	I
	Him	47
	pear	
	play	
	sweet	
	tickle	
	what	
	you	
handcream	angry	
	baby	
	banana	
	Bill	
	brush	
	eat	
	give	
	groom	
	hug	
	locative/point	
	me	
	more	
	Nim	
	open	

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
	out	*3*
	play	*2*
	sleep	*I*
	smell	*1*
	sorry	*I*
	tickle	*I*
happy	me	*I*
	Nim	*2*
harmonica	me	*I*
	Nim	*I*
hat	hug	*3*
	listen	*I*
	me	20
	more	2
	Nim	3
help	Bill	2
	clean	I
	drink	1
	hug	I
	me	*6*
	Nim	*4*
	open	*12*
	out	*4*
	pants	*I*
	shoe	*2*
Herb	eat	*I*
	me	*I*
	tickle	*2*
	you	*2*
, home	Alex	*I*
hot	CUp	*I*
	drink	*I*
	light	*1*
	Nim	*I*
	tea	*2*
	water	*2*
	Alex	*2*
	angry	*I*
	baby	*4*
	bad	*2*
	banana	*I*
	berry	*I*
	Bill	*I*
	bile	*2*
	clean	*I*
	come	*5*
	cracker	*2*
	Dick	*2*

Sequence Type		*Tokens*
	dirly	
	drink	*5*
	eat	*7*
	finish	*32*
	give	
	go	
	gum	
	hungry	
	in	
	Joyce	
	jump	2
	Laura	2
	me	74
	more	3
	music	I
	Nim	106
	nut	**1**
	open	6
	orange	2
	out	15
	play	4
	please	5
	Renee	34
	sorry	32
	Susan	**8**
	sweet	I
	time	2
	Tom	I
	toothbrush	I
	up	2
	wash	I
hungry	angry	I
	drink	!
	eat	13
	hug	5
	me	9
	Nim	7
	out	2
hurry	drink	**1**
	eat	2
	gum	I
	more	2
	play	**1**
hurt	bite	**1**
	eat	2
	hug	I
	me	2
ice	bile	I

Two-Sign Sequences *(COnt.)*

Sequence Type		*Tokens*
ice *(cont.)*	Nim	2
in	angry	
	bad	
	hire	
	box	
	brown	
	chair	
	coat	
	drink	
	grape	
	hat	
	hug	
	listen	
	me	2
	Nim	2
	out	5
	pants	"lO
	play	4
	raisin	I
	red	!
	shirt	7
	shoe	3
	sock	
	sweet	
	tea	
	water	
	work	
Joycc	kiss	
	me	
	play	
	tickle	
jump	chair	
	dirty	
	eat"	
	hug	11
	rue	7
	Nim	6
	open	2
	play	I
	rock	I
	tickle	2
	hug	I
	locative/point	I
	me	3
	Nim	I
	open	3
	out	I
	play	2

Sequence Type		*Tokens*
kiss	baby	*3*
	dog	*I*
	drink	*I*
	me	*1*
	Nim	*6*
Laura	bite	
	bug	
	grape	
	listen	
	locative/point	
	me	
	Nim	
	red	
	you	2
lie-down	sleep	2
light	give	2
	locative/point	I
	out	I
listen	Andrea	3
	apple	**1**
	Bill	3
in		
	locative/point	
	me	
	Nim	
	sorry	
	you	
locative/point	ball	
	banana	
	bug	
	chair	
	clean	
	drink	
	eat	
	fruit	
	give	
	gum	
	handcream	
in		
	light	
	me	
	Nim	
	orange	
	play	
	smell	
	spoon	
	tea	
	water	

Two-Sign Sequences *(cont.)*

~luence Type		*Tokens*
me	Andrea	*2*
	angry	*5*
	apple	17
	bad	2
	ball	10
	banana	34
	bite	2
	book	3
	brown	2
	brush	9
	clean	2
	come	2
	cook	I
	cracker	I
	dirty	2
	down	2
	drink	65
	eat	237
	flOWer	I
	give	II
	go	3
	grape	2
	gum	43
	handcream	3
	happy	2
	hat	26
	help	2
	hug	40
	hungry	2
in		5
jump		2
kiss		I
Laura		I
lisler~		I
locative/point		3
more		12
Nim		328
nut		4
open		10
orange		I0
out		5
pants		2
peach		I
play		8[
please		I
pole		!
raisin		4
red		I

Sequence Type		*Tokens*
	Renee	*2*
	shoe	**I**
	smell	**I**
	smile	**I**
	sorry	17
	Susan	I
	sweet	**8**
	tea	13
	tickle	20
	Tom	**4**
	toothbrush	I
	up	2
	Walter	2
	water	5
	what	I
	work	3
	yogurt	I
	you	41
more	apple	12
	ball	2
	banana	62
	berry	2
	Bill	I
	bite	2
	brush	5
	chair	19
	drink	99
	cat	287
	fruit	2
	gimme	I
	go	7
	grape	II
	groom	**4**
	gum	29
	handcream	21
	hug	
	hurry	I
	in	I
	jump	I
	key	I
	listen	!
	locative/point	I
	me	42
	Nim	24
	NUf	II
	open	I
	orange	6
	paint	I

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
more *(cont.)*	peach	2
	pear	13
	play	41
	pole	9
	raisin	I
	shoe	2
	smell	3
	spoon	2
	sweel	14
	swing	I
	lea	23
	lickle	136
	loot hbrush	3
	up	I
	water	10
	what	6
	yogurt	5
	hat	I
My	Nim	I
name	Andrea	2
Nim	apple	25
	baby	6
	bad	I
	banana	18
	Bill	2
	bird	I
	bile	4
	book	I
	brown	2
	brush	4
	bug	I
	chair	2
	color	2
	cracker	3
	dirty	2
	down	2
	drink	43
	eal	209
	finish	I
	fruit	6
	give	4
	go	4
	grape	5
	groom	I
	gum	21
	handcream	7
	hat	8
	hug	23
	h ungry	13
	i n	**3**
	Joyce	**I**
	jump	**I**
	key	**1**
	kiss	2
	Laura	3
	locative/point	**6**
	me	**89**
	more	7
	music	**I**
	nut	9
	open	5
	orange	5
	out	6
	pants	**I**
	paper	**i**
	peach	**I**
	pear	**4**
	p]ay	19
	raisin	**6**
	red	7
	Renee	**!**
	shoe	**1**
	sorry	2
	Susan	**I**
	sweet	3
	tea	7
	tickle	**16**
	toothbrush	**4**
	Walter	2
	water	2
	what	**I**
	who	**I**
	work	**I**
	yellow	**I**
	yogurt	**8**
	yOU	**4**
no	break	**!**
	climb	**i**
	drink	**I**
nut	cookie	**I**
	drink	**1**
	eal	37
	fruit	**I**
	give	2
	gum	**I**
	i n	**6**

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
	me	16
	more	3
	Nim	71
	open	6
	out	3
	red	2
	sweet	2
	what	**I**
	shoe	**I**
	chair	**I**
	panl'~	**1**
open	apple	2
	baby	
	bell	
	bracelet	
	bite	
	book	
	box	
	bug	2
	chair	**I**
	door	**I**
	down	**I**
	draw	**1**
	drink	3
	eat	**8**
	fruit	**I**
	give	2
	grape	3
	gum	**I**
	help	3
	hug	21
	i n	**I**
	key	2
	light	**I**
	locative/point	**4**
	me	13
	Nim	6
	nut	**4**
	orange	**I**
	out	6
	paper	**I**
	pea r	**I**
	play	2
	rock	
	shoe	**I**
	tickle	**I**
	wash	**I**
	what	**I**
	yogurt	*2*
orange	apple	*4*
	brown	***I***
	dirty	***4***
	drink	15
	eal	II
	rne	13
	Nim	15
	Renee	**I**
	sock~	2
	swcel	3
	oul	**I**
	yogurt	2
	you	**1**
out	baby	3
	banana	2
	Bill	**I**
	box	**I**
	break	**I**
	chair	**I**
	dirty	2
	drink	5
	eat	6
	finish	2
	go	**I**
	handcream	**I**
	help	**I**
	hug	32
	hurry	2
	i n	2
	key	**I**
	me	4
	Nim	6
	open	3
	pants	20
	pear	4
	plant	**I**
	play	3
	red	2
	shirt	5
	shoe	19
	sock	**1**
	tea	2
	wash	3
	water	2
	work	**I**
paint	yellow	**I**
pancake	eat	2

