

1987

Speech sound discrimination ability in a Lowland gorilla

May Goodreau
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SPEECH SOUND DISCRIMINATION ABILITY
IN A LOWLAND GORILLA

A Thesis

Presented to

The Faculty of the Division of Special Education and

Rehabilitative Services

Program in Communication Disorders and Sciences

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

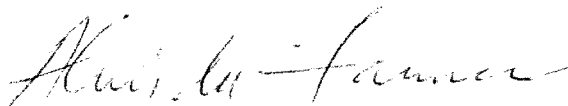
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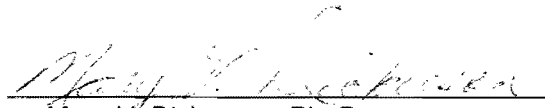
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May, 1987

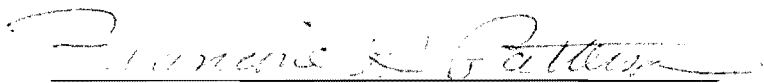
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AND REHABILITATIVE SERVICES
PROGRAM IN COMMUNICATION DISORDERS AND SCIENCES



Alvirda Farmer, Ph. D.

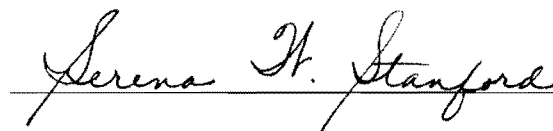


Mary V. Dickerson, Ph. D.



Francine G. Patterson, Ph. D.

APPROVED FOR THE UNIVERSITY



ACKNOWLEDGMENTS

This project--being unconventional for speech pathology--would never have been undertaken had it not been for the support Dr. Alvirda Farmer offered without reservation. It is Dr. Mary V. Dickerson with whom I share an interest in the area of speech sounds which is what prompted me to investigate Koko's skills along this line. To both of them, thank you.

It was another speech pathologist who encouraged me to persevere in a direction never before taken and to launch my thoughts. For this and for sharing enthusiasm in Koko and Mike's significance for the field of speech pathology, I thank Diane Brentari.

Family, friends, and co-workers were helpful along the way. These included Dan Goodreau, Deborah Hoefling, and Joanne Tanner. I am most especially indebted to Dave Goodreau for his support.

To Dr. Patterson I owe much appreciation for allowing me to be part of her work with Koko and Mike and for the time and effort she gave to this project. She has permitted me to not only pursue my personal interest, but also to relate more directly her most pertinent findings to our young field of speech pathology.

Last--and definitely not least--I thank Koko and Mike for "letting me in." They provided me with insight into their world. Without this my report of Koko's performance would lack contextual value. In more ways than one, I now truly appreciate Koko's cooperation. Hopefully, some of the insight she and Mike gave me will be passed on here.

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CHAPTER I

INTRODUCTION

A Gorilla "Language" Project despite Traditional Views

Speech and language use have traditionally been viewed as species-specific to humans (Chomsky, 1967, 1980; Hebb, Lambert, & Tucker, 1974; Marx, 1980; Sebeok & Umiker-Sebeok, 1980; Wiener, 1984). In other words, the ability to encode thoughts into acoustic signals (speech sounds) and to decode the signals heard has been regarded as unique to man. Controversy over this view has arisen as the results of nonhuman primate "language" projects have been reported. In particular, projects during the last two decades have included chimpanzees who have learned to communicate with symbolic geometric shapes (Premack & Premack, 1972; Rumbaugh, 1977) and chimpanzees (Gardner & Gardner, 1969) and gorillas (Patterson, 1979b) who have learned to communicate through sign language. These projects have been fascinating to many people and have made others uncomfortable. Some modern linguists and researchers from other disciplines, though lacking an agreed upon definition of language, deny that these nonhuman primates could be using language.

Despite these traditional as well as some current linguistic views--or perhaps because of them--media coverage of the communicative abilities of apes has recently increased. Such attention has been given to the gorillas, Koko and Michael, of the Gorilla Foundation in Woodside, California. They are the subjects in one of the longest ongoing studies of language abilities in apes, the only study of its kind with gorillas (Cohn, 1984). Dr. Francine Patterson began this project in 1972 when Koko was one year old (Patterson, 1979b).

One of the project's original goals was to teach Koko to communicate with humans through American Sign Language (Ameslan or ASL) (Patterson & Linden, 1981). Simultaneous communication was used with Koko (i.e., she was signed to while spoken to in corresponding American English). Patterson realized when she started working with Koko at the Children's Zoo in San Francisco that Koko was already responding to several spoken words (Patterson, 1979b). Currently, those who work with Koko find her able to understand virtually all that is said to her vocally, that is, without the signed counterpart (Cohn, 1984; Longman, 1984). However, it was not a goal of the project that she comprehend or produce spoken English (Patterson & Linden, 1981). Yet testing done early in 1976, when Koko was 4 1/2 years old, with the Assessment of Children's Language Comprehension (ACLC) (Foster, Giddan, & Stark, 1973), showed test scores to be similar when administered in sign only and voice only but somewhat better when administered in simultaneous communication (Patterson, 1979b).

The question, therefore, arises: How well can this representative of her species distinguish sounds in a meaningful context (i.e., words) from a foreign-to-her-species communication system in which she had no formal training?

This case study proposed to establish quantitatively how well Koko comprehends human speech. More specifically, the purpose of this study was to examine her ability to discriminate receptively American English phonemes within sets of minimal contrasts in words taken from her vocabulary.

Statement of the Problem

Research has been conducted with various nonhuman animals which established their ability to discriminate acoustic features of speech sounds (Bullock, 1977).

However, no objective measure has been reported of a nonhuman's ability to discriminate phonemes within a phonological context. No systematic investigation in areas of phonology has been done with apes despite abundant evidence that receptive functions, more sophisticated than needed for their intraspecies communication, are operating. Primate language use has been primarily examined for syntactic and semantic competence. Research regarding pragmatics in nonhuman primates is beginning to appear in the literature (Miles, 1976; Patterson, Patterson, & Brentari, 1986; Patterson, Tanner, & Mayer, in press; Plooij, 1978; Plooij, 1984). Information about phonological competence in nonhumans, albeit receptive only, can contribute important considerations for language skills development. Such information has not been reported in the literature.

The motor theory of speech perception is based on the premise that hearing speech sounds is dependent on the listener's motor-kinesthetic feedback of speech sound productions. If Koko's behavior measurably demonstrates that, despite an inability to produce speech sounds, she perceives them meaningfully in verbal context, this theory's validity is put into serious question.

Even though those who work most closely with Koko continually observe evidence of receptive phonological competence, "proving" this competence is very difficult, as will be detailed. Liberman and Pisoni (1977) in their quest for information on specialization for phonetic processes apparently appreciated at least some of the difficulties involved:

. . . we should want most urgently to know how well nonhuman animals cope with its [the human speech code] most general characteristics. Can they, for example, appreciate, even tacitly, that "bad" and "dab" are simply different permutations of the same three segments, or that words like "grew" and "ilk" share no segments

but have the same number? Unfortunately, the animal tests appropriate to those most general, and possibly most telling, questions are often impossible in practice, or so nearly so as to discourage even the most intrepid investigators. With that in mind, and in the hope that relevant experiments of some kind might nevertheless be done, we will set considerations of logical priority aside and give special emphasis to those less general and more simple--yet still apparently special--characteristics of phonetic perception for which the appropriate animal tests might be feasible (p. 62)

Hypothesis 1. Koko will discriminate with 80% accuracy between/among American English phonemes presented as minimal contrasts in sets of 4, 3, and 2 words from her vocabulary as depicted visually by magazine pictures.

CHAPTER II

REVIEW OF RELATED LITERATURE

To date information has not been compiled in a way that will illustrate the significance of Koko's performance when tested for the ability to discriminate speech sounds. Since speech-language pathology is generally a "hands on" (with humans) profession, members of this field have not particularly concerned themselves with ape language research and may be skeptical of the value in such pursuits. One purpose of this literature review, therefore, is to provide a reasonably comprehensive synthesis of relevant information, placing this study in its appropriate context.

The scope of the background offered is intended to give full meaning to this study and to the results themselves--just as the speech-language clinician incorporates all relevant facets of a child's daily life and background in an assessment to acquire the full perspective of speech and language behavior. Part of the fascination of ape language research is that it is, in essence, a multidisciplinary study (primarily by psychologists, linguists, philosophers, and primatologists). As would be expected, within each field differing views have emerged. Consequently, the present review only represents "the tip of the iceberg."

After dealing with the terminology, a brief overview of Koko's linguistic behaviors will be presented. Following will be a sketch of how researchers are dealing with ape language projects, differing views, related theories, and language competence criteria. Emphasis will be given to auditory discrimination, phonological processing, and studies conducted with animals in this regard. Focus will then be made on apes and gorillas, particularly in terms of gorilla vocalizations and intelligence. Finally,

specific evidence of Koko's speech sound discrimination ability will be presented.

Working Definitions

Speech sound discrimination is the primary term involved. Bernthal and Bankson (1981) explained it as "a form of auditory perception in which the listener/speaker distinguishes between sounds in the language and formulates a perceptual concept of the sound contrasts of the language" (p. 111).

"Defining language is like trying to identify an elephant while holding only its tail or trunk" (Miles, 1983, p. 45). Miles was concerned that defining language promotes a concept of it as a single thing. Without a generally accepted definition of language, however, those involved in researching or criticizing interspecies communication between apes and humans are at a loss semantically. It is noteworthy that some distinguished disbelievers of linguistic abilities in apes participated in controversy at a gathering in 1980, carefully entitled The Apes and Language Conference. If there is to be discussion of linguistic types of communicative behavior, whether among people, between the human and other species, or among nonhumans, the term language must be allowed, just as semantics, syntax, phonology, and so forth, must be allowed. Titles within the literature reflect this reality, for example, Children's Language (Vol.2) (Nelson, 1980), authored mostly by researchers who work with chimpanzees and gorillas; Language in Primates (DeLuce & Wilder, 1983), including nonhuman primates; Language Development (Vol. 2): Language, Thought, and Culture (Kuczaj, 1982), authored in part by researchers who work with chimpanzees; and Language Intervention from Ape to Child (Schiefelbusch & Hollis, 1979).

In Nicolosi, Harryman, and Kresheck's (1983) second edition of Terminology of Communication Disorders, language is defined as

1. Any accepted, structured, symbolic system for interpersonal communication composed of sounds arranged in ordered sequence to form words, with rules for combining these words into sequences or strings that express thoughts, intentions, experiences, and feelings; comprised of phonological, morphological, syntactical, and semantic components. 2. Symbolic formulation, vocal or graphic, of ideas according to semantic and grammatical rules for communication of thoughts and feelings. 3. Organized set of symbols used for communication; an interrelation of the reception, integration, and expression of information. (p. 128-9)

The first definition is ruled out here since it includes the formulation of sounds into words. For purposes here the second definition is ruled out because it excludes sign language. The third definition is applicable to Koko, Michael, and subjects in other similar research projects. Therefore, in this presentation, ape attempts at interspecies communication may be referred to as language or linguistic. These terms, as they pertain to Koko, will exclude speech and focus on the comprehension of human spoken language. However, the terms may also refer to her comprehension of ASL and expression in Gorilla Sign Language (GSL), the gorillas' modification of ASL.

Koko and Linguistic Behaviors

Patterson's work with Koko began in July, 1972, as the study for her doctoral dissertation in developmental psychology at Stanford University. She set out to explore the parameters of "comparative pedolinguistics" (Patterson, 1979a), that is, to find out how language function and form are similar in a human child and an ape child and how they are different (Patterson, 1980). Using ASL, Patterson implemented the Gardner's model for chimpanzee Washoe (Gardner & Gardner, 1969). The parameters thus included were vocabulary development, generalization, semantic relations, comprehension, and productivity (Patterson, 1980).

The various accounts of Koko's expressive linguistic behavior in GSL include the following evidence: (a) a vocabulary of 264 words by age 6-6 (by Patterson's

criterion of spontaneous and appropriate use on at least half the days of a given month), enabling her to convey such abstract concepts as causality and time, description of internal and emotional states, and assertion of falsehoods; (b) spontaneous incorporation of natural gorilla gestures and generation of novel signs into communication; (c) modulation of sign-gestures, that is, altering the core meaning of a sign by changing the articulation of one or more parameters (motion, location, configuration, facial expression, or body posture), for a semantic relation or function--location, size number, manner (degree-intensity or emphasis), agent-action, agent-object, possession or modification, question, negation-rejection, humor or word play; (d) gestural blends by which sign parameter articulations are merged to combine words; (e) spontaneous simultaneous signs by which two or more meanings can be expressed at the same time; (f) creation of compound names and metaphor, such as EYE HAT for mask and ELEPHANT BABY for Pinocchio; (g) noninstrumental and self-directing signing, that is, signing for its own sake without looking to external reward--manual babbling, spontaneous comments about the environment, and signing to herself; and (h) many other uses for communication--intentionality, displacement, prevarication, insult, argument, threat, and reference to emotional state (Patterson, 1980).

The literature contains comparisons of Koko's linguistic data with that of Washoe and deaf children as well as normal children (Patterson, 1979a; Patterson, 1980). Essentially Patterson found indications that language acquisition and use by Koko developed similarly to that of a human child but at a slower rate and required direct intervention (Patterson, 1980). This difference of degree rather than kind, she stated, would parallel development in the retarded or language delayed child most closely.