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
pancake *(conL)*	me	2
	Nim	2
pants	baby	I
	hug	3
	in	42
	locative/point	I
	me	4
	Nim	2
	on	2
	out	26
	play	I
paper	red	I
peach	apple	I
	eat	3
	fruit	2
	Nim	3
pear	drink	2
	eat	g
	give	2
	me	4
	Nim	20
	open	I
peek-a-boo	come	I
	Nim	I
play	Andrea	4
	angry	4
	ball	13
	banana	2
	Bill	II
	bug	3
	clean	I
	come	16
	dirty	I
	dog	6
	down	I
	drink	2
	eal	3
	finish	2
	game	I
	glue	3
	groom	I
	go	2
	gum	4
	handcream	I
	help	I
	hug	23
	in	I
	Joyce	2

Sequence Type		*Tokens*
	jump	*3*
	key	***8***
	locative/point	***4***
	me	375
	more	7
	Nim	67
	open	**4**
	orange	**I**
	out	**4**
	pole	2
	sho¢	2
	sorry	**I**
	smell	**I**
	Susan	2
	sweet	**I**
	tickle	**49**
	Tom	2
	up	**I**
	Walter	**4**
	what	**I**
	you	5
please	drink	**I**
	gum	**I**
	hug	**9**
	hurry	**I**
	me	**I**
	Nim	2
	open	**I**
	tickle	**I**
pole	me	2
	more	
	Nim	
	smell	
	up	
put	in	
pull	Nim	
	out	
	t iekle	
rain	water	2
raisin	apple	2
	eat	15
	give	2
	locative/point	1
	me	5
	more	I
	Nim	23
	nut	i
	open	I

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
really	dirty	I
red	Andrea	I
	apple	2
	ball "	2
	banana	I
	bird	2
	color	3
	cup	I
	drink	3
	eat	4
	finish	I
	flower	2
	fruil	3
	hug	I
	Laura	I
	locative/point	I
	more	I
	Nim	II
	Orange	I
	out	I
	paint	I
	shoe	2
	sweet	2
	lea	2
	time	]
	up	I
	work	I
Renee	cracker	I
	eat	I
	finish	3
	hug	3
	Nim	I
	out	2
	tickle	I
rock	give	I
	()pen	I
run	sorry	I
same	me	I
shirt	on	3
	out	2
	pant,i	I
shoe	chair	I
	cracker	I
	give	I
	help	2
	hug	I
	me	4
	more	I

Sequence Type		*Tokens*
	Nim	*3*
	off	*7*
	on	***I***
	orange	***I***
	out	***54***
	pear	***I***
	play	***I***
	red	***I***
	lea	***I***
sleep	apple	*6*
	hug	***I***
	lie.down	*2*
~,mcll	bug	***I***
	drink	***I***
	cat	*3*
	flOwer	*2*
	gum	***I***
	hot	***I***
	hug	*2*
	locative/point	***I***
	me	*2*
	Nim	***I***
	Open	*2*
	red	***I***
	loolhbrush	***I***
socks	in	***I***
	Nim	***I***
	01.II	***]***
sorry	angry	***I***
	baby	*3*
	bad	***t***
	Bill	*3*
	bite	***I***
	break	*4*
	come	*2*
	eat	***I***
	finish	***I***
	gum	*2*
	hug	***I***
	me	123
	Nim	II
	Oul	13
	pants	2
	play	***I***
	please	2
	Rene	***I***
	Su~an	***I***
	tickle	***I***

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
spoon	eat	7
	me	I
	Nim	3
stay	toothbrush	I
Susan	me	I
	Renee	I
	sorry	I
	lea	1
sweet	apple	3
	berry	I
	chair	2
	cracker	3
	drink	I0
	eat	27
	flower	2
	handcream	I
	hug	2
	in	I
	Laura	I
	localive/point	1
	me	23
	more	5
	Nim	85
	out	I
	open	I
	peach	1
	raisin	6
	red	3
	tea	I
	whal	I
	yellow	I
tea	drink	77
	eat	II
	handcream	I
	hat	2
	hot	I
	hug	2
	in	12
	me	17
	more	8
	Nim	14
	nut	I
	out	3
	smell	I
	tickle	4
	time	2
telephone	in	1
tickle	Alex	I

Sequence Type		*Tokens*
	apple	I
	baby	I
	ball	I
	bite	2
	brush	2
	chalk	I
	drink	2
	eat	2
	gum	I
	happy	2
	hug	IR
	jump	I
	locative/point	3
	me	316
	more	23
	Nim	107
	open	I
	play	26
	shoe	1
	tca	2
	you	10
time	eat	I0
	finish	I
	give	I
	go	I
	hug	i
	me	I
	open	I
	out	2
	toothbrush	I
	work	6
Tom	bite	I
	drink	I
	eat	2
	Nim	I
toothbrush	book	I
	drink	2
	eat	I
	handcream	I
	hug	2
	me	6
	more	I
	Nim	17
	raisin	I
	time	!
tree	break	2
up	hug	I
	open	1

Two-Sign Sequences *(cont.)*

Sequence Type		*Tokens*
	tree	I
	pole	2
Walter	Nim	I
	play	1
	you	I
wash	diaper	I
	drink	I
	waler	I
water	brush	5
	clean	2
	drink	8
	eat	2
	gimme	I
	give	4
	go	I
	handcream	I
	hot	2
	in	I
	me	13
	more	I
	Nim	I0
	Open	I
	toothbrush	2
	wash	4
what	ball	I
	bird	I
	book	3
	chair	I
	clean	I
	color	1
	drink	1
	eat	6
	fruit	I
	grape	I
	gum	I
	hug	3
	key	2
	locative/point	I
	me	4
	Nim	4
	Open	
	raisin	
	smell	
	sweet	
	time	
	toothbrush	
	you	
work		

Sequence Type		*Tokens*
white	eat	I
who	play	I
	you	I
work	finish	I
	grape	2
	hug	4
	out	2
	sorry	2
	time	
yelh)w	color	I
	eat	6
	Nim	3
	loothbrush	I
yogurt	apple	I
	cracker	1
	dirty	I
	eat	16
	me	2
	more	2
	Nim	57
	orange	2
	spoon	I
yon	banana	I
	Bill	I
	drink	2
	eat	8
	gum	1
	Herb	2
	in	1
	me	20
	Nim	7
	open	I
	orange	1
	Laura	7
	play	4
	shoe	I
	Susan	2
	sweet	2
	tea	I
	tickle	9
	Tom	I
	water	2
Totals:		1,374
		9,935

Three-Sign Sequences

Sequence Type			Tokens
Andrea	cracker	more	
	me	Nim	
	what	play	
angry	bite	angry	
	bile	sorry	
	come	hug	
	give	drink	
	hug	bile	
	hug	sorry	
	me	angry	
	me	Nim	
	sorry	angry	
	sorry	hug	
apple	drink	apple	
	drink	me	
	drink	Nim	
	eat	apple	2
	eat	drink	I
	eat	me	2
	cat	Nim	6
	eat	pear	I
	give	me	I
	grape	eat	2
	grape	Nim	I
	gum	me	2
	hat	me	1
	in	box	I
	me	apple	I
	me	eal	15
	m e	Nim	4
	more	eat	I
	Nim	apple	7
	Nim	eat	9
	Nim	give	2
	Nim	gum	I
	Nim	out	1
	orange	apple	I
	orange	eat	I
	out	hug	I
	peach	bite	2
	tea	Nim	I
baby	eat	apple	1
	eat	grape	I
	eat	nut	I
	hug	Nim	5
	me	Nim	I
	Nim	baby	7
	Nim	eat	**3**
	Nim	hug	
	pants	in	
bad	hug	me	
	me	eat	
	me	Nim	
	Nim	hug	
ball	give	me	
	in	hal	
	Nim	red	
	play	jump	
	same	eat	
banana	Andrea	Nim	
	bite	handcream	
	eat	Andrea	
	eat	banana	
	eat	drink	
	eat	me	I1
	eat	more	3
	eat	Nim	26
	eat	red	2
	give	hug	I
	give	Nim	2
	grape	banana	I
	hug	give	I
	hug	me	2
	hu~	Nim	I
	Laura	Andrea	I
	loc./point	banana	1
	me	banana	IO
	me	eat	I7
	me	hug	I
	me	more	I
	me	Nim	18
	more	banana	I
	more	eat	I
	more	me	I
	more	Nim	3
	more	**tickle**	**I**
	Nim	banana	6
	Nim	drink	2
	Nim	eat	33
	Nim	me	4
	Nim	more	1
	smell	eat	**1**
	toothbrush	me	**I**
	toothbrush	Nim	I
	wash	pants	I
berry	give	eat	**1**