Views on Ape Language

The literature reflects as long ago as 1661 (Pepys, 1946) the plausibility that an ape could understand spoken English and might be taught to communicate with humans. A few attempts at teaching spoken language to apes have been reported. The Hayeses' chimpanzee Viki mastered four words ("mama," "papa," "cup," and "up") in six years (Hayes, 1952), but no one claimed any real success until Laidler (1978) reported that the orangutan Cody learned "kuh," "puh," "fuh," and "thuh" between the ages of 5 to 16 months and used them to make requests.

Editors Sebeok and Umiker-Sebeok in Speaking of Apes (1980) presented an exhaustive review of the subject of language communication among primates with particular attention given to chimpanzees. Yet they admitted to intentionally skirting "the consequential issue so competently discussed" (p. 53) by a number of contributors to their work, such as Bronowski and Bellugi, Brown, Chomsky, Lenneberg, Limber, and McNeil. That issue is, namely, whether what is being taught is really language. Their reluctance to address the issue in their study, they stated, was essentially due to two questions posed by Chomsky-- "What is human language?" and "What is a language?"--neither of which has a final answer.

Others subsequently "picked up the ball" and pointed out that, by dwelling on the human uniqueness question, valuable research findings may be overlooked (Miles, 1983). Miles was concerned that questioning when a type of communication can be called language would stymie ape language research. Instead she preferred an approach which identifies and analyzes the various cognitive and communicative processes that underlie language. She noted that recent investigations have included social and other nonlinguistic prerequisites to language development. Stokoe (1983) asserted that,

regardless of unavailable answers, the opportunity should not be lost to learn "the proper lessons from the whole story" (p. 150). Stokoe used Clever Hans' behavior as an illustration.

Clever Hans was a horse who, in the early 1900's, seemed to count and do math by stamping one foot the right number of times. It was found that observers were inadvertently signalling expectancy and anticipation, thus providing cues for the horse to start and stop stamping the correct answers. The horse was actually reading nonverbal communication. It was documented photographically (Pfungst, 1965) that Clever Hans could detect head movements of a few millimeters .

Stokoe's point was that this phenomenon can be viewed as fraud or it can be valued as offering important insights to (a) how much Hans learned about human behavior and (b) communication between animals and man. He believes that "language or anthrosemiotics came from zoosemiotics and that the harder we look the more likely we will be to discover how" (Stokoe, 1983, p. 152). He cautioned against a confusion of the abstract term language with specific receptive and productive language uses by apes. At the same time he suggested that ape behaviors which are like behaviors of children acquiring a language must be acknowledged as such in the communication/language sciences.

There are at least twelve different theories of the evolution of language (Laidler, 1978). Some do not view human communication at the end of a continuum with animal communication as does Stokoe. Chomsky (Chomsky & Premack, 1979), for instance, believes that language develops in young children because they are born with a language acquisition device. This nativistic theory holds that children only need to be exposed to language in use, that they do not learn language, only a specific set of language habits

(Chomsky, 1980). He claims that language processing is categorically different from communication processing in other primates (as different as breathing is from walking) and that language functions are distinct from other cognitive processes (Chomsky & Premack, 1979).

Wiener (1984) calls Chomsky's view speculation. Noting that evolution tends to be very conservative and entirely new features rare, she holds that categorical perception is more likely an old feature evolutionarily used in many primate systems, rather than a feature recently evolved to facilitate the comprehension of human language.

Much criticism of linguistic performance among apes has focused on syntax. Skeptics have not been satisfied that ape signing has demonstrated syntactic competence (Brown, 1980; Terrace, Pettito, Sanders, & Bever, 1979). Wiener (1984) stated that syntax is considered the element of human language which most clearly separates it from other animal systems. She noted that the origins of syntax are unclear and there is much speculation about its nature. Granting that nothing quite like human syntax has been found in an animal communication system, she asserted that animal communication is clearly rule governed. Lexical as well as phonological syntax were found to be demonstrated in nonhuman primates by Marler (1977). He reported already complex phonological elements being combined in rule-governed ways to produce a range of meanings.

Problems with Language Competence Criteria

It appears that inappropriate criteria are sometimes used in looking for ape language competence. For example, looking for syntactic competence in an English gloss of an ASL utterance, from human or nonhuman primates, is like making an apples and

oranges comparison. The syntactic characteristics of oral and nonoral languages are different. O'Sullivan, Fouts, Hannum, and Schneider (1982) cautioned against the use of English paradigms on nonoral language and called for a reexamination of the criteria used in ape research.

O'Sullivan et al. (1982) were not only concerned in this regard with grammar. They objected to use of a mean length of utterance (MLU) measurement to contrast human infant and chimpanzee rates of progress in language use. The simultaneity feature of ASL means, in effect, that multiple grammatical processes may be contained within a single signed unit. Moreover, an increased utterance length does not, of itself, signify increased semantic and syntactic complexity (Klima & Bellugi, 1979). Thus the meaningfulness of the standard MLU quantitative measurement of units is questionable.

Findings (Klima & Bellugi, 1979) suggest that propositions provide a better means of comparing ASL and English than morphemes do and that a pragmatic model would be more appropriate for ape language researchers (O'Sullivan et al., 1982). O'Sullivan et al. pointed out that the interpretation in context provided by pragmatics allows the consideration of gestures which are less than explicitly translatable. Consequently a pragmatic analysis would provide more information regarding propositional content and a better estimate of semantic complexity.

In addition to viewing apes' expressive abilities through signs, a pragmatic approach would also be useful for looking at receptive abilities with spoken English. Some research has found that as much as 75% of the meaning in human conversation is nonverbal (Mehrabian, 1968). Since apes have a natural propensity for communicating via gestures (Chevalier-Skolnikoff, 1977) it should not be surprising that they are able to comprehend meaning in a language system which is based on speech

but is perhaps only 25% verbal communication.

Within the context of the ape language controversy, objection to a pragmatic model can be anticipated. Some (e.g., Sebeok & Umiker-Sebeok, 1980) have objected that experimentation has not provided absolute controls, that social cues have been involved. Proponents of a pragmatic model would certainly accept and support the integration of social cues as part of the behavioral analysis. It has only been in the last decade or so that the literature has included among language disorders the inability in adolescents or adults to accurately process nonverbal communication. This language component cannot now be ignored simply because the subjects in question are of another species.

Pfungst's photographic "proof" (Timaeus, 1973) that Clever Hans watched nonverbal cues to count and do math included eight channels: eyes (blinks, direction change); head (movement up, down, or to the side); lip changes; body (changes in postural tension); hand movements; jaw (changes in muscle tension); voiceless counting along; and breathing patterns. This is evidence that animals can have well-refined perception of nonverbal information. The recent interspecies communication programs with chimpanzees and gorillas also indicate that they apply their native communication skills (as documented by field studies) to their language experiences as research subjects (Patterson, 1979b; Patterson & Linden, 1981).

It has been noted that those who seem to have had the greatest success with chimpanzees and gorillas (as measured, e.g., by vocabulary size) have been the same researchers who have made an effort to establish relationships, so to speak, with the subjects (Gardner & Gardner, 1969; O'Sullivan et al., 1982; Patterson & Linden, 1981). It is doubtful anyone will deny the significance of the social nature of language development in children and in the evolution of language. It seems to be generally

recognized by the lay person as well as the communication/language/psychology professional that the primary care giver, traditionally thought to be the mother, knows better than anyone else what a child is communicating, even though the "proof" is less than scientific. Likewise, it is difficult for those closest to the animals in the ape language projects to "prove" all their claims. Indeed they are sometimes criticized (e.g., Terrace, 1985) for having the very relationship which has engendered motivation to communicate on the part of the apes in the first place. Ape studies have shown chimpanzees to be more eager to please, in the sense of "performance," than the gorilla is inclined to be (Maple & Hoff, 1982; Yerkes & Yerkes, 1929). Certainly in Koko and Michael's case a degree of trust is prerequisite to interaction (Patterson, 1986b; personal observation). These factors contribute to the difficulty in satisfying the scientific community in regard to any level of linguistic competence.

There has been a tendency to ignore the phonological component of language in ape language research. This may be due in part to the extremely limited success in teaching apes to vocally produce "words." Without speech the investigation must focus on the receptive half of phonological processing. In any case, some believe that a receptive measure is a more accurate measure of language competence (Marquardt & Saxman, 1972).

Auditory Discrimination versus Phonological Reception

Whether or not auditory discrimination difficulties are causally related to language disorders continues to be a controversial issue. Several models of language processing have assumed intact auditory discrimination for normal language development and processing (Aram & Nation, 1982). There is evidence that prelinguistic auditory operations, inclusive of linguistic and nonlinguistic auditory

information, may indeed interfere with discrimination of linguistic stimuli. Aram and Nation (1982) concluded that skepticism is warranted here: "Whether a distinct auditory discrimination operation exists for speech sounds apart from other auditory parameters remains to be determined" (p. 102). Meanwhile, an analysis of perceptual responses, especially discrimination, provides one of a few good means of inferring phonological competence (Locke, 1980a, 1980b).

Consistent with an objection to calling chimpanzee and gorilla communicative behavior language, some investigator-writers also refrain from calling speech sound discrimination phonological. Others, apparently in an effort to describe language types of behavior, are not hesitant to use linguistic terminology. Liberman and Pisoni (1977), for example, used the term phonetic as differentiated from acoustic. Liberman, Crelin, and Klatt (1972) used the same term to refer to the use of speech sounds and called this linguistic but distinct from language. However, they all view the encoding process (language) as occurring between the phonetic level and speech.

Auditory Discrimination. Even if receptive language skills are viewed as uniquely human, other auditory discrimination skills are not. Speech sound discrimination ability is needed by nonhumans for neither communication nor for survival in their natural environment, but other auditory discrimination ability is necessary.

In Autumn, 1976, a multidisciplinary conference was held in West Berlin to consider the underlying nature of hearing and language disorders, as well as methods of diagnosis and rehabilitation (Bullock, 1977). At this Dahlem Workshop on Recognition of Complex Acoustic Signals papers were presented documenting numerous studies involving animals. Marler's (1977) report alone on the "The Structure of Animal Communication Sounds" referenced studies on bats, dolphins, whales, and numerous

species of birds, monkeys, and apes.

Observations of speech sound perception by animals were first reported at the turn of the century (Thorndike, 1970). After 1912 there was a fifty-two year gap in the publication of experimental studies. Subjects in studies reported since the mid-1960s have included cats, chinchillas, dogs, and rhesus monkeys. Overall, the studies showed that these mammals can be trained to discriminate vowel categories (such as /i/ versus /u/ or /æ/ versus /a/) when produced in isolation (Miller, 1977). Cats were found capable of discriminating /kæt/ from /bæt/ within the first 20-60 milliseconds of the word (Warfield, Ruben, & Glackin, 1966). Evidence provided by various experiments shows that certain mammals (chinchillas and monkeys) can distinguish plosives by place of articulation when they occur initially in consonant-vowel (CV) syllables (Miller, 1977). Chinchillas trained to discriminate aspirated from unaspirated plosives in CV syllables were able to generalize their training to new talkers and new vowels. Test results with chinchillas' and monkeys' perception of voice onset time (VOT) using synthetic stimuli indicated an ability to distinguish voiced and voiceless plosives in CV syllables.

Miller (1977) stated that the recognition of speech sounds is based on auditory perceptual mechanisms common to, at least, mammals. At the same time, noting the subjects' difficulties with experimental tasks, Miller saw implications that many nonhuman mammals are limited in their ability to distinguish human speech by the detectability, resolution, and patterning of the acoustic energy.

Theories from the late 1960s and early 1970s suggest that speech perception is a species-specific behavior (Kuhl & Miller, 1975), and that "specialized processing" is required for the recognition of at least some classes of speech sounds (Liberman,

1970). The idea of "phonetic feature detectors" is that special processing is necessary for complicated and abstract characteristics of the acoustic signal and that animals lack the speech sound decoder (Eimas & Corbit, 1973). The "motor theory" of speech perception suggests that it is the knowledge of the acoustic results of articulatory maneuvers which somehow mediates the perception of speech (Liberman, 1970).

Marler (1977) likewise, in his review of comparisons and contrasts between animal vocal behavior and speech, referred to the lock-and-key analogy to perceptual processing. The relationship between the sensory and motor components of a communication system is thought to be highly specific in the context of dynamic evolutionary interplay.

Phonological Reception. The purpose in the previously discussed tests with animals was to view a sensory (auditory) phenomenon only. Even though speech sounds, both spoken and synthesized, were used, no linguistic processing of the sounds was being tested. Rather they simply established that some mammals are able to distinguish one speech sound from another speech sound, some distinctions being between minimal contrasts in features.

It is a big leap into the area of language to then ask if nonhuman animals are able to process speech sounds phonologically, that is, to perceive them in consistently meaningful ways for the purpose of communication. To date, the literature reflects very limited investigation in this area.

In their early works Thorndike (1970) and Shepherd (1911, 1912) concluded that some animals recognize certain words and speech sounds and distinguish them "in phonetically irrelevant dimensions such as loudness, pitch, and voice quality" (Miller, 1977, p. 50). In 1928 an account was given of the examination of Fellow, a

1970). The idea of "phonetic feature detectors" is that special processing is necessary for complicated and abstract characteristics of the acoustic signal and that animals lack the speech sound decoder (Eimas & Corbit, 1973). The "motor theory" of speech perception suggests that it is the knowledge of the acoustic results of articulatory maneuvers which somehow mediates the perception of speech (Liberman, 1970).

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Phonological Reception. The purpose in the previously discussed tests with animals was to view a sensory (auditory) phenomenon only. Even though speech sounds, both spoken and synthesized, were used, no linguistic processing of the sounds was being tested. Rather they simply established that some mammals are able to distinguish one speech sound from another speech sound, some distinctions being between minimal contrasts in features.

It is a big leap into the area of language to then ask if nonhuman animals are able to process speech sounds phonologically, that is, to perceive them in consistently meaningful ways for the purpose of communication. To date, the literature reflects very limited investigation in this area.

In their early works Thorndike (1970) and Shepherd (1911, 1912) concluded that some animals recognize certain words and speech sounds and distinguish them "in phonetically irrelevant dimensions such as loudness, pitch, and voice quality" (Miller, 1977, p. 50). In 1928 an account was given of the examination of Fellow, a

4-year-old German Shepherd male (Warden & Warren, 1928). Fellow's owner

sought to teach him in various ways to understand human language in the sense of responding in the appropriate manner to commands . . . Fellow has been talked to constantly almost from birth in much the same manner as a young child during the years of taking on language. (p. 16-17)

The owner's claim that Fellow understood 400 or more words was a claim that associations had been formed between specific words and specific objects, places, or acts. During the course of the examination the dog performed satisfactorily to commands given by Fellow's owner through a closed door, ruling out the Clever Hans phenomenon. Subsequent tests, however, revealed the influence of visual cues. In an attempt to deliberately confuse the dog with a visual cue contradictory to the verbal command, the dog followed the visual cue; for example, given the command, "Go put your head on the chair," the dog jumped up on the table at which the owner was looking.

Miller (1977) acknowledged that dogs, horses, mules, buffalo, oxen, and elephants have all been observed responding to the spoken commands of humans in the course of their training and work, suggesting some ability to classify speech sounds. Yet Healy (1973) expressed doubt that chimpanzees could learn the complex and abstract phonemic aspect of language. Those involved in ape language research projects have since reported more impressive observations. Fouts, Couch, and O'Neil (1979) reported, for example, the chimpanzee Ally's performance when given novel vocal commands to place one of 5 items in one of 3 places. Ally's total score of 40% was far above chance level. Comprehension vocabularies of 50 to 100 words for some chimpanzees have been reported (Kuczaj, 1982) and 800 for Koko (Cohn, 1984).

At the Dahlem Workshop on Recognition of Complex Acoustic Signals, Liberman and Pisoni (1977) presented "Evidence for a Special Speech-Perceiving Subsystem in

the Human." They pointed out the following:

If it were possible to perceive the words of language simply as auditory patterns-- that is, without regard to their constituent phonetic elements--then neither phonetic structure nor its perception would be of great biological interest. But such a nonphonetic strategy would, in practice, severely limit the number of words a listener could identify and immensely complicate the processes by which he extracts those words from the stream of speech. (p. 59)

They discussed the need for specialized processes by which, not only feature detectors clarify an auditory signal, but also recover, or decode, a phonetic message in order for speech to be perceived. The possibility of being able to listen to speech and extract meaning without phonological processing was considered--perhaps phones only could be recovered for a focused purpose such as rhyming or alliteration. They concluded that it must be possible to deal directly with the meaningful segments as holistic auditory patterns, but there would be limitations: (a) this system would fail before all patterns (words) were identified because complex and rapid adjustments to variations in speaking rate and in phonemic syllable position and context are required, and (b) coarticulation does not respect word boundaries, so the listener cannot simply recover discrete phonetic segments from the continuous acoustic signal of speech. Without a phonetic structure, therefore, an animal would have difficulty retrieving words of his vocabulary--though they said nothing of how this (receptive) vocabulary would ever develop and stabilize under these limitations--from fluent speech (25-30 phonemes per second [Liberman, 1970]). "Hence we should suppose that a creature may not bypass the phonetic structure if he would perceive most of what is said to him" (p. 74). Similarly, literature in psychology reflects the same conclusion: "Apparently it is the child's innate capacity for auditory analysis that distinguishes him from the chimpanzee" (Hebb, Lambert, & Tucker, 1974, p. 153).

Ape Vocal Anatomy versus Speech Physiology

Lieberman and Pisoni (1977) asserted that the distinctive characteristic of speech perception processing is a kind of knowledge of what vocal tracts do when they make linguistically significant gestures. They and others (such as Marler, 1977) believe in a biologically based link between speech perception and speech production. The implication in the "motor theory" of speech perception is that the listener must have had the experience of the articulation (the kinesthetic feedback) to know what the speaker's vocal tract is doing.

Lieberman et al. (1972) did a comparative study of the phonetic ability of newborn and adult humans, Neanderthal man, and the chimpanzee. Using computerized models constructed from casts made of the four vocal tracts, they looked at the constraints supralaryngeal vocal tract variations impose upon the phonetic repertoire. The findings regarding the chimpanzee were that the language universal vowel triangle (/a, i, u/) is not possible due to (a) the limited dimensions for cavity shaping and articulation and (b) lack of a two-tube resonant system, that is, a separation of an oral from a pharyngeal cavity. All "subjects" appeared to have mechanisms that would allow the production of both labial and dental consonants provided other muscular and neural factors were present. Noted were the achievements of the Hayeses (1952) with chimpanzee Viki producing /p/ and /m/. Lieberman et al. (1972) speculated that chimpanzees may not use dental consonants in contrast with labial consonants because they cannot perceptually differentiate these sounds.

Subsequently Laidler (1978) reported that the infant orangutan Cody learned to produce "kuh," "puh," "fuh," and "thuh" at a younger age and much faster than chimpanzee Viki produced her four words. These unvoiced sounds were chosen for ease

of articulation, according to Laidler, and taught by a manual shaping method (by initially occluding the nostrils to prevent air escape) using operant conditioning techniques. He noted a greater similarity of chimpanzee than orangutan larynx and facial musculature to those of man and believed that use of his techniques with chimpanzees would have produced more success than he did with Cody.

The speech/language literature does not reflect a comparison of the gorilla and human vocal tracts. At this point only extrapolations can be made. The size of the gorilla vocal tract means that it does not have the same constraints Lieberman et al. (1972) found in the newborn human or chimpanzee vocal tract. However, the larger-than-human vocal tract of the gorilla is, according to a frontal view (personal observation), a very deep, very horizontal single tube resonant system (approximately 37cm [15 in] for Michael versus 17 cm in the human from lips to vocal folds).

Even though the gorilla vocal tract has adequate dimensions for the production of a variety of vowel sounds (Fossey, 1972; Schaller, 1963) and a wide range of articulatory mobility, no attempt to teach speech sounds to a gorilla has been reported to date. The high position of the vocal folds near the posterior of the gorilla horizontal vocal tract provides a safeguard against choking (Lieberman et al., 1972). Unlike humans, the gorilla would be able to breathe even with food lodged in the larynx. It appears that, to an extent, humans forfeited their adaptation to the primary vegetative functions of swallowing and respiration in favor of speech production (Negus, 1949), the only function for which the human vocal tract is better adapted.

Gorilla Vocalizations

Fossey, after 2255 contact hours with free-living mountain gorillas and observation of two captive infant gorillas in Central Africa, described 16 types of

vocalizations (1972). The repertoire includes various belches, grunts, hoots, cries, barks, screams, pants, growls, roars, and chuckles. Spectrographic and social/contextual data were presented. Spectrograms of gorilla vocalizations show frequencies ranging from a baseline of 0 through 6 kHz. Fossey described, for instance, the hoot series as a "prolonged series (at times almost undetectable to the human ear) but which can build up into 'plaintive' sounding, strained 'hoos' of longer duration which sound rather like the whine of a dog" (p. 50). It is noteworthy that the vocalization frequencies cluster below 3 kHz, as do human speech sounds. Vocalizations were found to vary quantitatively and qualitatively according to their expressive function and by age and sex classes.

Fossey's (1972) findings on the communicative behavior of the feral mountain gorilla were similar to those of Schaller's earlier work (1963). Schaller had identified 22 vocalizations, but admitted having difficulty classifying them since "a single sound can be the product of more than one emotion and possess more than one function" (p. 210). He noted that, even though the basic number of vocalizations is small, the variation in pitch, intensity, quality, and pattern of each sound broadened the scope of their vocal repertoire. He found the gorillas responding to the sounds they heard selectively, depending on the conditions under which a vocalization was emitted and the member of the group emitting it. Schaller also observed that one vocalization could mean two different things by changing the accompanying gestures.

Fossey (1979) provided a developmental profile, including vocal behavior, of the infant mountain gorilla to age 36 months. The progression goes from puppy-like whines at birth, to "temper tantrum screams, howls, and pig-grunts" (p. 150) in the second year, to "basic disyllabic variants of the belch vocalization" (p. 151) in the

third year.

Captive western lowland gorillas reached only stage 1 of the vocal modes in the Piagetian Sensorimotor Intelligence Series, as tested by Chevalier-Skolnikoff (1977):

. . . they fail to manifest stage 2 repetitive self-vocalization (cooing), and stage 3 repetitive vocal attempts to effect changes in the environment (babbling, or vocal "games"), or stage 4 combinations of sounds, or stage 5 experimentation with sounds. In the auditory modality, apes appear to be intermediate between monkeys and humans (p. 168)

These test results contrast with data from feral gorilla studies. Fossey's (1972) report of disyllabic belches and Schaller's (1963) examples of two- and three-toned vocalizations, for instance, are stage 4 combinations of sounds. Similarly, Koko has shown a sensitivity to human vocal inflection and has, on occasion, imitated and closely matched the pitch variation patterns with her own purr vocalization (Tanner, 1984a), placing her well beyond stage 1 of the Piagetian vocal modes.

Gorilla Intelligence

The gorillas did complete, however, all six stages of the Imitation Series (Chevalier- Skolnikoff, 1977) which measures cognitive development. They were found able to learn new bodily, facial, and manual motor patterns by repeating imitative matching behavior and to imitate new motor patterns on the first try without practice. These findings are in keeping with the species' natural (gestural) forms of intracommunication. Maple and Hoff (1982) called gorillas the most intelligent of the nonhuman primates though others (Yerkes and Yerkes, 1929) described specific abilities in other great apes as superior.

Koko's IQ has tested at 85-95 with several administrations of the Stanford-Binet Intelligence Scale and other such instruments as detailed by Patterson in her dissertation (1979b). This score range resulted in spite of the human cultural bias of

the test, which placed Koko at a disadvantage.

Evidence of Speech Sound Discrimination

There is abundant evidence that Koko more than just hears speech sounds. Rather, she hears them meaningfully. Koko was able at an early age, for instance, to follow spoken instructions when a companion's hands were otherwise occupied and unavailable for signing (Patterson & Linden, 1981). This is what prompted Patterson to determine Koko's ability to comprehend English relative to her comprehension of signed and signed/spoken communication. Using the ACLC Patterson found Koko's scores to be the same for sign only and voice only administrations, with bimodal administration resulting in scores about the same as for children her age who were neurologically or educationally handicapped (Patterson, 1979b; Patterson & Linden, 1981).

There is also evidence more specific to speech sound discrimination. Koko has demonstrated an ability to rhyme English words spontaneously since she was 7 years old (Patterson, 1978b; Patterson & Linden, 1981). Patterson found her able to provide rhymes upon request, for example, HAIR BEAR and ALL BALL, and to give a rhyming reply to spoken and signed words, DO for "blue," WRONG for "long," WASH for "squash." She was then tested with a toy animal game. The animals were arranged in a row in front of her and she was asked questions:

Barbara Hiller: Which animal rhymes with hat?

Koko: CAT.

Barbara: Which rhymes with big?

Koko: PIG THERE. (She points to the pig.)

Barbara: Which rhymes with hair?

Koko: THAT. (She points to the bear.)

Barbara: What is that?

Koko: PIG CAT.

Barbara: Oh, come on.

Koko: BEAR HAIR.

Barbara: Good girl. Which rhymes with goose?

Koko: THINK THAT. (Points to the moose.) (Patterson & Linden, 1981, p. 141)

Similarly Koko has matched initial word sounds (Patterson, 1978b; Tanner, 1983).

Her use of "phonemic paraphasias" illustrates her attention to phonemic patterns: KNEE/ "need," CHEEK/"cheese," and LEMON/"eleven." She also interchanges homonyms: EYE with the pronoun or letter "I" and KNOW for NO, for example (Patterson & Linden, 1981).

When lacking a sign in her vocabulary, Koko has borrowed stressed phonemic series within spoken words to invent a corresponding sign. Her use of a KNOCK sign for "obnoxious" is one such example. She was accustomed to hearing people use the word "obnoxious" regarding undesirable behavior. After a while of her using a KNOCK sign in a context of irritation or rejection, the people around her realized the intended communication (Patterson & Linden, 1981; personal communication, September, 1985), and this has been a regular part of her vocabulary ever since. Her use of a BLOW sign for "You blew it!" developed similarly. More recently, when asked repeatedly to produce a urine sample, she responded from the toilet APPLE APPLE APPLE APPLE emphatically with two fists to her cheeks instead of the usual one hand to the cheek (F. G. Patterson, personal communication, March, 1986).

These demonstrations of phoneme awareness are also significant on another level. They require more processing steps of Koko in terms of multimodal translations than the human speaker/listener uses. She must first perceive phonemic similarities, decode them as such, but then encode them through her manual/visual modality back into a form that makes sense only in the spoken/auditory modality. Further processing is required for her to recognize and decode the written word and match it with a sign (encode) as she does in her reading program (Tanner, Branchaud, & Peterson, 1983).