Three-Sign Sequences *(cont.)*

Sequence Type			Tokens
Bill	grape	berry	*!*
	Andrea	eat	*I*
	give	gum	*I*
	grape	Nim	*f*
	gum	eat	*2*
	listen	hug	*I*
	me	Bill	*I*
	Nim	eat	*2*
	Nim	nul	
	Nim	play	
	nut	me	
	Play	Nim	
bird	nte	bird	
bile	angry	Nim	
	apple	bite	
	hug	bite	
	me	bile	
	me	sorry	
	me	you	
	Nim	bite	
black	give	black	
book	give	me	
	me	Nim	
	me	open	
break	banana	Nim	
	eat	tickle	
brown	Nim	more	
	shoe	hug	
brush	hat	me	
	listen	chair	
	me	brush	
	me	hug	
	me	Nim	
	me	you	
	Nim	baby	
	Nim	me	
bug	Nim	hug	
can't	happy	hug	
cat	come	me	
	loc./point	book	
chair	eat	chair	
	me	eat	
	more	chair	
	smell	red	
clean	me	eat	
	Nim	out	
	out	clean	
	out	pants	
close	out	in	
color	Bill	Nim	
	brown	groom	
	eat	yellow	
	Nim	brown	
	Nim	color	
	Nim	eat	2
	orange	eat	I
	orange	Nim	I
	red	apple	I
	red	color	I
	red	Nim	2
conic	drin k	eat	I
	give	sweet	I
	guilt	come	I
	hug	come	2
	kiss	hug	[
	me	come	I
	me	hug	I
	me	Nim	2
	me	Walter	I
	more	come	]
	play	hurry	I
cookie	Nim	eat	I
cracker	eat	cracker	2
	eat	Nim	4
	give	loc.tpoini	1
	me	cracker	4
	me	eat	2
	Nim	cracker	4
	Nint	eat	I
	orange	eat	I
Dick	me	eat	I
dirty	eat	dirty	I
	finish	hug	3
	hug	dirty	4
	hug	finish	3
	hug	Nim	3
	hug	Renee	I
	in	water	I
	me	dirty	I
	me	eat	I
	Nim	dirty	]
	Nim	hug	I
	Open	ou[	#
	orange	hug	I
	out	Nim	I
	pants	in	I

Three-Sign Sequences *(cont.)*

Sequence Type			Tokens
dirty *(cont.)*	red	out	
	sorry	bite	
	sorry	hug	
draw	hug	pancake	
drink	banana	apple	
	banana	Nim	
	ca!	book	
	eat	out	
	eat	dirty	
	eat	drink	II
	cal	grape	I-
	eat	hurry	1
	eat	loc./point	I
	eat	me	1
	eat	more	2
	eat	Nim	4
	eat	nut	3
	eat	tea	3
	eat	toothbrush	I
	give	me	I
	give	Nim	I
	groom	eat	I
	point	Nim	2
	me	drink	I 0
	me	eat	12
	me	give	I
	me	loc./point	1
	me	more	I
	me	Nim	14
	me	tea	I
	more	drink	I
	more	eat	3
	more	me	I
	more	Nim	1
	more	lea	2
	Nim	down	I
	Nim	drink	1 0
	Nim	eat	4
	Nim	loc./point	4
	Nim	me	4
	Nim	orange	I
	Nim	..... out	]
	Nim	peach	I
	Nim	sweet	3
	Nim	tea	**2**
	orange	eat	I
	red	drink	2
		smell	eat
		sweet	hug
		sweet	hungry
		sweet	me
		sweet	Nim,
		sweet	tea
		tea	drink
		tea	eat
		tea	mOre
		tea	Nim
		toolhbrtv, h	clean
		water	drink
		what	drink
eat		apple	eat
		apple	gum
		apple	me
		apple	Nim
		apple	pear
		baby	Nim
		banana	eat
		banana	me
		banana	Nim
		banana	*open*
		brown	eat
		color	eat
		color	Nim
		cracker	Nim
		drink	Andrea
		drink	banana
		drink	eat
		drink	give
		drink	hug
		drink	me
		drink	more
		drink	Nim
		drink	orange
		drink	red
		drink	sweet
		drink	tea
		finish	down
		finish	eat
		fruit	grape
		fruit	gum
		fruit	me
		fruit	Nim
		give	eat
		grape	drink
		grape	eat

Three-Sign Sequences *(cont.)*

Sequence Type			Tokens
	grape	hug	*I*
	grape	Nim	*6*
	green	Nim	
	groom	eat	
	gum	Bill	
	gum "	eat	
	gum	hurry	
	gum	Nim	
	gum	same drink	
	hug	open	
	hug	yogurt	
	hungry	hug	
	hungry	Nim	
	in	eat	
	jump	tickle	
	loc./point	hurry	
	loc./point	me	
	loc./point	smell	
	loc./point	sweet	
	me	apple	
	me	drink	3
	me	eat	16
	me	grape	**I**
	me	gum	2
	me	hug	**I**
	me	hungry	**I**
	me	more	**I**
	me	Nim	**48**
	me	nut	**I**
	me	open	**I**
	me	raisin	**1**
	me	tea	**I**
	more	banana	2
	more	chair	**I**
	more	drink	**I**
	more	eat	II
	more	gum	**I**
	more	me	**4**
	more	Nim	2
	Nim	apple	5
	Nim	,, banana	**I**
	Nim	cracker	**I**
	Nim	dirty	**I**
	Nim	drink	2-
	Nim	eat	**46** egg
	Nim	give	finish
	Nim	grape	**I**
		Nim	hot 2
		Nim	hug 4
		Nim	hungry 2
		Nim	loc./point 2
		Nim	me 2
		Nim	more 2
		Nim	nut 4
		Nim	orange 2
		Nim	peach I
		Nim	pear I
		Nim	play I
		Nim	raisin 2
		Nim	sweet 5
		Nim	tea I
		Nim	white 1
		Nim	yogurt 7
		nut	eat **2**
		nut	Nim 2
		nut	raisin eat
		orange	yogurt
		out	apple
		pea r	drink eat
		pear	handcrcam berry
		pea r	eat
		pear	grape
		raisin	me
		raisin	more 4
		raisin	Nim 4
		raisin	Nim I
		raisin	hug I
		raisin	hug I
		raisin	finish I
		red	Nim 3
		sorry	raisin I
		Susan	drink 2
		sweet	eat
		sweet	me
		sweet	eat
		tea	hug
		tea	Nim
		tickle	eat
		time	Nim
		time	Nim
		what	Nim
		yogurt	finish
		yogurt	
		eat	
		angry	
		dirty	

Three-Sign Sequences *(cont.)*

Sequence Type			*Tokens*
finish *(cont.)*	dirty	hug	*I*
	eat	drink	*I*
	eal	hug	*2*
	hug	finish	*3*
	hug	give	*I*
	hug	Nim	18
	hug	sorry	2
	me	finish	!
	me	Nim	2
	more	me	I
	Nim	drink	I
	Nim	hug	3
	out	hug	
	shoe	out	
	sorry	finish	
	wash	hug	
flower	bug	flower	
	eat	flower	
	eat	sweet	
	smell	flower	
	sweet	eat	
fruit	eat	fruit	
	eat	Nim	
	grape	eat	
	me	eat	
	me	Nim	
	Nim	Bill	
	Nim	eat	
	Nim	fruit	
	pear	Nim	
	red	fruit	
gimme	eat	gum	
	eat	me	
	Nim	eat	
	red	berry	
	red	drink	
give	apple	hot	
	apple	me	
	ball	give	
	banana	eat	
	drink	give	
	drink	me	
	drink	Nim	
	drink	tea	
	eat	banana	
	eat	black	
	eat	chair	
	eat	drink	

Sequence Type			*Tokens*
	eat	give	4
	eat	loc./point	1
	eat	me	**2**
	eat	**Nim**	**6**
	eat	orange	
	eat	spoon	
	eat	sweet	
	eat	toothbrush	
	egg	eat	
	grape	plate	
	jump	ball	
	Laura	drink	
	Laura	give	
	Laura	toothbrush	
	me	apple	2
	me	all	2
	me	banana	3
	me	brush	3
	me	color	I
	me	drink	5
	me	eat	15
	me	fruit	1
	me	give	I
	me	gum	3
	me	handcream	4
	me	hat	I
	me	light	2
	me	loc./point	4
	me	more	2
	me	Nim	I0
	me	nut	I
	me	orange	I
	me	raisin	I
	me	sock	I
	me	sweet	2
	me	tea	**1**
	me	tickle	2
	me	water	2
	more	drink	I
	more	cat	I
	more	gum	2
	more	Nim	I
	more	tea	2
	Nim	color	I
	Nim	cracker	I
	Nim	eat	5
	Nim	give	2
	Nim	grape	I