"Koko hears and understands English words and can connect letters with their phonetic values," said Tanner (1983, p. 7) who works with Koko.

Tanner (1984b) reported that Koko invented her own version of finger spelling and further developed it with Tanner. (The gorillas have difficulty anatomically producing finger-spelled letters in the conventional manner.) Similar to a code used by radio communicators to disambiguate letter sounds, Koko would spell "cat" as CAT, APPLE, TEETH. However, she selects the appropriate letter when asked as a letter in voice only. Some of the code words, such as TEETH/"T" and EYE /"I" illustrate the phonetic influence on her choices.

CHAPTER III

METHODOLOGY

Subject

Koko is a female lowland gorilla born at the San Francisco Zoo on the Fourth of July, 1971. One year later Dr. Francine Patterson began teaching her to communicate through signs. Koko's human companions spoke while signing to her. Over time evidence became increasingly certain that she understood what was being said to her without accompanying signs. After 14 years of direct daily exposure to spoken English, her ability to discriminate speech sounds was tested.

The nature of a controlled test situation and the nature of the subject Koko are not very compatible. Recent as well as classic literature on gorillas describes characteristic behavior which makes them less than desirable as test subjects (Maple & Hoff, 1982; Patterson & Linden, 1981; Yerkes & Yerkes, 1929). They have been described as "intractable" and "negativistic" (Schiefelbusch & Hollis, 1979, p. 225). The Yerkeses (1929) expressed well the difficulty of describing gorilla disposition and temperament. They called it "unusually embarrassing" to attempt because of the "highly diversified and seemingly contradictory nature of reports" (p. 455). This statement can be made about differences between gorillas or about an individual gorilla over time, even a very short time due to mood changes (Patterson & Linden, 1981; Schaller, 1963). In a test situation, willingness to perform could conceivably vary from one test item to the next.

Every effort was made in test design to accommodate "the nature of the beast." The major concern was for test validity, and all decisions were made accordingly. Careful

judgments and trade-offs were necessary in the design. To motivate adequate and appropriate participation Koko's temperamental characteristics and likes/dislikes had to be anticipated and weighed: fascination with the bizarre versus distraction by/focus on detail; limited direct experience in the human world versus a vocabulary related to human experiences; an eagerness to interact versus stubbornness; selective curiosity versus boredom (F. G. Patterson, personal communication, August, 1985-March, 1986; Patterson & Linden, 1981). "Paradoxically, it may be that an exposition of the gorilla's intellectual capacities will prove to be a test of our ingenuity in devising stimulating new tasks" (Patterson, 1979b, p. 181).

Another constraint Koko's spontaneous behavior imposed upon the test situation was that she is likely to ingest or otherwise destroy manipulables. Then again she is not likely to participate in an activity with visual materials if she does not have direct (visually and tactually) access to them, thus requiring another balancing act in test design. She enjoys books and magazines which she can take into her room and view at her leisure. Manila folder material is something she does not ingest, apparently due to an unappealing taste. The primary test materials consisted, therefore, of colorful magazine pictures, each depicting a familiar concept (thing or activity) glued to manila folder material and heavily laminated.

Unsuitability of standardized assessment tools. Any test battery involving listening skills in a child would include an audiometric examination. For reasons already mentioned this was not feasible.

Originally a battery of standardized tests was considered for testing a variety of language skills, with emphasis on the phonological ones. The Test for Auditory Comprehension of Language (TACL) (Carrow, 1973) seemed one good choice. It was

thought that a good score, particularly for the morphological construction items, would indicate considerable phonological ability as required to discriminate suffixes. It would also allow for comparison to children 3 to 7 years of age. The test format is similar to that of the ACLC (Foster et al., 1973) which Koko had been given previously. It seemed a simple matter to propose the administration of the TACL and to expect a wealth of information on Koko's receptive language abilities. Upon viewing videotaped segments of the ACLC administration from years past and reading (Patterson, 1979b) and hearing of behavioral obstacles (F. G. Patterson, personal communication, August, 1985-March, 1986) it became clear that eliciting Koko's cooperation had not been easy and is no easier now. Chances of Koko's adequate participation in a TACL administration were not good.

Noting that "same" and "different" were in Koko's vocabulary, a discrimination test such as the widely used Auditory Discrimination Test (Wepman, 1973) was considered; however, Patterson anticipated that this activity would be perceived by Koko as boring and not elicit adequate participation for successful administration (F. G. Patterson, personal communication, August, 1985). Koko has made good use of a computer in the past (Patterson, 1978a). This would "spice up" these and innumerable other test activities, but such instrumentation is not available at this time.

The test used for the present study actually bears resemblance to the Modified Rhyme Test (MRT) (Kreul, Nixon, Kryter, Bell, Lang, & Schubert, 1968). This test could not be used, however, since many of the words are not in Koko's vocabulary (Patterson, 1986a). There would be, therefore, the likelihood of boredom, and/or it would become a memory test instead of a test of phonological discrimination.

Limitations. With any single-subject study the limitations to making

generalizations are obvious. How representative Koko's abilities are of gorillas' potential is anyone's guess at this point since hers is a one-of-a-kind longitudinal study. The literature (Redshaw, 1975; Yerkes & Yerkes, 1929), as well as observations (Patterson & Linden, 1981; personal observations), reflect how different one gorilla's performance can be from another's.

Even valid test results may not be a reflection of Koko's original potential. Although she was born in captivity and, therefore, exposed from birth to human speech peripherally, there was a one-year delay in exposure to the kind of speech/language a human infant normally experiences. If such a delay occurred during such a critical stage for a human infant, serious delays in speech/language development would be expected, and the prognosis for ultimate language competence would be guarded. Consequently, direct comparisons with child language development--even if theoretically other major variables, such as IQ and age equivalency, could be factored out--need to be made with caution.

Another consideration regarding Koko's potential is her physical health during her first year. Inadequate nourishment from her mother and an outbreak of illness in the zoo's gorilla compound almost resulted in death for Koko (Patterson & Linden, 1981). At 6 months she weighed 4 pounds, 4 ounces, the average weight for a newborn gorilla. She was malnourished, dehydrated, hairless, and had diarrhea and septicemia. After a period of round-the-clock care she recovered and, by her first birthday, weighed 20 pounds. There were subsequent concerns about neurological damage (Patterson, 1980) although medical examinations indicated no discernible lasting harm had resulted from her earlier condition (Patterson & Linden, 1981).

Procedures

Test. Several demonstrations of appropriate test participation were provided by human companions only. The activity was modeled as a game for good listeners, excluding Koko, with the exact materials and format. It was expected that this exposure and Koko's exclusion from the exercise would accomplish several important things: (a) the "rules of the game" would be clarified, (b) a kind of jealousy or desire to imitate her models would promote a desire to become a participant (F. G. Patterson, personal communication, March, 1986), and (c) appropriate treatment of test materials by Koko would more likely result.

Koko was presented with sets of 4, 3, or 2 visual depictions of her vocabulary words (Patterson, Koko's daily sign checklist, 1986a; F. G. Patterson, personal communication, August, 1985-March, 1986) which differ from one another by one phoneme only. Blends were not used, unlike the similarly developed test, the MRT, to truly minimize the phonemic contrasts. (See Appendix A)

Koko was shown one card at a time with the tester (Dr. Patterson) including the spoken test word in their dialogue about the picture. This picture was set aside (out of view) and another in the set introduced and discussed. After all pictures in a set were shown and named aloud separately, the set was given to Koko on her side of the mesh. A carrier phrase, "Give me the _____" or "Show me _____," was used in the examiner's normal conversational voice to elicit test item responses. (The purposes of these carrier phrases were (a) to reduce coarticulatory influence on the target word by the neutrality of the final schwa in /ə ə/ [Kreul et al., 1968] or by the openness of the vowel in /mi/, and (b) to provide the language context, the normal environment for phoneme reception [Schwartz & Goldman, 1974].) Koko was given a small food item or

activity reward for correct answers only.

Scoring test items presented some difficulty. By using the carrier phrases "Show me ____" or "Give me the ____" she was originally expected to point to or pass back one picture card in response. Upon test administration, it was realized that Koko was not going to stop at one limited response but would sometimes (a) continue signing about all test items, or (b) return the whole package as if disinterested or distracted by the waiting reward, or (c) use a mixture of signing, pointing, kissing, and passing back within her response, or (d) as in the case of the one vowel contrast she missed, point to the wrong picture but immediately seem to object to her answer (GORILLA ANIMAL BAD THAT, BAD BAD THAT). In the interest of maintaining the procedure as a test of speech sound discrimination--and not of Koko's ability to follow directions precisely--a judgment was made that, in the case of multiple responses, the first response would be accepted as the test response. If she tried to hand back the whole package, it was returned and she was asked again with a carrier phrase. As a consequence of this criterion she lost credit even when it was indicated in another way that she heard the word as distinct from the others in the set. For example, when asked for "back" she looked at the back of the "black" card, turned it over and pointed to it. This criterion also meant that she scored credit for a few responses which were questionable. Of 10 questionable responses 6 were in Koko's favor and 4 against her, so this scoring criterion did not shift the results much more in one direction than another. Even though using the consistent criterion of "first response counts" was a compromise, it seemed the most objective means of handling this dilemma. (Appendix B provides sample test item dialogues which illustrate scoring difficulties.)

Percentage scores were calculated for groups of test items and for the total 55 test

items. As unanticipated patterns in Koko's test performance appeared, the test items were regrouped, scores again calculated, and checked for levels of significance.

Experiment: Assigning Sign Names. Koko was provided with a series of 15 colored magazine pictures of infant faces, each accompanied by a designated nonsense name of CVC, CCVC, CVCC, CVCVC, and so forth. She was asked to give them sign names. This experimental game was intended to find to what extent and how Koko would play with the name sounds when function and visual characteristics/distractions were minimized.

(The significance of this last factor should be noted in that ASL communicators typically give one another names based on some personal or physical characteristic.)

CHAPTER IV
RESULTS AND DISCUSSION

Test Results

Scores. Of the total 55 test items, Koko scored 43 correctly or 78.2% which is just under the 80% accuracy criterion required to accept the hypothesis. Table 1 shows the breakdown according to the position of the minimal contrast phonemes within the test words and the number of words per test item.

Table 1

Scores according to Phoneme Position and Set Size

Package #	Phoneme Position	Set Size (Words per Test Item)	Number Correct	Percent Correct
1	initial	4	7/8	87.5%
2	initial	3	10/13	76.9%
3	initial	2	9/12	75.0%
4	final	4, 3, or 2	6/6	100.0%
5	medial	3 or 2	6/7	85.7%
6	medial	2	<u>5/9</u>	<u>55.6%</u>
			43/55	78.2%

Since test items consisted of 2, 3, or 4 choices, the 55 items were not weighted equally in terms of chance. It is important, therefore, to view the items in groups of equal chance.

Table 2

Scores according to Set Size

Package #	Number Correct per Number of Items	Percent Correct
4 Words per Test Item		
1	7/8	
4 (part)	<u>2/2</u>	
	9/10	90%
3 Words per Test Item		
2	10/13	
4 (part)	3/3	
5 (part)	<u>3/3</u>	
	16/19	84.2%
2 Words per Test Item		
3	9/12	
4 (part)	1/1	
5 (part)	3/4	
6	<u>5/9</u>	
	18/26	69.2%

This breakdown is revealing in that test performance improved as the number of choices per test item increased. This performance pattern was not anticipated--nor logical to expect--but may reflect a "motivation-to-participate" factor. Koko may have perceived the 2-word sets as boring, just two pictures to look at, rather than a challenging game/test of 3 or 4 for

which her response required more attention/involvement. This speculation is supported by a couple of observations:

1. The first test package administered (Package #4) consisted of sets of 3 and 4 words, and she scored 100%. The second package administered (Package #7) consisted of sets of 2 words, and her score dropped to a low of 55.6%.

2. Looking back at the ACLC test scores (Patterson, 1979b), there was a similar occurrence between her scores for 3 and 4 critical elements when the test was administered sign only (scores of 30 and 50 respectively).

The present study's observed correct responses for sets of 2, 3, and 4 choices were compared to the chance level expected number of correct responses by using a single sample chi-square (χ^2) test. Had Koko been performing at chance level her scores would have been much lower as seen by the values in Table 3.

Table 3

Goodness-of-Fit Comparison between Koko's Correct Responses (Observed) and Chance Level Responses (Expected)

Responses	Sets of Words per Test Item		
	2	3	4
Observed	18	16	9
Expected	13	6.3	2.5

The Goodness-of-fit analysis indicated that Koko's responses were significantly better than chance: $\chi^2 (2, N = 43) = 6.66, p \leq .05$. Although the hypothesis cannot actually be accepted, the significance level of her performance clearly indicates Koko was discriminating speech sounds.

Error analyses. The odd number of test items and their groupings do not lend themselves to a tidy analysis, nor does the random occurrence of phonemes. (Appendix C specifies the incidence of each phoneme tested and the incidence of those they were tested against.) However, descriptive analyses and extrapolations may be made from test item responses, particularly when patterns emerge from erroneous responses.

1. Phoneme position: At 100% it appears that final position phoneme discrimination is strongest. With only 6 items tested, however, comparison to other positions need to be made cautiously, especially since the test items are not equally weighted. Still it is noteworthy that these results are consistent with Koko's interest in rhyming words. Initial position discrimination scores were next with 78.8% correct and medial position weakest with 68.8% correct. Koko's test performance with final phoneme discrimination was not consistent with children's acquisition of speech sounds in that the final ones stabilize after the initial ones; however, in regard to medial phonemes, her performance was consistent on three counts, (a) that medial sounds may stabilize last, (b) vowel sounds are acquired early, and (c) consonant clusters are acquired late (Bernthal & Bankson, 1981). A further breakdown of results for medial phonemes shows Koko scored 85.7% on medial vowels (Package #5) and 55.6% on medial consonants (Package #6) which were mostly 2-consonant clusters versus single consonants (only 2 words per test item).

2. Voicing, manner, and place: According to Table 5 the substitution, addition and deletion errors show that Koko's erroneous responses had little in common with the requested word in regard to voicing, manner, or place features (the phonetic features most frequently considered). Analysis according to Chomsky and Halle's (1968) 13 distinctive features also shows little relatedness between request and error. This means

Table 4

Scores according to Phoneme Position

Phoneme Position	Number Correct	Percent Correct
Initial	26/33	78.8%
Medial	11/16	68.8%
Final	6/6	100.0%

that hints (i.e. features) provided by the erroneous choices that are different from the requested word did not deter Koko from choosing them. Twice out of 9 items in Package #6 Koko erroneously responded with a word containing a liquid in favor of its omission, however, she reversed this by a \emptyset /l error on a subsequent test item.

3. To look for error patterns in Koko's test performance for comparison to children's mastery of phoneme productions is perhaps not as meaningful here as expected. Even though all but 5 consonants (/ŋ, v, ʃ, ʒ, hw/) were represented within the test, only one word per set was vocally requested. Of the 12 errors, one was a close vowel and is not reflected on the mastery of phonemes table (Appendix D). According to the table's order of acquisition, the 11 consonant errors span the developmental period from 3 to 6 years and do not correspond to the human child's developmental delay pattern. For example, the words /zu/ and /zip/ elicited a correct response.

Looking at Appendix D again, this time for the sounds Koko chose as substitutions for or additions to the phonemic content of a requested word, almost the same broad span

Table 5

Feature Analysis of Errors

Package #	Phoneme Position	Error	Number of Feature Differences**	Traditional Phonetic Features		
				Voicing	Manner	Place
1	initial	s/p	3	+	-	-
2	initial	f/k	6	+	-	-
		s/r	4	-	-	-
		b/f	3	-	-	-
3	initial	sw	11	-	-	-
		k/d	6	-	+	-
		b/θ	3	-	-	-
5	medial	ɛ/ɪ	3	NA*	NA*	close (vowel)
6	medial	r/∅	NA	-	-	-
		l/∅	NA	-	-	-
		∅/l	NA	-	-	-
		w	12	NA*	-	-

Note. + represents the 2 phonemes having the feature in common; - represents that the feature is not shared

* NA: Not applicable since the other choices could only be "same."

** Chomsky & Halle (1968)

is used. It is noticeable that (similar to the l/∅ and ∅/l errors previously noted) /f, k, r, l/ accounted for 5 out of the 12 erroneous responses given and, in other test items,

they accounted for 5 of 12 requested words missed. These data might make one suspect a kind of auditory perceptual perseveration on the most frequently occurring phonemes in the English to which she is exposed. There may be something to this according to the percentages charted in Shriberg and Kent (1982). A stronger case would be made for this speculation using their chart for adult speech rather than the chart for young elementary school children's speech. It is, in fact, almost exclusively adult speech she hears.

4. Vowels versus consonants: Only 1 response of 8 vowel contrasts (12.5%) was missed, and it is close to the substituted vowel in articulation, ϵ/I . Of the 47 consonant test items, there were 11 erroneous responses (23.4%). This comparison is consistent with the earlier acquisition of vowel sounds in children.

5. Confusion matrix comparison: Looking at Koko's response errors in comparison to the confusions hearing-impaired listeners have (Appendix E), there is little to relate Koko's test performance to their data. Only 8 of her errors could be used (i.e. neither vowels nor / \emptyset / are part of the confusion matrix). Of the 8, only 2 appeared on the the table: b/f correlated at .13 and f/k correlated at .04. This is consistent with the findings above that there appears a lack of feature relatedness between her choice and the request. The errors appear to be more random than related to an auditory confusion. For the same reasons that the voicing, manner, and place features of the response errors showed little relevance to the requested response, they are not likely to be correlated on this confusion matrix either. The contrasting phonemes within each set, however, were not selected on the basis of a likelihood for confusion.

6. Audiographic view: Northern and Downs' (1978) "Frequency Spectrum of

Familiar Sounds" (Appendix F) shows Koko's test errors falling over a wide span between 400-8000 Hz. Yet within the span and beyond the lower frequency end of it are phonemes which she responded to correctly. Basically, her errors were different from those found in the disordered auditory perception of the hard-of-hearing population.

Reliability sample. The first 10 items of Package 2 were readministered as a test-retest reliability sample. These test items consisted of 3-word sets. She scored 40% the second time versus 70% on these particular items in the original test. She missed 3 new items in addition to missing the 3 items she missed the first time. Of the 3 items in error both times, only 1 was the same error substitution both times. This result is not supportive in the usual sense of reliability but is again consistent with the anticipated boredom factor. The tasks were no longer novel.

Overview. Looking for the influence of voicing, manner, and place in Koko's response errors, looking for patterns consistent with developmental delay or auditory confusion or even acoustic imperception may seem to provide little information and make her errors appear random and, therefore, meaningless. Looking for error patterns expected in human behavior and not finding them could lead, especially the skeptic, to suspecting random behavior in the selection of correct responses as well, particularly when viewing the score for Package #6. However, there were only 12 errors out of 55 items and there are some meaningful patterns in the correct responses.

That her performance with final position phonemes was high (100%) is not surprising in that her experience and interest in rhyming words has reinforced attention to these phonemes more than any others. According to current gorilla companions, it is still true that listening to rhyming lines (e.g. Dr. Seuss's Green Eggs

and Ham) has a definite entertainment value for the gorillas (H. M. Huber, personal communication, February 13, 1987). The high success level may be attributable to a combination of the "fun" factor, plus a well-reinforced skill level, plus more word pictures per set.

Koko's performance improved impressively as the number of words in a test item increased--from 69.2% when 2 words were involved to 90% when 4 words were involved. This seems to be a highly influential variable in the test situation. This finding was surprising and yet in keeping with the subject's normal behavior. Similar results have been found on other tasks with apes (F. G. Patterson, personal communication, March, 1987). As previously described she can become easily bored and "turn off" to an activity or materials. It would be helpful to know if Koko's performance with final sounds would have been sustained through the administration of one more test package consisting of 2 words per set of final sounds. The results would be telling in terms of both her speech sound discrimination ability with final phonemes in words and, within that advantageous context, how much the 2 words/pictures only would influence her performance.

The combination of 3 factors--the position as medial, 2 words/pictures only, and the context of a blend--seems to account for the lowest package score in the test, 55.6%, which is only slightly above chance. Package #5 tested medial vowel sounds out of sets of 3 and 4 words each, and the score was 85.7%, so medial sound perception is not in itself the problem. It was only when medial sounds were presented in sets of 2, one of the 2 being within a blend context, that the score dropped below other package scores.

Test fatigue per se was not a primary factor since the test items were

administered one per day. The low score occurred for the second package administered. (Administration order did not correspond to the package numbers but was randomized [4, 6, 2, 1, 5, and 3], so Package #6 was not last.) The low score was a particularly dramatic contrast since it followed the 100% scored on the first package administered. Patterson did similarly report in her dissertation (1979b) that Koko's "best performance was obtained on the first phase of the test [the ACLC] After responding correctly on the first few trials of a session, Koko would sometimes lapse into a series of consecutive errors" (p. 179).

As test administration proceeded it became obvious that a relevant development was taking place at the beginning of the testing period, October 29, 1986 to February 16, 1987. Koko started using her CORN sign for the word "card." Not having a sign for the picture cards which Dr. Patterson was giving her and talking about each day, Koko labeled them herself with a word which has the first and third phonemes in common, /kɔrn/ for /kɔrd/. Dr. Patterson acknowledged Koko's use of CORN/card in their session on December 8th, but in reviewing a transcription of the test sessions it is clear that Koko initiated the use of this sign certainly by November 18th and used it almost daily at the beginning of each session. During a late November session she became emphatic in its use, signing CORN THERE . . . GOOD CORN THERE . . . CORN CORN THAT . . . CORN CORN CORN CORN CORN THERE . . . ME ME CORN NEED THAT to each of the 3 cards separately. Subsequent sessions included utterances such as CORN HURRY DO GIMME, KOKO-LOVE CORN, BREAD CORN THERE (for the picture card depicting bread).

Experiment Results

Of the 15 experimental consonant/vowel items, Koko's signed responses to 3 nonsense names (20%) suggested phonemic play (see Appendix G for responses). It

appears that she played more with the sounds she heard in the spoken name as the number of phonemes increased (similar to performing better as the number of test items increased). In response to the nonsense CCVC CCVC /stɪŋgl̩aɪz/, for example, she responded, ". . . GREEN EYE M|KE SURPRISE . . . THAT EYE," to the baby picture on the floor. (The graphemes underlined correspond to the phonemes contained in the nonsense name.) The /aɪ/ diphthong is represented 3 times. Being a phoneme of longer duration it may lend itself more to this kind of play than other phonemes. This is especially true since it preceded /z/, forming the accented syllable in a word which is positively weighted for her--she likes surprises!

Her responses to the CVCC /nɔrd/ were "DRINK NIPPLE, DRINK BIRD DRINK." Her repeated use of the /r/ and /d/ phonemes, even if in reverse order, are suggestive of an auditory focus and selection for play. One response to the CVCVC nonsense name /zɪpə/ was "NIPPLE NIPPLE," a reiteration of 4 of the 5 phonemes contained in the stimulus item.

It was not expected that the "baby naming game" would elicit or incorporate phonemic play with every item. Some days the experimental items did not seem to stimulate much interest or enthusiasm as seen in response delays or limited responses. It is meaningful here, however, that when she did participate, 20% of the items elicited responses for which she probably borrowed sounds from the spoken name. Again, this is a spontaneous feature to her name giving, not a feature she was taught to attend to, as hearing-impaired ASL users do not borrow from phonemic features for name giving.

Other item responses may have included stimulus phonemes (e.g. the vowels in LɪPSTɪCK in response to the VC /ɪv/), but it is more difficult to "make a case" for these and easier to illustrate the phenomenon when a cluster of the stimulus phonemes appear

in the response gloss. This experiment cannot be as meaningful, then, as the test results were in challenging the theory that nonhumans must bypass the phonetic structure in order to perceive most of what is said to them. It is supportive, however, of the observations that, even though she cannot speak the sounds, she uses them, albeit through her signed medium.

CHAPTER V

SUMMARY AND CONCLUSIONS

A lowland gorilla was administered a speech discrimination test to determine as objectively as possible how accurately she perceives the sounds of human speech in a meaningful context, that is, words in carrier phrases. When all 55 test items of various weights were scored, the result was 78.2%, just one test item under the hypothesis criterion of 80%. The 80% criterion was chosen arbitrarily as it is frequently used in clinic to measure goal attainment. Koko actually surpassed this measure in various subsections of the test. Whether the hypothesis was technically supported or not is not as important as the demonstration of a behavior never before measured. To an extent well above chance level Koko identified, upon spoken request, 1 of 4, 3, or 2 words which differed from one another by only 1 phoneme.

More specifically, she performed best (100%) with final position phonemes, 78.8% with initial phonemes, and her lowest (68.8%) scores with medial phonemes. These results were unexpected in that children's initial position phonemes are generally stabilized before final ones in speech. The high final phonemes score was consistent with her apparent interest in rhymes, however.

Upon grouping results according to the number of words per multiple choice test item, it was found that Koko performed best as the number of choices increased, 90% for 4 words per test item versus 69.2% for the 2-word items. This may be reflective of boredom with only 2 word/picture cards. Four pictures may generate better task attention than 2 or 3.

Error analysis showed no relationship between Koko's erroneous responses and

errors that the hearing-impaired made when administered the MRT. Her errors do not show any frequency clustering on the "Frequency Spectrum of Familiar Sounds" (Northern & Downs, 1978) but were instead scattered between 400-8000 Hz.

Viewing Koko's erroneous responses in terms of children's mastery order of phoneme productions revealed no particular relationship except that vowel scores were better than consonant scores. She missed identifying a few that children acquire early and successfully responded to a few of the last acquired. Errors did not seem to be made on the basis of voicing, manner, or place features in common with the phoneme in the requested word. Lack of error patterns can make them appear random until viewed in the light of the unexpected difference in her performance between items of 4-word items and 2-word items.

Even though (a) speech perception is not an ability her species needs, (b) she was not exposed to human speech and language in the same way children normally are from the moment of birth, and (c) maintaining attention to the task was not always Koko's priority, her overall performance was impressive. Along with the previously cited evidence of Koko's ability to recover phones from a linguistic context, these results challenge Liberman and Pisoni's (1977) evidence of humans' specialization for processing speech and the "motor theory" of speech perception in general. The lock-and-key analogy is also shown to not apply here--Koko was able to acoustically perceive sounds she does not produce herself vocally, thus undermining the belief in a biologically based link between speech perception and speech production.