Three-Sign Sequences *(cont.)*

Sequence Type			*Token*
	Nim	jump	
	Nim	loc./poim	
	Nim	me more	
	Nim	pole	
	Nim	sweet nut	
	raisin	eat	
	spoon	Andrea	
	sweel	Nim	
	sweet	cracker	
	tea	eat	
	tea	drink	
	toothbrush	Nim	
	what	hug	2
	yogurt	Nim	
grape	banana	Nim	
	dick	me	
	eat	grape	
	eat	Alex	
	eat	apple	
	eat	baby	
	eat	drink	
	eat	give	
	eat	hurry	
	eat	loc./point	
	eat	me more	
	eat	Nim	37
	cat	raisin	I
	eat	sweet	I
	cat	grape	]
	groom	Nim	2
	hug	eat	**3**
	me	Nim	5
	me	eat	13
	Nim	in	!
	Nim	finish	I
	Oul	pear	I
groom	peach	loc./point	I
gum	me	gum	I
	apple	gum	I
	drink	Andrea	I
	eat	drink	2
	eat	gum	7
	eat	hug	I
	eat	Nim	8
	gimme	drink	I
	gimme	Nim	I

Sequence Type			*Tokens*
		give	Nim I
		me	ball *I*
		me	eat 10
		me	gum 4
		me	Nim **8**
		me	smell I
		more	cal I
		Nim	eat II
		Nim	me I
		Nim	please I
		you	eat I
handcream		berry	eat I
		brown	eat I
		brush	*Nim* I
		give	handcream I
		give	me 2
		in	apple
		me	give
		more	handcream
happy		me	Nim
		tickle	more
harmonica		drink	hug
hat		me	drink
		me	hat
		me	Nim
		Nim	hat
		Nim	me
help		shoe	out
Herb		me	play
here		cracker	loc,/point
hot		give	me 2
		Nim	eat I
hug		Bill	me I
		dirty	Nim I
		eat	Nim I
		finish	hug 4
		finish	Nim 2
		finish	out I
		help	up I
		me	finish !
		me	hug 6
		me	more 2
		me	Nim 17
		Nim	eat I
		Nim	finish 2
		Nim	hug 14
		Nim	me 3
		Nim	more 3

Three.Sign Sequences *(cont.)*

Sequence Type			*Tokens*
hug *(cont.)*	Nim	sleep	I
	Nim	sorry	2
	Nim	Susan	
	out	Renee	
	sorry	angry	
	sorry	hug	
	sorry	me	
	sorry	Nim	
	Susan	Nim	
	tea	drink	
hungry	eat	drink	
	eat	hungry	
	loc./point	me	
	me	Nim	
	Nim	fat	
	Nim	hug	
	Nim	me	
in	give	in	
	grape	Nim	
	me	Nim	
	pants	in	
Jews-harp	cat	Nim	
Joyce	jump	me	
	Nim	me	
	tickle	me	
jump	more	tickle	
	Nim	Jump	
key	eat	me	
	me	key	
	me	Nim	
	Nim	key	
kiss	Joyce	bite	
	Nim	eat	
Laura	apple	give	
	bite	Laura	
	bite	loc./point	
	eat	apple	
	eat	me	
	me	Laura	
	me	orange	
	red	give	
Listen	apple	orange	
	Bill	Andrea	
	hug	hal	
	me	eat	
	me	yon	
	Nim	Laura	
me	angry	peek-a-boo	

Sequence Type			*Tokens*
	angry	sorry	1
	apple	gum	11
	apple	me	1
	ball	me	1
	banana	eat	$
	banana	me	2
	banana	Nim	
	berry	eat	
	brown	in	
	brush	in	
	brush	Nim	
	cat	Nim	
	color	out	
	cracker	hat	
	dirty	sorry	
	drink	apple	
	drink	in	
	drink	loc./point	
	drink	Nim	
	drink	tea	!9
	cat	apple	9
	eat	banana	10
	eat	brush	I
	eat	drink	2
	eat	grape	2
	eat	gum	5
	eat	hug	I
	eat	kiss	I
	eat	loc./poim	I
	eat	me	4
	eat	more	5
	cat	Nim	12
	eat	orange	12
	eat	pear	rl
	eat	red	I
	eat	toothbrush	1
	finish	hug	I
	give	ball	I
	give	eat	2
	give	me	
	grape	eat	
	gum	eat	
	gum	Nim	
	hat	give	
	hat	in	
	hat	me	
	hug	banana	2
	hug	finish	I

Three-Sign Sequences *(cont.)*

Sequence Type			*Tokens*
hug	me		2
hungry	eat		
hungry	grape		
hungry	me		
hungry	pear		
jump	hug		
jump	play		
listen	tea		
loc./point	eat		2
more	apple		4
more	banana		2
more	drink		2
more	eat		19
more	give		I
more	orange		I
more	tea		3
more	tickle		I
Nim	Andrea		2
Nim	apple		1
Nim	bug		I
Nim	drink		8
Nim	eat		21
Nim	gum		2
Nim	hat		I
NJm	hug		7
Nim	hungry		I
Nim	in		I
Nim	kiss		I
Nim	loc./point		2
Nim	me		13
Nim	more		I
Nim	orange		I
Nim	out		I
Nim	play		13
Nim	tea		.1
Nim	tickle		I
Nim	time		I
Nim	up		I
Nim	water		I
Nim	what		!
Nim	you		3
orange	eat		2
ou!	play		I
pants	hug		I
play	Bill		I
play	me		5
play	Nim		I
play	tickle		5

Sequence Type			*Tokens*
	play	you	3
	raisin	eat	1
	raisin	nut	I
	shoe	play	I
	smell	shoe	I
	smell	sweet	2
	smell	you	I
	sorry	bite	I
	sorry	hug	2
	sorry	Nim	I
	Susan	play	I
	sweet	brown	I
	sweel	eat	I
	sweet	me	1
	sweet	Nim	2
	Sweet	wha!	I
	tickle	Andrea	I
	tickle	hug	1
	tickle	Nim	2
	tickle	play	
	toothbrush	hat	
	up	hug	
	water	Nim	
	you	play	
more	apple	eat	
	apple	Nim	
	baby	hug	
	baby	Nim	
	banana	eat	
	banana	me	
	banana	Nim	
	book	handcream	
	chair	eat	
	chair	me	
	close	hug	
	dirty	eat	
	drink	Bill	
	drink	eat	
	drink	give	
	drink	Nim	
	drink	tea	
	drink	toothbrush	
	drink	water	
	eat	apple	
	eat	banana	
	eat	Bill	
	eat	drink	
	cat	fruit	

Three-Sign Sequences *(cont.)*

Sequence Type			Tokens
more *(cont.)*	eat	gum	2
	eat	loc./point	I
	eat	.... me	12
	cat	more	3
	eat	Nim	19
	eat	nut	2
	eat	red	I
	eat	same	I
	eat	sweet	3
	eal	lickle	I
	grape	eat	2
	grape	give	I
	grape	hug	I
	grape	Nim	i
	give	gum	1
	gum	eat	2
	gum	me	
	gum	Nim	
	handcream	brush	
	hungry	hug	
	loc./point	more	
	me	banana	
	me	drink	
	me	eat	6
	me	grape	I
	me	more	I
	me	Nim	4
	me	tea	I
	me	tickle	2
	me	you	I
	Nim	eat	**9**
	Nim	hug	1
	Nim	me	2
	Nim	play	2
	Nim	tickle	
	nut	ball	
	nut	give	
	orange	eat	
	peach	eat	
	pear	eat	
	play	me	2
	same	more	
	smell	gum	
	sweet	more	
	sweet	Nim	
	tea	drink	
	tea	hug	
	tea	me	
	tickle	drink	
	tickle	eat	
	tickle	me	
	tickle	more	
	tickle	Nim	
	tickle	play	
	tickle	Susan	
	tickle	you	
	what	raisin	
Nim	Andrea	Joyce	
	apple	Nim	
	baby	hug	
	banana	eat	
	banana	fruit	
	banana	more	
	banana	Nim	
	Bill	Andrea	
	Bill	play	
	brush	me	
	brush	Nim	
	clean	baby	
	drink	eat	
	drink	help	
	drink	hug	***1***
	drink	loc./point	***2***
	drink	me	*3*
	drink	Nim	*3*
	drink	you	***!***
	eat	apple	***1***
	eat	banana	*3*
	eat	cracker	***!***
	eat	drink	***8***
	eat	fruit	
	eat	give	***I***
	eat	grape	***9***
	eat	gum	***I***
	eat	loc./point	***!***
	eat	me	***8***
	eat	more	*3*
	eat	Nim	17
	eat	nut	3
	eat	orange	**I**
	eat	orange	**I**
	eat	peach	**I**
	eat	pear	**I**
	eat	raisin	2
	eat	red	.21
	eat	sweet	**9**