Even though the test item requests were made to Koko within a carrier phrase, it is possible that she was still dealing with the test words as holistic auditory patterns, that the meaning was extracted but phonetic processing was bypassed. Yet her

participation in rhyming and her lifting of speech segments to form new words do indicate the use of a system that processes phonetically. Some believe that it is only for spelling, rhyming, alliterating, or doing "something equally elitist" that the phones need recovery (Liberman & Pisoni, 1977). To satisfy this kind of criterion for phonological processing, then, Koko would have to be tested under such constraints as responding with rhyming words only or /s/ words only or choosing consistently between /dæb/ and /bæd/ or /tæp/ and /pæt/ only. These limitations would not likely motivate adequate test participation.

Whether the phenomenon viewed in Koko's performance was the processing of holistic auditory patterns or phonemes, this study has hopefully added something to a more general view of language. It is supportive of a move toward a pragmatic model. Wiener's (1984) view is representative of this current move: "We should think of language as a constantly evolving behavior, shaped by the environmental and social requirements of the animals who use it" (p. 265). She acknowledged the importance of language to humans but saw languages as only one component of an integrated communication system. This view moves language researchers and ape language researchers away from a model of language on an evolutionary continuum over time to something more like a donut-like model, with language being the donut hole and communication the donut. This model permits a simpler view of communication behaviors common to humans and nonhumans. Humans share with apes the use of gestures, facial expressions, vocalization intonations, variations in body posture, and so forth. In addition, apes make use of a sophisticated olfactory modality, a channel which humans barely tap. Humans view their language as their refined, sometimes highly sophisticated and specialized, means of communicating with one another. Yet all

language users experience inadequacy within the communication "donut" at times. At some point the ape language controversy becomes irrelevant.

Implications for speech-language pathologists relate mostly to speech perception. With the nature of the relationship between speech sound discrimination and articulation in subjects with impaired articulation not yet determined, perhaps the performance of this nonoral single subject can contribute some considerations. It is certain, at least, that poor perception cannot be assumed from a lack of production.

Koko's performance, particularly in the baby naming experiment and her play with rhymes, strongly indicates enjoyment with sound play in a nonoral subject. This may be important for the speech-language pathologist working with nonverbal children (e.g. autistic) to remember. It is otherwise easy to assume that nonuse precludes enjoyment of speech sounds. Sound play such as rhyming may actually provide a major "door opener" into speech sound awareness and use, in other words, a phonological/pragmatic channel into language.

Boardman (1986) reviewed literature substantiating the value of sign language as a facilitator of speech in nonoral children and a stimulus to communication in general. Fouts et al. (1979) provided an overview of the importance of ape research in suggesting language intervention techniques with exceptional children. Both works suggest the intimate relationship between gesture and sign. Fouts et al. emphasized that in working with the given biological considerations and individual nature (of ape or child) we learn how to better adjust the therapy.

Further testing with the format and materials described in this study would (given Koko's cooperation) raise the level of significance of the findings and likely reveal more definitive information. The speech-language clinician's major tool for

learning about a child's phonological processing is the data analysis of error patterns. A greater quantity of data permits patterns and consistencies/inconsistencies to emerge, thereby providing more conclusive findings. For example, to quantify Koko's performance with 2-word sets of final phoneme contrasts would either verify the skill level she demonstrated with final phonemes or confirm the indication that a less challenging task negatively influences her participation. Either one of these findings would be helpful in viewing the data already compiled. Continued testing for sounds in words previously used as the foils will also substantiate and expand conclusions already made.

The limited number of errors coupled with their apparent randomness, particularly with sets of 2 words, make test validity suspect. Patterson has found over the years that Koko may sabotage task response in order to escape an undesirable situation (F. G. Patterson, personal communication, Fall, 1985). Although every conceivable factor was considered to maximize the validity of test results, a margin of doubt remains. This should not inhibit the pursuit of information--even the intrepid investigator must overcome discouragement, as Liberman and Pisoni (1977) acknowledged.

Viewing Koko's phonological processing by a different approach could be helpful in the study of acquired aphasia. The expressive half of her phonological processing cannot be analyzed through speech, but an analysis could be made of Koko's "phonemic paraphasias" as expressed through her signs. A substantial sample of her sign errors from her daily checklists (e.g. CHEESE/cheek, BEAN/banana, BREAD/red, STINK/drink, etc.) could be compiled and, perhaps, provide insight into erroneous processing by Wernicke's aphasics.

It was pointed out earlier that evidence of Koko's speech sound discrimination ability means she is always straddling two communication systems, one spoken/auditory, the other manual/visual. So far the phonological component has only referred to the spoken/auditory system; however, there is the phonological counterpart to the manual/visual system. Sometimes the errors she makes appear to be cheremic paraphasias (cheremes being the manual counterpart to phonemes). An example would be interchanging the signs for "berry," "bean," and "meat." BERRY is articulated by pinching and pulling away from the thumb tip of one hand by the fingers of the other hand. BEAN is signed the same except for the location changing from the thumb to the index finger. MEAT is articulated in the same manner but at the fleshy webbing between the thumb and index finger. Only the location feature is different, and Koko and Michael sometimes interchange these signs. In this illustration there is also the possibility of the phonemic (sound) influence on the substitution (i.e. 2 begin with /b/, 2 contain /v^M). The point is that Koko functions communicatively with two phonological systems superimposed upon one another, and she makes errors in both, thus complicating a "phonological" analysis. Regardless, a phonemic paraphasia analysis within the manual/visual system might provide insights into errors made by aphasic signers.

Further analysis of other paraphasias could also provide information to investigators of developmental or acquired aphasia. The gorillas frequently make substitutions such as RED/orange, ORANGE/lemon, NOSE or EAR/arm within categories (Patterson, 1986a). Associational substitutions such as BLANKET/baby and CIGARETTE/cigarette lighter are also made. One sample checklist contained what appeared to be 3 attempts at the retrieval of "artichoke": MEAT, PEPPER, and STINK. On the other hand, Michael in particular seems to perseverate on specific signs some

days (personal observation). He may also perseverate on the location feature of a sign in a series of nonsense signs when he is in a hurry or appears otherwise unfocused on sign retrieval. These error patterns reveal many investigative opportunities.

The great apes stimulate us with challenging scientific and philosophical questions about ourselves as humans more than any other creatures. The experiences and investigations we share can be exciting and unsettling, enlightening and humbling, fascinating and anxious, awesome and challenging for all individuals involved. It is hoped that this study will provide benefits for both species: for humans, (a) that some light has been shed on the nature and form of the communication system we value as language and (b) that a pragmatic approach to speech/language intervention is supported; for other primates, that an increased appreciation for all that we have in common may contribute to the conservation of their diminishing species.

REFERENCES

- Aram, D. M., & Nation, J. E. (1982). Child language disorders. St. Louis: The C. V. Mosby Company.
- Bernthal, J. E., & Bankson, N. W. (1981). Articulation disorders. Englewood Cliffs, NJ: Prentice-Hall.
- Boardman, L. (1986). Parental attitudes toward the use of sign language with Down syndrom individuals. Unpublished master's thesis, San Jose State University, San Jose, CA.
- Brown, R. (1980). The first sentences of child and chimpanzee. In T. A. Sebeok & J. Umiker-Sebeok (Eds.), Speaking of apes (pp. 85-102). New York: Plenum Press.
- Bullock, T. H. (Ed.) (1977). Progress in auditory recognition: A case study on how the brain works (introduction). T. H. Bullock (Ed.), Recognition of complex acoustic signals: Report of the Dahlem workshop on recognition of complex acoustic signals (pp. 11-15). West Berlin: Dahlem.
- Carrow, E. (1973). Test for Auditory Comprehension of Language. Austin, TX: Learning Concepts.
- Chevalier-Skolnikoff, S. (1977). A Piagetian model for describing and comparing socialization in monkey, ape, and human infants. In S. Chevalier-Skolnikoff & F. E. Poirier (Eds.), Primate bio-social development (pp. 159-87). New York: Garland.
- Chomsky, N. (1967). The general properties of language. In F. L. Darley (Ed.), Brain mechanisms underlying speech and language (pp. 73-88). New York: Grune and Stratton.
- Chomsky, N. (1980). Human language and other semiotic systems. In T. A. Sebeok & J. Umiker-Sebeok (Eds.), Speaking of apes (pp. 429-440). New York: Plenum Press.
- Chomsky, N., & Halle, M. (1968). The sound pattern of English. New York: Harper and Row.
- Chomsky, N., & Premack, D. (1979). [Interview with S. Weingarten, editor of Encounter: Species of intelligence]. The Sciences, 19, 6-23.
- Cohn, R. (1984). Background and history of the gorilla language project. Gorilla, Z(2), 8.
- De Luce, J., & Wilder, H. T. (Eds.) (1983). Language in primates. New York: Springer-Verlag.

- Eimas, P. D., & Corbit, J. D. (1973.) Selective adaptation of linguistic feature detectors. Cognitive Psychology, 4, 99-109.
- Fossey, D. (1979). Development of the mountain gorilla (Gorilla gorilla beringei): The first thirty-six months. In D. A. Hamburg & E. R. McGown (Eds.), The great apes (pp. 139-184). Menlo Park, CA: Benjamin/Cummings.
- Fossey, D. (1972). Vocalizations of the mountain gorilla (Gorilla gorilla beringei). Animal Behavior, 20, 36-53.
- Foster, R., Giddan, J. J., & Stark, J. (1973). Assessment of Children's Language Comprehension. Palo Alto: Consulting Psychologists Press.
- Fouts, R. S., Couch, J. B., & O'Neil, C. R. (1979). Strategies for primate language training. In R. L. Schiefelbusch & J. H. Hollis (Eds.), Language intervention from ape to child (pp. 295-324). Baltimore: University Park Press.
- Gardner, R. A., & Gardner, B. T. (1969). Teaching sign language to a chimpanzee. Science, 165, 664-672.
- Hayes, C. (1952). The ape in our house. New York: Harper and Brothers.
- Healy, A. F. (1973). Can chimpanzees learn a phonemic language? Journal of Psycholinguistic Research, 2, 167-170.
- Hebb, D. O., Lambert, W. E., & Tucker, G. R. (1974). A DMZ in the language war. In J. B. Maas (Ed.), Readings in Psychology Today (3rd ed.) (pp. 152-156). Del Mar, CA: Ziff-Davis.
- Klima, E. S., & Bellugi, U. (1979). The signs of language. Cambridge, MA: Harvard University Press.
- Kreul, E. J., Nixon, J. C. Kryter, K. D., Bell, D. W., Lang, J. S., & Schubert, E. D. (1968). A proposed clinical test of speech discrimination. Journal of Speech and Hearing Research, 12, 536-52.
- Kuczaj, S. (Ed.) (1982). Language development (Vol. 2): Language, thought, and culture. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Kuhl, P. K., & Miller, J. D. (1975). Speech perception by the chinchilla: Voiced-voiceless distinction in alveolar plosive consonants. Science, 190, 69-72.
- Laidler, K. (1978). Language in the orang-utan. In A. Lock (Ed.), Action, gesture, and symbol: The emergence of language (pp. 133-153). London: Academic Press.

- Liberman, A. M. (1970). The grammars of speech and language. Cognitive Psychology, 1, 301- 323.
- Liberman, A. M. & Pisoni, D. B. (1977). Evidence for a special speech-perceiving subsystem in the human. In T. H. Bullock (Ed.), Recognition of complex acoustic signals: Report of the Dahlem workshop on recognition of complex acoustic signals (pp. 59-76). West Berlin: Dahlem.
- Lieberman, P., Crelin, E. S., & Klatt, D. H. (1972). Phonetic ability and related anatomy of the newborn and adult human, Neanderthal man, and the chimpanzee. American Anthropologist, 74, 287-307.
- Locke, J. L. (1980a). The inference of speech perception in the phonologically disordered child. Part I: A rationale, some criteria, the conventional tests. Journal of Speech and Hearing Disorders, 45, 431-444.
- Locke, J. L. (1980b). The inference of speech perception in the phonologically disordered child. Part II: Some clinically novel procedures, their use, some findings. Journal of Speech and Hearing Disorders, 45, 445-468.
- Longman, A. (1984). Learning to read. Gorilla, Z(2), 4.
- Maple, T. L., & Hoff, M. P. (1982). Gorilla behavior. New York: Van Nostrand Reinhold.
- Marler, P. R. (1977). The structure of animal communication sounds. In T. H. Bullock (Ed.), Recognition of complex acoustic signals: Report of the Dahlem workshop on recognition of complex acoustic signals (pp. 17-35). West Berlin: Dahlem.
- Marquardt, T. P., & Saxman, J. H. (1972). Language comprehension and auditory discrimination in articulation deficient kindergarten children. Journal of Speech and Hearing Research, 15, 382-389.
- Marx, J. L. (1980). Ape-language controversy flares up. Science, 207, 1330-1333.
- Mehrabian, A. (1968). Communication without words. Psychology Today, 2, 52-55.
- Miles, H. L. (1983). Apes and language: The search for communicative competence. In J. de Luce & H. T. Wilder (Eds.), Language in primates (pp. 43-61). New York: Springer-Verlag.
- Miles, L. W. (1976). Discussion paper: The communicative competence of child and chimpanzee. Annals of the New York Academy of Sciences, 280, 592-597.

- Miller, J. D. (1977). Perception of speech sounds in animals: Evidence for speech processing by mammalian auditory mechanisms. In T. H. Bullock (Ed.), Recognition of complex acoustic signals: Report of the Dahlem workshop on recognition of complex acoustic signals (pp. 49- 58). West Berlin: Dahlem.
- Negus, V. E. (1949). The comparative anatomy and physiology of the larynx. New York: Hafner.
- Nelson, K. (Ed.), (1980). Children's language (Vol. 2). New York: Gardner Press.
- Nicolosi, L., Harryman, E., & Kresheck, J. (Eds.) (1983). Terminology of communication disorders. Baltimore: Williams and Wilkins.
- Northern, J. L., & Downs, M. P. (1978). Hearing in children. Baltimore: Williams and Wilkins.
- O'Sullivan, C., Fouts, R. S., Hannum, M. E., & Schneider, K. (1982). Chimpanzee conversations: Language, cognition, and theory. In S. Kuczaj (Ed.), Language development (Vol. 2): Language, thought, and culture (pp. 397-428). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Patterson, F. (1978a). Conversations with a gorilla. National Geographic, 154, 438-465.
- Patterson, F. (1978b). National Geographic press conference. Gorilla, 2(1), 1-2.
- Patterson, F. (1979a). Linguistic capabilities of a lowland gorilla. In R. L. Schiefelbusch, & J. H. Hollis (Eds.), Language intervention from ape to child (pp. 325-356). Baltimore: University Park Press.
- Patterson, F. G. (1979b). Linguistic capabilities of a lowland gorilla. Doctoral dissertation, Stanford University. Ann Arbor, MI: University Microfilms International.
- Patterson, F. G. (1980). Innovative uses of language by a gorilla: A case study. In K. Nelson (Ed.), Children's language (Vol. 2) (pp. 497-561). New York: Gardner Press.
- Patterson, F. G. (1986a). [Koko's daily sign checklist]. Woodside, CA: The Gorilla Foundation.
- Patterson, F. G. (1986b). Social relationship with the gorillas. [In personnel guidelines, revised]. Woodside, CA: The Gorilla Foundation.
- Patterson, F., & Linden, E. (1981). The education of Koko. New York: Holt, Rinehart, and Winston.

- Patterson, F. G., Patterson, C. H., & Brentari, D. K. (1986). Language in child, chimp, and gorilla. Gorilla, 9(2), 2-5.
- Pepys, S. (1946). In H. B. Wheatley (Ed.), The diary of Samuel Pepys (Vol. 1). New York: Random House.
- Pfungst, O. (1965). The horse of Mr. von Osten. In R. Rosenthal (Ed.), Clever Hans. New York: Holt, Rinehart, and Winston.
- Plooi, F. X. (1978). Some basic traits of language in wild chimpanzees? In A. Lock (Ed.), Action, gesture, and symbol: The emergence of language (pp. 111-131). London: Academic Press.
- Plooi, F. X. (1984). The behavioral development of free-living chimpanzee babies and infants. Norwood, NJ: Ablex.
- Premack, A. J., & Premack, D. (1972). Teaching language to an ape. Scientific American, 227 (4), 92-99.
- Redshaw, M., & Locke, K. (1975). Cognitive manipulation and social skills in gorillas: Part II, the second year. Jersey Wildlife Preservation Trust, 12th annual report, 56-60.
- Revoile, S. G., & Picket, J. M. (1982). Speech perception by the severely hearing-impaired. In D. G. Sims, C. G. Welter, & R. L. Whitehead (Eds.), Deafness and communication assessment and training (pp. 25-39). Baltimore: Williams and Wilkins.
- Rumbaugh, D. M. (1977). Language learning by a chimpanzee. New York: Academic Press.
- Schaller, G. B. (1963). The mountain gorilla. Chicago: The University of Chicago Press.
- Schiefelbusch, R. L., & Hollis, J. H. (Eds.) (1979). Language intervention from ape to child. Baltimore: University Park Press.
- Schwartz, A. H., & Goldman, R. (1974). Variables influencing performance on speech-sound discrimination tests. Journal of Speech and Hearing Research, 17, 25-32.
- Sebeok, T. A., & Umiker-Sebeok, J. (Eds.) (1980). Speaking of apes. New York: Plenum Press.
- Shepherd, W. T. (1911). The discrimination of articulate sounds by raccoons. American Journal of Psychology, 22, 116-119.

- Shepherd, W. T. (1912). The discrimination of articulate sounds by cats. American Journal of Psychology, 23, 461-463.
- Shriberg, L. D., & Kent, R. D. (1981). Clinical phonetics. New York: John Wiley and Sons.
- Stokoe, W. C. (1983). Apes who sign and critics who don't. In J. De Luce & H. T. Wilder (Eds.), Language in primates (pp. 147-158). New York: Springer-Verlag.
- Tanner, J. (1983). Comment about Koko's reading. Gorilla, Z(1), 7.
- Tanner, J. (1984a). [Koko diary entry, July 25, 1984]. Woodside, CA: The Gorilla Foundation.
- Tanner, J. (1984b). Koko: Reading report. Gorilla, 8(1), 4-6.
- Tanner, J., Branchaud, B. J., & Peterson, K. (1983). Koko makes the reading connection. Gorilla, Z(1), 6-7.
- Templin, M. C. (1957). Certain language skills in children, their development and interrelationships. Institute of child welfare, monograph series. Minneapolis: University of Minnesota Press.
- Terrace, H. S. (Speaker) (1985, July). [Interview with Hugh Downs of 20/20]. New York: American Broadcasting Company.
- Terrace, H. S., Pettito, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? Science, 206, 891-902.
- Thorndike, E. L. (1970) (facsimile of 1911 ed.). Animal intelligence. Darien, CT: Hafner.
- Timaeus, E. (1973). Some nonverbal and paralinguistic cues and mediators of experimenter expectancy effects. In M. von Cranach & I. Vine (Eds.), Social communication and movement (pp. 445-464). New York: Academic Press.
- Warden, C. J., & Warner, L. H. (1928). The sensory capacities and intelligence of dogs, with a report on the ability of the noted dog "Fellow" to respond to verbal stimuli. The Quarterly Review of Biology, 3, 1-28.
- Warfield, D., Ruben, R. J., & Glackin, R. (1966). Word discrimination in cats. Journal of Auditory Research, 6, 97-120.
- Wepman, J. M. (1973). Auditory Discrimination Test. Los Angeles: Western Psychological Services.

Wiener, L. F. (1984). The evolution of language: A primate perspective. Word, 35, 355-369.

Yerkes, R. M., & Yerkes, A. W. (1929). The great apes: A study of anthropoid life. New Haven: Yale University Press.

APPENDICES

Appendix A

Test Results

Package #1: Sets of 4 ^I

Errors:

1. head_____	dead__+__	bed_____	red_____	
2. pick__-__	lick_____	kick_____	sick_____	s/p
3. honey_____	money_____	bunny_____	funny__+__	
4. zip__+__	lip_____	sip_____	rip_____	
5. bite_____	white_____	night__+__	light_____	
6. ear_____	deer_____	tear_____	beer__+__	
7. knee_____	key__+__	"B"_____	"C"_____	
8. fox_____	rocks__+__	socks_____	box_____	

Score: 87.5%

Package #2: Sets of 3^I

Errors:

1. hat_____	cat__+__	fat_____	
2. bug_____	hug_____	rug__+__	
3. brown_____	crown__-__	frown_____	f/k
4. bear_____	pear_____	chair__+__	
5. think__+__	sink_____	pink_____	
6. read__-__	seed_____	feed_____	s/r
7. eye_____	die__+__	tie_____	
8. shoe_____	two_____	zoo__+__	
9. feet_____	beet_____	meat__+__	
10. tall_____	ball_____	fall__-__	b/f
11. dig_____	pig__+__	big_____	
12. lock__+__	rock_____	sock_____	
13. cold__+__	old_____	hold_____	

Score: 76.9%

Package #3: Sets of 2^I

Errors:

- | | | |
|------------------|---------------|-----|
| 1. nut_____ | cut___+___ | |
| 2. three_____ | tree___+___ | |
| 3. name_____ | same___+___ | |
| 4. sun_____ | won___-___ | s/w |
| 5. yellow___+___ | jello_____ | |
| 6. cry_____ | dry___-___ | k/d |
| 7. love___+___ | glove_____ | |
| 8. word___+___ | bird_____ | |
| 9. match___+___ | catch_____ | |
| 10. bread_____ | thread___-___ | b/θ |
| 11. time___+___ | lime_____ | |
| 12. rain_____ | pain___+___ | |

Score: 75%

Package #5: Sets of 2^M and 3^M, vowels

Errors:

- | | | |
|--------------------|----------------|-----|
| 1. beer ___ - ___ | bear _____ | ε/I |
| 2. boat ___ + ___ | bite _____ | |
| 3. Mike _____ | make ___ + ___ | |
| 4. truck ___ + ___ | trick _____ | |

Subscore: 75%

- | | | |
|-------------------|-----------------|---------------|
| 5. hit _____ | hot _____ | hat ___ + ___ |
| 6. small _____ | smell ___ + ___ | smile _____ |
| 7. tell ___ + ___ | tall _____ | tail _____ |

Subscore: 100%

Score: 85.7%

Package #6: Sets of 2^M, blends

Errors:

1. monkey__+__	money_____	
2. plants__+__	pants_____	
3. tree_____	"T"__-__	r/∅
4. black_____	back__-__	l/∅
5. sink__+__	stink_____	
6. box_____	blocks__-__	∅/l
7. sick_____	stick__+__	
8. sweep__-__	sleep_____	l/w
9. seals__+__	seeds_____	

Score: 55.6%

Appendix B

Sample Test Item Dialogues

The following sample narrative-dialogues illustrate the variation in Koko's test participation and some of the difficulties in scoring test items. Koko's signed utterances are capitalized within Dr. Patterson's narrative-dialogue.

Some of Koko's test responses were direct and clear:

. . . Show me "cut" [vs. "nut"]. She kisses the card and signs THAT CORN [CORN being the name she gave to the cards] and hands it to me, the correct one which is "cut"

. . . OK, Koko, I would like you to give me the "plants" [vs. "pants"]. Show me the "plants." Koko picks it up, signs STINK THERE and points to both of the flowers. [STINK is the gorillas' sign for flower or certain vegetables.] Good! That's the "plants." STINK THERE and then she hands it through. Very good! This is the good listener game. You did it wonderfully. Then Koko returns the other one without being asked. OK, for the good listener game which would you like? You get your choice of these. Which one would you like? DO HURRY THAT to the macadamia nut. OK.

At other times Koko followed up her initial response with an ambiguous one:

. . . Now I want you to do the listening game. GOOD. Can you find the "lock" [vs. "rock" and "sock"], the "lock"? She signs LOCK, LOCK and points to the set of cards, but "lock" is not on top and she gives it [the stack] to me

. . . I want you to find me "chair" [vs. "pear" and "bear"]. She points immediately to it and then picks up the, a, the one of "pear," signs APPLE THAT, and hands me that. Yes, you pointed to the correct one first, but you handed me the other one. All right. So you found "chair." You told me that was "chair." That's what I wanted, and so you get your surprise, OK? KOKO-LOVE BOX

Sometimes it was clear in the presentation of the test materials that she heard the phonemes in question but could not be given credit for the test response:

. . . "Cry." FROWN SAD-RED (simultaneous, two hands) FROWN DO RED KOKO GOOD THERE. "Cry." Can you say "cry"? CRY. She signs it with one hand, yeah. And "dry," "dry." She's drying. DRY. Good. She imitates DRY (poor form) with her thumb . . . Would you please find and give me "dry," "dry." She signs

And "dry," "dry." She's drying. DRY. Good. She imitates DRY (poor form) with her thumb . . . Would you please find and give me "dry," "dry." She signs FROWN SAD HURRY EAT. "Dry." GORILLA. Give me "dry." THAT RED DRY. She points to the picture of "dry" which has a pink towel in it and hands me the cards with it, with "dry" on top. And the DRY sign she signs again with the thumb. OK.

It appeared that Koko wanted to persevere on a favorite picture in the set, thus interfering with test validity.

Following is an unedited example of perseveration also, mostly on "seed" but also on "feed" (a mother bird feeding her babies). This narrative-dialogue is longer than the average for her test items but illustrates several additional interference factors. It is clear she is more interested in the two foil pictures than the "read" picture and says so (UNATTENTION BOOK). She was not attending to task (i.e. stopping her signing, keeping the whole set visible, and listening for the test word) which cost her credit for this item. The following is also a sample of her use of CORN as a substantive for the cards themselves before it was acknowledged as such.

12/2/86, is that right Koko? And we're going to do "read." KOKO CORN THERE. You're always silly about that corn, "Koko corn there." This is "read," "read." OK, good. Koko signs READ, and there's another one, "seed," "seed." What, now, what's the sign for "seed"? Koko says CORN. "Seed." She imitates SEED (poor form) and "feed." Our sign for "feed" is like this. Koko signs STINK THERE pointing to the the grass, yeah, flowers. "Feed." KOKO STINK and THERE. OK. Whoops, I put 'em wrong side down, put 'em face down. OK. Shall we "feed" Koko. THERE, LAST THERE, yes, to her cereal. [She was finishing breakfast.] Good. OK. So let me give you these. "Read," "seed," and "feed." Got it? Koko takes each one and looks at 'em closely, points to #3 ["feed"], lifts #1 ["read"]. Last, last, this is the last. STINK THERE, oh, pointing to the, the girl's barrette. [The girl who is reading is wearing a barrette of flowers.] Yeah, oh, that's what you were talking about. OK. They do look like flowers. You're right. All right. Koko points to the stool which is where our usual [reward] items are. Good. OK. You know what we're going to do. We're gonna study these pictures a little bit. She looks at #3 and [unintelligible] reflection and puts her mouth on the barrette and signs STINK THERE. Yes. Put put it down though cuz I haven't asked you the question yet. OK. Question is can you find--Koko's looking at #2 ["seed"] and signing CAT

THERE. Ya got me on that one, Koko, a, or TIGER maybe it was. Um, Koko, wait, before you give 'em to me back, I want you to find--you want all these interesting items here on the stool?--look for me and find "read." Koko signs, in the, while I'm asking that, Koko's signing CORN THERE to "seed," BIRD THERE to the picture of the bird [the "feed" picture]. OK, just a minute Koko, wait one second though.