Three-Sign Sequences *(cont.)*

Sequence Type			Tokens
	eat	tickle	*I*
	eat	water	*I*
	eat	what	*2*
	eat	yogurt	*3*
	gimme	gum	
	give	water	
	give	what	
	grape	eat	
	grape	me	
	groom	baby	
	gunl	eal	
	gum	me	
	hug	bad	
	hug	blue	
	hug	drink	
	hug	eat	
	hug	finish	
	hug	me	
	hug	Nim	
	hug	Renee	
	hungry	Nim	
	hurry	gum	
	kiss	ba by	
	Laura	sorry	
	loc./point	eat	
	loc./point	up	
	me	drink	
	me	eat	
	me	gum	
	me	in	
	me	Joyce	
	me	Laura	
	me	loc./point	
	me	Nim	
	me	open	
	me	orange	
	me	play	
	me	sorry	
	me	tickle	
	more	drink	
	more	eat	
	more	Nim	
	nut	Nim	
	open	hug	
	orange	eat	
	orange	go	
	orange	Nim	
	pants	in	
	peach	And rea	
	pear	eat	
	play	me	
	sleep	hug	
	sorry	Bob	
	sweet	eat	
	sweet	gimme	
	sweet	me	
	sweet	Nim	
	gweel	you	
	[it:kit	me	
	tickle	more	
	time	me	
	toothbrush	Nim	
	water	down	
	yogurt	Nim	
	you	me	
nut	baby	eat	
	baby	nut	
	Bill	eal	
	eat	drink	
	eat	me	
	eat	Nim	
	eat	nut	
	give	me	
	help	out	
	hurry	eat	
	me	drink	
	me	eat	*2*
	me	more	***I***
	me	Nim	*4*
	more	nut	***I***
	Nim	eat	*4*
	Nim	me	*5*
	Nim	nut	15
	Nim	please	
	open	hug	
	Out	red	
	Tom	eat	
	work	out	
on	baby	chair	
	baby	Nim	
Open	apple	Nim	
	banana	me	
	Bill	open	
	color	red	
	drink	open	
	eat	grape	

Three-Sign Sequences *(cont.)*

Sequence Type			*Tokens*
open *(cont.)*	grape	fruit	
	grape	in	
	grape	Nim	
	handcream	tickle	
	help	me	
	help	open	
	hug	me	
	Nim	drink	
	Nim	eat	
	Nim	nut	
	Nim	sweel	
	please	me	
	sorry	open	
	toolhbrush	open	
orange	apple	Nim	
	Bill	Andrea	
	drink	in	
	drink	more	
	eat	loc./point	
	eat	me	
	cat	more	
	eat	Nim	
	eat	orange	
	eat	sweet	
	in	hat	
	me	eat	
	me	Nim	
	me	lea	
	more	give	
	Nim	drink	
	Nim	eat	
	Nim	me	
	Nim	orange	
	red	me	
	sweet	eat	
	lea	drink	
	yogurt	orange	
orange	Nim	color	
orange	Nim	eat	
	Nim	orange	
	Nim	Renee	
out	baby	out	
	drink	out	
	finish	hug	
	gum	Bill	
	hug	me	
	hug	Nim	
	hug	out	

Sequence Type			*Tokens*
	hug	Renee	
	hug	sorry	
	me	Nim	
	me	you	
	Nim	hug	
	Nim	out	
	open	hug	
	pants	out	
	play	finish	
paint	yellow	black	
	yellow	Nim	
pancake	eat	Nim	
	me	Nim	
pants	in	finish	*2*
	in	hug	*1*
	Nim	hug	*1*
	out	pants	*!*
peach	eat	Nim	*1*
	grape	banana	*1*
	Nim	eat	*2*
	pear	apple	*1*
pear	apple	eat	*1*
	banana	eat	*1*
	eat	Nim	*4*
	hug	Nim	*1*
	hug	pear	*1*
	me	Nim	*3*
	Nim	eat	*4*
	Nim	give	*!*
	Nfm	grape	*1*
	Nim	hug	*1*
	Nim	pear	*2*
play	Andrea	Bill	*2*
	ball	Bill	
	Bill	Andrea	
	Bill	you	
	chair	eat	
	come	play	
	come	open	
	dirty	me	
	drink	Bill	
	eat	play	
	hat	me	
	hat	Nim	
	hug	Nim	
	hug	play	
	Joyce	play	
	me	Andrea	

Three-Sign Sequences *(cont.)*

Sequence Type			*Tokens*
	me	angry	*1*
	me	come	*2*
	me	flower	*1*
	me	hug	*5*
	me	jump	*1*
	me	Nim	**81**
	me	play	14
	me	Susan	2
	me	tickle	13
	me	you	3
	more	tickle	*1*
	Nim	Bill	2
	Nim	bug	2
	Nim	gum	
	Nim	hug	
	Nim "	me	
	Nim	play	
	Nim	tick le	
	nut	drink	
	open	tickle	
	out	hug	
	out	shoe	
	shoe	play	
	smell	red	
	Susan	me	
	Susan	play	
	tickle	groom	
	tickle	hug	
	tickle	me	
	tickle	Nim	
	tickle	play	
	tickle	water	
	Walter	Nim	
	Wailer	play	
	water	Nim	
	water	tickle	
	you	me	
	you	Nim	
please	water	drink	
point/loc,	eat	drink	
	eat	whal	
	give	gum	
	give	me	
	grape	eat	
	hug	me	
	listen	me	
	me	grape	
	me	Nim	

Sequence Type			*Tokens*
	me	smell	
	more	banana	
	Nim	eat	
	Nim	me	
	tea	me	
	water	handcream	
	wager	Nim	
pole	more	pole	
pull	Nim	pull	
	tickle	pull	
raisin	eat	me	
	.cat	more	
	eat	Nim	4
	eat	raisin	
	me	Nim	
	Nim	eat	
	Nim	raisin	
	nut	raisin	
red	eat	sweet	
	gum	Nim	
	Laura	berry	
	Nim	color	
	Nim	loc./point	
	Nim	red	
	Nim	sweet	
	please	hug	
shoe	baby	hug	
	handcream	Nim	
	hug	Nim	
	Nim	eat	
	OUt	me	
	OUl	tickle	
	play	tickle	
smell	drink	eat	
	loc./point	you	
	me	eat	
	me	listen	
	tea	drink	
sucks	me	Nim	
sorry	angry	sorry	
	dirty	hug	
	dirly	SOrry	
	hug	me	
	hug	music	
	hug	Nim	5
	hug	sorry	5
	me	sorry	2
	Nim	hug	I

Tbree..Sign Sequences *(cont.)*

~ T y p e			*Tokettȼ*
sorry (Conf.) Nim		sorry	***1***
spoon	eat	drink	***!***
	eat	Nim	*2*
	me	drink	
	me	eat	
	Nim	eat	
sweet	apple	Nim	
	drink	eat	
	drink	me	
	dnnk	Nim	**3**
	drink	sweet	**3**
	eat	me	**3**
	eat	Nim	**6**
	eat	sweet	**!**
	fish	Nim	**I**
	give	sweet	**I**
	gum	eat	**1**
	hungry	me	**I**
	in	tea	**I**
	Laura	eat	**I**
	me	eat	**4**
	me	hug	2
	me	Nim	**4**
	me	sweet	2
	more	me	**I**
	Nim	color	**I**
	NJm	drink	**I**
	Nim	eat	10
	Nim	me	5
	Nim	.more	**I**
	Nim	open	**I**
	Nim	red	**I**
	Nim	shoe	**!**
	Nim	Susan	**I**
	Nim	sweet	**14**
	pancake	apple	
	raisin	Nim	
	red	Nim	
	tea	drink	
swing	more	swing	
tea	bread	give	
	cracker	me	
	drink	ball	
	drink	eat	
	drink	hug	
	drink	me	
	drink	more	
	drink	Nim	

Secp~nce Type			*Tokens*
	drink	tea	
	eat	more	
	eat	Nim	
	cat	nut	
	eat	tea	
	grape	eat	
	in	me	
	in	spoon	
	me	drink	
	me	eat	
	me	hug	
	me	in	
	me	orange	
	me ,	tea	
	more	drink	
	more	eat	
	more	Nim	
	Nim	drink	
	Nim	eat	
	Nim	lea	
	play	drink	
	sorry	eat	
	water	drink	
	water	hot	
	water	tea	
thirsty	drink	Nim	
tickle	banana	Nim	
	bite	book	
	me	give	
	me	gum	
	me	hug	
	me	Lau ra	*2*
	me	loc./point	*2*
	me	more	*5*
	me	Nim	*44*
	me	play	*5*
	me	tickle	19
	me	you	3
	more	me	7
	more	tickle	3
	Nim	baby	2
	Nim	eat	2
	Nim	me	**1**
	Nim	play	**1**
	Nim	tickle	4
	Nim	you	**1**
pear	grape		**I**
play	me		2

Three-Sign Sequences *(cont.)*

~atv TT,pe			*Tokens*
	play	more	
	play	Nim	
	play	tickle	
	play	you	
	shoe	apple	
	shoe	grape	
	smile	banana	
	Walter	Nim	
	Walter	play	
time	eat	come	
	eat	hug	
	eat	Nim	
	hug	Nim	
	hug	time	
	Nim	eat	
	Nim	hug	
	work	Nim	
toilet	hug	Nim	
toothbrush	banana	*Nim*	
	me	Nim	
	me	toothbrush	
	Nim	baby	
	Nim	eat	
	Nim	toothbrush	
wash	eat	me	
	water	drink	
water	drink	Nim	
	eat	Nim	
	give	eat	
	me	drink	
	me	you	
	Nim	wash	
	Nim	water	
	tickle	fruit	
	tickle	Nim	
	what	out	
what	book	point	
	come	open	
	drink	eat	
	eat	Nim	
	gum	drink	
	inc./point	what	
	Nim	eat	
	Nim	me	
	Nim	red	
	Nim	you	
who	play	me	
work	time	Nim	

Seque~,~re 7),pe			Tokemr
yellow	sweet	eat	**I**
yogurt	eat	clean	!
	eat	me	**!**
	cat	Nim	7
	cat	sorry	**I**
	eat	yogurt	2
	grape	Nim	I
	me	eat	**2**
	me	Nim	2
	me	yogurt	1
	Nim	eat	**2 0**
	Nim	me	2
	Nim	yogurt	4
you	give	nut	I
	Laura	you	1
	me	brush	I
	me	eat	**3**
	me	Laura	I
	me	Nim	5
	me	play	8
	me	tickle	I
	me	you	I
	play	me	~
	tickle	hug	1
	tickle	me	8

Totals: 1,313 2,925

Four-Sign Sequences

Sequence Type				Tokens
Andrea	banana	eat	Nim	1
	hug	me	Nim	1
angry	bug	Nim	flower	1
	hug	angry	sorry	1
	me	sorry	hug	1
	sorry	hug	angry	2
	sorry	hug	me	
apple	bite	apple	Nim	
	cat	apple	eat	
	eal	me	Nim	
	gum	apple	gum	
	me	apple	play	
	me	Nim	key	
	me	tickle	eat	
	more	eat	apple	
	Nim	apple	more	
	Nim	eat	give	
	Nim	me	Nim	
	peach	fruit	apple	
baby	grape	eat	baby	
	hug	Nim	brush	
bad	hug	Nim	hug	
banana	drink	me	cat	
	drink	me	Nim	
	drink	me	point	
	eat	banana	eat	2
	eat	banana	give	1
	eat	banana	Nim	2
	eat	me	Nim	4
	cat	more	eat	1
	eat	more	hug	i
	emt	Nim	banana	2
	eat	Nim	me	!
	me	banana	eat	!
	me	banana	me	1
	n~	banana	Nkn	2
	me	eat	banana	4
	me	eat	me	1
		eat	Nim	2
	me	more	eat	1
	me	Nim	eat	1
	me	Nim	me	4
	more	banana	Nim	1
	Nim	banana	cat	2
	Nim	banana	me	!
	Nim	banana	Nim	5
	Nim	banana	Susan	!
	Nim	drink	eat	!

Four-Sign Sequences *(cont.)*

Sequence Type					Tokens
banana (cont.)	Nim	eat	banana		2
	Nim	eat	me		1
	Nim	eat	more		1
	Nim	eac	Nim		1
	Nim		banana		1
	Nim	more	banana		!
	nut	eat	Nim		1
Bill	Nim	Bill	Nim		1
bite	angry	bite	hug		i
	hug	bile	hug		1
book	me	eat	groom		2
brown	swe¢l	Nim	¢al		
brush	me	Nim	brush		
	Nim	cat	hurry		
chair	eat	drink	flower		
clean	dirty	out	loc./point		
	eat	yogurt	eat		
color	eat	omer	Nim		
	Nim	color	orange		
	Nim	eat	me		
	Nim	eat	orange		
	Nim	sac	red		
	Nim	me	Nim		
come	give	me	COlllle		
come	me	Nim	hug		
	more	me	eat		
	Open	me	open		
cracker	me	eat	sweet		
	Nim	cracker	Nim		
Dick	eat	grape	Nim		
'dirty	eat	grape	Nim		
	finish	bug	Nim		
	hug	finish	dirty		
	hug	me	Nim		
	smell	Pants	in		
	smell	*dirty*	smell		
dog	play	Nim	come		
drink	apple	gum	apple		
	apple	drink	eat		
	brown	give	me		
	eat	drink	eat		
	eat , .	give	me		
	eat	me	eat		
	eat		Nim		
	eat	more	eat		
	eat	Him	me		
		swe~	drink		
		drink	apple		

Four-Sign Sequences *(cont.)*

Sequence Type				*Tokens*
drink *(cont.)*	give	drink	give	2
	me	drink	me	I
		eat	me	I
		more	me	I
	me	Nim	Nim	i
			eat	I
			me	2
		orange	tea	I
		tea	sweet	!
	more	drink	me	I
			Nim	2
		eat	sweet	I
	Nim	drink	drink	I
			eat	I
		eat	Nim	5
		me	drink	
			drink	
	sweet	drink	Nim	
		eat	sweet	
	tea	drink	drink	
		me	tea	
	apple	gum	Nim	
		me	banana	
	baby	Nim	Nim	
	bad	eat	eat	
	banana	eat	sweet	
			loc./point	
		me	Nim	
		Nim	eat	
	drink	eat	banana	
			eat	
		gum	dHnk	
		me	Nim	
			Nim	
		Nim	eat	
			Nim	
		orange	me	
		sweet	orange	
	finish	hug	eat	
	give	more	drink	
		Nim	Renee	
	grape	eat	eat	
			eat	
			grape	
			Nim	
		Nim	eat	
	gum	Nim	hug	
			gum	

Four-Sign Sequences *(cont.)*

Sequence Type				Tokens
eat (cont.)	hat	me	banana	I
	hungry	give	Nirn	I
	hurry	eat	nut	I
	loc./point	banana	Nim	I
	me	cracker	Nim	I
		drink	eat	!
		eat	me	2
	me	Nim	drink	3
			eat	2
			give	
			hungry	
		Open	me	
		sweet	what	
	more	drink	eat	
		eat	sweet	
		me	Nim	
	Nim	orange	eat	
		apple	Nim	
		banana	Nim	
			Andrea	
		eat	eat	
			apple	
			banana	
			give	
			grape	
			me	
			Nim	
			what	
		give	yogurt	
		me	Nim	
			eat	
		raisin	swee[	
		red	Nim	
		sweet	sweet	
	orange	Nim	eat	
	raisin	eat	eat	
		Nim	Nim	
	smile	Nim	eat	
	spoon		banana	
	sweet	me	Nim	
		eat	give	
			me	
			sweet	
		me	Nim	
		more	eat	
	tea	Nim	eat	
	yogurt	pear	eat	
		eat	Nim	

Four-Sign Sequences *(cont.)*

Sequencv Type			
eat (conL)	yoghurt	Nim	eat
egg	more	egg	more
finish	dirty	pants	in
	hug	finish	hug
	me	finish	me
	pants	in	clean
fruit	eat	me	Renee
	eat	Nim	eat
	more	Nim	fruit
	nut	drink	Nim
gimme	sweet	Nim	gimme
give	banana	loc./point	banana
		more	me
		Nim	banana
			eat
			me
	crayon	give	crayon
	eat	banana	apple
		groom	me
	eat	me	eat
			give
			Nim
		Nim	me
	grape	Nim	eat
	loc./point	cracker	give
		tickle	Nim
	me	apple	eat
		banana	eat
		eat	apple
			banana
			nut
			orange
		give	me
		light	give
		ioc./point	handcream
		Nim	eat
		red	eat
		smell	Nim
	Nim	eat	Nim
	raisin	in	Nim
	sweet	eat	Nim
	tea	drink	eat
grape	dirty	me	Nim
	drink	grape	berry
	eat	me	eat
			Nim
		Nim	baby
			eat

Tokens

Four-Sign Sequences *(conL)*

~quence Type					*Tokens*
grape (cont.)	**eat**			give	*I*
				hug	*I*
			Nim	me	*2*
			eat	eat	
			grape	grape	
			me	apple	
gum	apple		open	Nim	
	eat		eat	banana	
	eat		me	drink	
	me		me	eat	
			gum	gum	
			Nim	NJm	
				gum	
			eat	me	
			gum	grape	
handcream	baby			eat	
	give		Nim	Nim	
	Nim		me	hug	
harmonica	me		eat	handcream	
hat	play		Nim	handcream	
hug	come		me	harmonica	
	me		me	tickle	
			hug	open	
			sleep	me	
	more		sorry	me	
	Nim		spoon	Nim	
			hug	hug	
			sorry	hungry	
hungry	Renee		bug	Renee	
	eat		what	Renee	
	me		eat	hug	
in	dirty		in	Nim	
	drink		me	dirty	
	eat		grape	drink	
	panls		dirty	ca!	
	tea		hug	play	
	you		eat	tOothbrush	
key	me		key	in	
	what		red	drink	
Laura	eat		Nim	Nim	
	give		loc./point	me	
	me		banana	me	
I~./point	bad		eat	eat	
	banana		Nim	apple	
	eat		I~./I~inl	eat	
	give		eat	eat	
			Nim	Nim	
				eat	

Four-Sign Sequences *(cont.)*

Sequence Type				*Tokens*
loc./point *(cont.)*	Nim	eat	gum	*1*
	Nim	me	eat	*1*
		water	Nim	*1*
	sweet	eat	more	*1*
		eat	Nim	*1*
	Andrea	yon	me	*1*
	angry	hug	bite	*1*
	apple	eat	apple	*1*
	drink	Nim	eat	*1*
	drink	Nim	red	*1*
	eat	banana	eat	*1*
			handcream	*1*
			more	*2*
		drink	more	
			sweet	
		me	eat	
			gum	
			Nim	
		more	banana	
		Nim	eat	
			hug	
		tea	drink	
	give ,	gum	me	
	grape	Nim	eat	
	gum	me	gum	
	hug	jump	eat	
		me	Nim	
	key	hug	me	
	loc,lpoint	Nim	loc./point	
	more	eat	loc./point	
	Nim	banana	Nim	
		bug	Nim	
		drink	Nim	
		eat	apple	
			cracker	
			grape	
			me	
			more	
			orange	
		handcream	eat	
		me	eat	
			pants	
			you	
		more	eat	
		play	tickle	
			you	
		same	gum	
		sweet	me	

Four-Sign Sequences *(cent,)*

Sequence Type				*Token*
me (cont.)	Nim	tickle	me	
			Nim	
	play	red	Nim	
	raisin	me	raisin	
	sweet	me	eat	
		water	me	
	tea	drink	more	
	tickle	Nim	hug	
more	banana	eat	banana	
			Nim	
		me	Nim	
	drink	more	eat	
		Nim	more	
	eat	brown	eat	
		drink	me	
	eat	gum	me	
		more	drink	
			eat	
		Nim	more	
		tea	me	
	fruit	Nim	raisin	
	key	banana	eat	
	me	banana	eat	
		drink	eat	
		eat	apple	
			Nim	
		Nim	more	
		lea	drink	
	Nim	eat	grape	
		fruit	raisin	
		more	Nim	
	orange	drink	out	
	OUl	fruit	hug	
	pear	apple	pear	
	sweet	eat	Nim	
	tea	drink	tea	
		me	apple	
		more	tea	
	tickle	me	Nim	
		more	me	
		Nim	more	
	toothbrush	Nim	toothbrush	
Nim	banana	eat	drink	
		Nim	banana	
	Bill	eat	gum	
	bite	Nim	bite	
	color	eat	color	
		Nim	me	

Four-Sign Sequences *(cont.)*

Sequence Type			*Token*
Nim (cont.)	cracker	Nim	cracker
	drink	me	eat
		Nim	Nim
	eat	banana	drink
		drink	eat
		grape	eat
		hug	pear
		hungry	Nim
		loc./point	eat
		me	me
		Nim	gum
	eat	Nim	dirty
		orange	eat
		raisin	grape
		red	drink
		sweet	eat
		what	grape
		yogurt	me
	give	loc./point	nut
	grape	eat	grape
		Nim	eat
	gum	eat	grape
	gum	gimme	berry
		me	Nim
	Herb	tickle	red
	hug	Nim	banana
	loc./point	eat	eat
	me	eat	more
			Nim
			apple
			Nim
			eat
			loc./point
			gum
			gum
			me
			hug
			berry
			banana
			drink
			Nim
			peach
			raisin
		Laura	loc./point
		more	banana
		Nim	eat
			me

Four-Sip Sequences *(cont.)*

Sequence Type				*Toke~*
Nim (cont.)	more	banana	me	
	play	Walter	play	
	red	raisin	Nim	
	sweet	color	red	
		eat	sweet	
		Nim	color	
	tickle	chair	red	
	you	me	go	
nut	eat	nut	eat	
	give	me	me	
	me	nut	eat	
	Nim	eat	Nim	
			eat	
		me	Nim	
	open	nut	nut	
open	Alex	me	Nim	
	eat	hug	Nim	
	grape	out	nut	
		eat	Nim	
	light	out	banana	
orange	drink	me	grape	
		me	grape	
	give	orange	open	
	me	loc./point	eat	
		eat	Nim	
	more	orange	Nim	
		me	orange	
	shoe	orange	drink	
	apple	me	give	
	dirty	eat	give	
	shoe	hug	eat	
out	me	out	Nim	
pancakes	Nim	Nim	Nim	
pancake	eat	eat	out	
	in	me	shoe	
pants	on	hug	eat	
	out	hug	pancake	
peach	eat	pants	pancake	
peat	eat	Bill	Nim	
		more	good	
	Nim	Nim	in	
		pear	Nim	
		apple	give	
			eat	
			eat	
			eat	

Four-Sign Sequences *(cont.)*

Sequence Type				*Tokens*
pear (cont.)	Nim	me	Nim	*I*
		pear	Nim	*2*
play	hat	me	hat	*i*
	jump	play	Nim	*!*
	me	come	me	*1*
		Nim	hat	*!*
			play	*4*
			tickle	*I*
		play	Nim	*2*
			tickle	*I*
	more	me	Nim	*t*
	Nim	tickle	me	*2*
	tickle	me	tickle	
	waiter	me	waiter	
	waiter	hug	play	
raisin	eat	me	Nim	
	grape	eat	Nim	
	more	raisin	eat	
	Nim	me	eat	
		raisin	Nim	
red	drink	Nim	give	
	Nim	eat	me	
same	drink	same	drink	
shoe	eat	out	shoe	
	out	shoe	out	
smell	loc./point	smell	eat	
sorry	angry	sorry	hug	
	hug	me	toothbrush	
		please	sorry	
		sorry	me	
	me	Nim	eat	
	Nim	bite	hug	
spoon	Nim	eat	Nim	
Susan	eat	Nim	eat	
sweet	angry	gum	sweet	
	banana	sweet	Nim	
	drink	Nim	drink	
	eat	sweet	Nim	
		me	Nim	
		eat	red	
		Nim	drink	
		sweet	drink	
			hungry	
		color	orange	
		drink	sweet	
		loc./point	give	
		me	Nim	
		red	Nim	
		sweet	color	

Four-Sign Sequences *(cont.)*

,.~'¢luence Type				Token
sweet (cont,)	Nim	sweet	me	
tea	Andrea	tea	drink	
	drink	eat	me	
			more	
		me	eat	
			tea	
		Nim	drink	
		tea	drink	
	give	me	Nim	
	here	tea	here	
	hug	eat	drink	
	me	eat	drink	
			Nim	
		loc./point	drink	
		more	tea	
	Nim	Nim	drink	
	shoe	eat	drink	
	water	water	Nim	
tickle	eat	gimme	tea	
		gum	cracker	
	in	*Nim*	*me*	
	loc./point	tickle	Nim	
	me	*Nim*	*me*	
	me	more	Nim	
		Nim	cracker	
	"		hug	
			me	
			more	
			play	
			tickle	
			you	
		play	Nim	
		tickle	hug	
	more		me	
	Nim	tickle	more	
		me	Nim	
		tickle	me	
	play		Nim	
		me	Nim	
	tea	Nim	me	
time	banana	drink	hug	
	out	me	grape	
toothbrush	eat	hug	Sorry	
	open	toothbrush	eat	
water	drink	more	banana	
		me	drink	
what	eat	water	drink	
	me	me	Nim	
		gum	eat	

Sequence of Five or More Signs *(cont.)*

Sequence Type	*Token.*
drink	eat drink eat drink
	eat drink eat drink tea
	eat drink eat Nim
	eat drink eat Nim locative/point drink
	eat drink eat Nim tea
	eat drink medrink Nim
	eat drink me tea me
	eat drink Nim drink
	eat drink tea eat drink
	eat me eat Nim drink me
	eat me Nim me
	eat Nim drink tea drink
	eat sweet drink give
	give drink give Nim give
	give me eat me eat
	me drink me drink me drink tea
	me drink me drink me Nim drink
	me drink me Nim
	medrink Nim drink me
	me give sweet eat
	me Nim cracker Nim drink
	more drink give drink give
	more drink lea drink
	Nim drink Nim drink Nim
	Nim hug cracker Nim eat
	Nim orange drink eat
	orange locative/point me eat
	tea drink me tea
	tea more drink tea
	apple grape raisin pear
	apple Nim apple orange
	apple Nim eat pear
	banana Nim drink Nim
	banana Nim me banana
	come me come eat grape
	drink eat drink eat drink
	drink eat drink eat drink eat drink eat drink
	drink eat drink eat drink eat drink eat drink eat drink eat drink
	drink meeat Nim eat
	drink Nim me eat
	me eat drink eat
	meeat drink Nim
	me eat me banana
	me eat me eat
	me eat me eat me eat me eat me eat me Nim
	me Nim banana eat Nim
	me Nim eat give me
	me Nim eat grape

Sequences of Five **or More** Signs *(COnL)*

,~quence Type	*Token*
eat (cont.)	me Nim eat me hug
	me Nim eat yogurt
	me Nim Joyce hug
	me Nim me eat
	me Nim me Nim
	me orange apple orange
	more apple groom pear
	more eat Nim me
	more eat nut me r'4im nut give
	more tickle Nim me
	Nim banana eat banana
	Nim eat grape gum apple
	Nim eat grape Nim eat
	Nim eat me Nim eat
	Nim eat me spoon eat
	Nim eat Nim banana
	Nim eat Nim eat
	Nim eat Nim eat blue
	Nim fruit eat Nim eat pear
	Nim locative/point red me
	Nim more eat Nim
	Nim raisin Nim raisin
	Nim sweet more eat
	Him yogurt eat Nim
	Nim yogurt Nim yogurt
	raisin grape eat raisin
	raisin nut eat raisin drink eat drink cat
	spoon eat Nim spoon
egg	eat egg eat egg eat
finish	out time hug out
fruit	eat Andrea peach Andrea
give	drink give eat Nim eat
	drink me eat tea drink me
	eat cracker me Nim more
	eat give drink eat give
	eat give Nim eat
	eat hug drink give eat drink Rive banana eat give
	eat toothbrush sweet give banana apple
	locative/point banana drink give
	me banana eat more
	me drink eat Nim
	me eat banana me
	meeat meant Nim apple
	me eat same eat
	me give me give me
	me Nim drink give
	me Nim eat hug
	me Nim sweet eat

Sequences of Five or More Signs *(cont.)*

Sequence Type		*Tokens*
give *(cont,)*	me same eat Nim same	*i*
	Nim eat banana eat nut	*I*
	Nim point Nim me	*I*
	Nim play apple gum orange	*1*
	orange eat me eat orange me orange	*I*
	orange me give eat orange me eat orange give me eat orange give me you	
grape	eat fruit Him pear	
	eat me eat grape	
	eat me Nim eat	
	eat Nim eat Nim	
	eat Nim grape eat	
	in loeative/point Nim eat	
	me grape me locative/point Nim me grape eat	
groom	black Nim spoon eat	
gum	come eat gum cracker	
	eat banana eat sweet me me gum me eat	
	more me more eat	
	you me you me	
	finish Nim dirty hug	
	Nim hug Nim book	
hungry	eat me Nim locative/point	
i n	hat in hat in hat in hat	
jump	me jump me jump	
listen	me listen locative/point give listen	
locative/point	drink more eat banana	
me	apple more banana apple	
	banana me eat me	
	banana Nim me eat more eat banana eat	
	color same Nim give eat Nim eat	
	drink eat drink eat drink eat drink eat drink eat Nim	
	drink me drink eat drink me drink sweet eat Nim	
	eat Andrea apple Andrea apple Andrea apple raisin	
	eat drink angry drink eat	
	eat drink give eat	
	eat fruit ball fruit	
	eat me eat water	
	eat nut you me nut me eat	
	eat same you same me	
	give eat apple orange apple me	
	give gum me Him give me	
	give Him you locative/point	
	gum me eat gum	
	gum Nim eat gum	
	more drink tea Nim	
	more eat hug eat	

Sequences of Five or More Signs *(cont.)*

Sequence Type		*Tokens*
me (Cont.)	more eat more banana brush handcream	
	Nim eat drink Nim me	
	Nim eat Nim me	
	Nim eat sweet red	
	Nim groom Andrea key	
	Nim me jump tickle me	
	Nim me Nim Dick drink eat	
	Nim me Nim me	
	Nim me Nim me Nim	
	Nim me Nim smell Nim	
	Nim play locative/point berry	
	Nim smell bug me sweet	
	Nim sweet Nim sweet	
	Nim tickle Nim tea	
	Nim tickle what more me	
	smell locative/point smell me you	
	smell nut smell gum tea	
	you me Nim you me you Waiter	
	banana eat me Nim	
	drink more Nim more	
	drink Nim drink Nim more drink	
	eat please sweet Nim	
	eat time give drink tea	
	fruit grape Nim eat	
	Nim me what tickle	
	same eat in me in	
	time give drink eat	
	what more eat more locative/point	
	banana eat banana Nim eal	
	drink me drink me	
	drink more Nim more	
	drink Nim me eat	
	eat banana me Nim	
	eat drink eat drink	
	eat drink more eat	
	eat egg eat Nim eat	
	eat me locative/point Nim me eat Nim eat me	
	eat Nim eat grape Nim	
	gum give gum Nim	
	gum Nim gum me gum	
	Laura banana Nim eat	
	locative/point drink me drink	
	me banana eat Nim banana	
	me eat drink Nim	
	me Nim me drink	
	me Nim me Nim	
	me sweet eat sweet	
	more banana eat me	

Sequences of Five or More Signs *(cont.)*

Sequence Type	*Token*
Nim *(cont.)*	sweet Nim eat red
	sweet orange sweet Nim
nut	eat Nim g!ve nut
	eat nut me Nim
	me Nim drink Nim
	me nut give me eat Him nut
	more me eat nut
open	me eat jump me Laura
orange	me Laura orange give
pants	out pants out pants
peach	eat sum eat Nim
pear	Nim give eat Nim
	Nim pear angry pear
	Nim pear Nim pear
play	come me Nim me
	me more me more jump
	me Nim me play ball
	me Nim play me
	me Nim play me jump tickle me Nim tickle play
	me Nim Walter play me Nim
	me play me Nim hat
	me play me play tickle
	me play tickle hat Nim
	me tickle hat tickle me play banana
	me Walter me tickle
	me you Nim play pole
please	hub finish angry please
raisin	eat raisin Nim eat
	Nim more raisin Nim
sorry	angry hug sorry hug
	hug sorry angry sorry
	play me tickle eat open
sweet	cracker more sweet eat sweet me eat
	cracker Nim me give
	drink eat me eat
	drink me sweet drink Nim sweet me sweet eat sweet
	eat meeat sweet Nim give eat Nim meeat sweet
	eat Nim me orange me Nim eat
	give me Nim eat sweet
	me eat Nim you
	Nim eat more red
tea	drink give tea drink Nim
	drink me tea eat
	drink Nim drink tea
	drink tea drink tea drink
	in tea in tea in
	me Nim eat drink Nim
tickle	me Nim tickle Nim

Sequences of Five **or More** Signs *(cont.)*

Sequence Type	*Token*
tickle (cont.)	me Nim you me Nim
	me tickle me Nim
	~ne tickle me Nim me
	me tickle me tickle
time	Nim time Nim time
toothbrush	me Nim toothbrush Nim
what	key give me Nim
yogurt	Nim eat yogurt eat yogurt
	Nim meeat Nim
	locative/point give me eae
	me eat banana eat me eat
	me eal Nim eat cracker

TOTALS: 300