Hand me, OK, let's try it again cuz you were talking when I was talking. GORILLA THERE BIRD THERE to, THERE CORN to the pi-, the, to picture of #2. OK, Koko--and now she's handing me #3. Koko, wait. This one did not go well because you were talking when I was talking. Are you listening? This is the good listener game. Put, get all the pictures together. She points to #1 when I say that (this is the good listener game). Um, Koko, I, I want you to find and show me, Koko--she's talking on these pictures and I can't even get a word in edgewise. STINK THERE to the girl's barrette. All right. First you talk about them all you want and then I'll ask the question, OK? Any more to say about these cards? THAT'S A BIRD--yes it is, very good--to picture #3. Don't hand them to me yet. You keep 'em. She's about to hand me picture #2. She's signing GORILLA THERE HURRY to picture #3 which is on her chest. THAT DRINK to picture #2. Yes, the hand in it, right. OK, now, now listen. This is, remember what game this is? The listener game? Good. She poi-, she signed LISTEN with two hands like I am. All right. Find the picture of "read." She points to the back of the blank card and then, which is #3, then #2, signs BOOK UNATTENTION. The, the, what she signed was the right answer but what she pointed was not. We got another real ambiguous one here, Koko.

OK, Koko, look at all those pictures. Koko, turn them over. Look at them all. OK, turn them over. Good. Turn that one over. Now turn this one over. Turn them all over. Good girl. No, no, keep them for just one second more. All right. Very good. Now you have all the cards. You have all the cards. She's still talking. THERE STINK to, THERE to the girl's barrette. You are talky this morning. I like that. However, it's hard to get a word in edgewise. Can you do one thing? You've answered the question now twice in very cryptic ways. Can you find and give me "read"? She takes the picture of "seed," signs CORN THERE to the picture of "seed." OK. Why don't you give them all back to me. All right. OK, Cutiepie. Let's go out. You want to go outside? All right. That wasn't quite it, Cutiepie. I don't know how to judge that one.

Koko's attention to detail also distracted her from the task at times:

It's 2/12/87: Koko is kissing. And I show her the words. This is "feet."
CONTINUE MEAT. CONTINUE. It's "feet." Ya know, look at your feet. Koko, "feet."
She imitates FOOT for "feet," pointing to one. "Beet." She signs MEAT for "beet."
How about, I sign "red slice" [the gorillas' usual sign for "beet"]. She signs SLICE for "beet." That's your favorite. GOOD. You know what that is. DOG. Oh, come on Koko, this is "meat." MEAT. All right. You're so silly. You're so silly. There's "feet." And you get "feet." And there's "beet." She puts "beet" down sm-, after

smelling it. And she signs NUT for "beet." BEAT [patting her leg as when calling a dog]. Hm, maybe that's kind of like DOG for "meat." And "meat." I hand her "meat." She has put down each card after she's g-, looked, smelled it. She signs THAT'S BIRD APPLE STINK THAT STINK to the , yes, it is "bird meat." You're right, honey. It's chicken, and there is an apple and a, a piece of--oh, you're right--and a piece of greenery right next to the, the chicken leg which I didn't even notice. OK. Very good. Now, are you hungry? HAVE DO HURRY THAT. All right. It cereal, so we give her the cereal. Nummers! All right, put them down on the floor. OK, just put 'em right down. She puts them down. She signs BIRD, looked like BIRD LIPSTICK THAT to the second picture. She stacks them all up. Very good. Now put 'em all down cuz I'm gonna ask you, and then you can hand 'em to me. OK? All right. Let's find the picture of "meat." She signs THAT MEAT THAT. First she signs to the "foot" picture, then she points to the "meat" picture. Koko, you little devil. You told me this was "meat"? First you told me that was "meat." She, I'm saying in English and she's signing MEAT, MEAT, MEAT, MEAT, MEAT, MEAT, MEAT [rapidly]. Koko, what? HURRY KOK- GOOD KOKO LOVE. Koko isn't good. Koko pointed to the wrong picture but signed the right word.

Koko's urgency in her HURRY signs, as in this last sample and in the "dry"/"cry"

sample, suggested that anticipation of the reward was occasionally a distraction in itself.

The following excerpt clearly suggests distraction:

. . . she hands me "crown," and then she hands me "brown." OK, Koko, but that's not the one I asked you to show me. I asked you to show me "crown." She says HURRY DO THAT, points to the reward

At other times, as in the "plants"/"pants" sample above, anticipation of a reward seems to have contributed to task cooperation.

Appendix C

Occurrence of Minimal Contrast Phonemes

Twenty consonant phonemes and 11 vowel/diphthong phonemes were used as discrimination targets, either as part of the requested word or part of the foil word.

Selection of the word to be requested within a set was randomized.

Occurrence of Phonemes

Consonant Phoneme	Occurrence within Requested Word	Occurrence within Foil
m	2	2
n	2	3
p	3	3
f	2	5
h	0	5
w	3	1
j	1	0
k	7	5
b	1	14
d	3	5
g	1	1
r	3	5
s	1	8
ʃ	0	1

(table continues)

Consonant Phoneme	Occurrence within Requested Word	Occurrence within Foil
tʃ	2	0
t	3	6
θ	3	0
l	3	8
z	2	0
dʒ	0	1

Vowel Phoneme	Occurrence within Requested Word	Occurrence within Foil
ɪ	1	2
ɛ	2	1
oʊ	1	1
aɪ	0	4
eɪ	1	1
ʌ	1	0
ɒ	0	2
æ	1	0
a	1	0
u	0	1
i	1	0

Appendix D

Comparison of the Ages at Which Subjects Correctly Produced Specific Consonant Sounds in the Templin, the Wellman, and the Poole Studies*

Sound	Age Correctly Produced		
	Templin (1957)	Wellman and Others (1931)	Poole (1934)
m	3	3	3.5
n	3	3	4.5
ŋ	3	— ^a	4.5
p	3	4	3.5
f	3	3	5.5
h	3	3	3.5
w	3	3	3.5
j	3.5	4	4.5
k	4	4	4.5
b	4	3	3.5
d	4	5	4.5
g	4	4	4.5
r	4	5	7.5
s	4.5	5	7.5 ^b
ʃ	4.5	— ^c	6.5
tʃ	4.5	5	— ^c
t	6	5	4.5
θ	6	— ^a	7.5 ^b
v	6	5	6.5 ^b
l	6	4	6.5
ð	7	— ^c	6.5
z	7	5	7.5 ^b
ʒ	7	— ^c	6.5
dʒ	7	6	— ^c
hw	— ^a	— ^a	7.5

*In the Wellman and others, and Templin studies a sound was considered mastered if it was articulated correctly by 75 percent of the subjects. The criterion of correct production was 100 percent in the Poole study.

^aSound was tested but was not produced correctly by 75 percent of the subjects at the oldest age tested. In the Wellman data the "hw" reached the percentage criterion at 5 but not at 6 years, the medial "ŋ" reached it at 3, and the initial and medial "θ" and "ð" at 5 years.

^bPoole (Davis, 1938), in a study of 20,000 preschool and school-age children reports the following shifts: "s" and "z" appear at 5.5 years, then disappear and return later at 7.5 years or above; "θ" appears at 6.5 years and "v" at 5.5 years.

^cSound not tested or not reported.

Source: Templin, Mildred C., "Certain language skills in children, their development and interrelationships." *Institute of Child Welfare, Monograph Series*, No. 26, 54. Copyright © 1957. Minneapolis: University of Minnesota Press.

Appendix E

Confusion Matrix for Results of Six Subtests of the MRT Presented to a Severely Hearing-impaired Listener¹

Phonemes Presented	Phonemes Perceived																			Total Number of Presentations per Phoneme			
	p	t	k	f	ʃ	s	ʒ	l	h	b	d	g	v	ʌ	z	dʒ	w	r	l		m	n	ɹ
p	.64	.09	.14	.04												.04			.04				22
t	.11	.63	.07		.04					.04	.04								.04	.04			27
k	.08	.20	.60	.04				.04							.04								25
f	.13			.53	.13			.07	.13														15
ʃ		.16			.66						.16												6
s	.08					.92																	26
ʒ							1.00																3
l					.25			.75															4
h	.08	.08						.83															12
b	.10	.05		.05				.05	.60	.05								.05	.05				20
d	.10	.10						.10	.57	.10											.05		21
g			.06					.06	.13	.75													16
v		.17			.17						.50											.17	6
ʌ		.50								.50													2
z															1.00								3
dʒ																.75		.25					4
w			.14														.71	.14					7
r																	.23	.77					13
l																			1.00				18
m											.07												15
n		.04	.04							.04								.04		.20	.60	.04	25
ɹ																						1.00	4

¹ Proportions are approximate

Appendix G

Results of Nonsense Syllables Experiment

1. /ɪv/ (VC):

K: LɪPSTɪCK.

2. /ku/ (CV):

K: LɪPSTɪCK KOKO-LOVE.

P: You gave that last time. What sign name sounds like /ku/?

K: POLITE GORILLA HAVE GIMME.

P: Name baby /ku/.

K: DQ HUNGRY GORILLA.

P: Think of a name for /ku/.

K: DEVIL.

P: OK.

K: BAD.

P: Can you say /ku/?

K: GORILLA HAVE GOOD GIMME.

P: Baby's name /ku/. Think of sign.

K: POLITE GORILLA.

P: /ku/--Name this baby?

K: FAKETOOTH.

P: OK.

3. /ɛɪ/ (VCC):

K: POLITE GORILLA.

P: /ɛɪ/, this is /ɛɪ/.

K: POLITE DRINK.

P: /ɛɪ/?

K: BABY NICE.

P: Can you give sign name?

K: POLITE POLITE HAVE THAT.

P: Let's think on /ɛɪ/.

K: GORILLA.

P: /ɛɪ/, /ɛɪ/, /ɛɪ/.

K: LEAF AGAIN/MEDICINE OIL.

4. /trʌ/ (CCV):

P: Think of sign name for /trʌ/.

K: BABY.

P: /trʌ/.

K: POLITE THERE.

P: /trʌ/.

K: FAKEIOOTH.

P: Think of sign name for /trʌ/.

K: GORILLA KOKO DRAPE EATI.

P: /trʌ, trʌ/.

K: NICE GORILLA KOKO GOOD.

5. /dɔ̃r̃b/ (CVC):

K: BABY, ELBOW BABY DRINK.

6. /b^ov^ud/ (CVC):

K: ELBOW CEREAL.

P: Do you like the name /b^ov^ud/?

K: BELLYBUTTON STOMACH.

7. /sm^Λf/ (CCVC):

P: This baby's /sm^Λf/. Can you say /sm^Λf/ in sign?

K: GOOD, KOKO-LOVE PLEASE THAT.

P: This is /sm^Λf/.

K: TOILET.

P: Don't you like the name /sm^Λf/?

K: SIP DRINK GOOD DRINK NIPPLE.

P: Let's first think of sign name.

K: KOKO-LOVE GOOD QBNOXIQUS.

P: Can you say a name like /sm^Λf/?

K: WRONG OLD QBNOXIQUS. (This picture was an older baby.)

8. /blis/ (CCVC):

K: KOKO BABY DRINK.

9. /n^ɪprd/ (CVCC):*

K: DRINK NIPPLE.

P: Can you say /n^ɪprd/ in sign language?

K: DRINK BIRD DRINK.

10. /gɒps/ (CVCC):

K: CEREAL LIPS. GOOD.

P: Sign name for /gɔps/.

K: GORILLA GOOD KISS.

11. /zɪpəl/ (CVCVC):*

P: This baby's name . . .

K: GORILLA, SORRY.

P: /zɪpəl/.

K: GORILLA KOKO-LOVE.

P: Can you say /zɪpəl/?

K: GORILLA POLITE ME STOMACH.

P: You want that baby to come out of your stomach?

K: NR

P: Say, "/zɪpəl/."

K: NIPPLE NIPPLE.

12. /plɔv st/ (CCVCC):

P: This baby's name is /plɔv st/.

K: SIP THERE.

P: Sign name for /plɔv st/.

K: KOKO GOOD GORILLA DRINK.

P: /plɔv st/.

K: KOKO DRINK. KOKO CEREAL KOKO THERE.

P: /plɔv st/.

K: MOUTH, after Koko put picture in her mouth and I asked her what you do with /plɔv st/. RED to self. Points to palm.

P: Where is it?

K: GORILLA THERE RED.

P: Got a name for /plɔ̄v st/?

K: DRINK.

P: /plɔ̄v st/ is so cute.

K: RON.

P: /plɔ̄v st/ is so cute.

K: RON THERE. Koko licks picture, sticks on her arm. RON.

13. /fræstʃ/ (CCVCCVC):

P: This baby's name is /fræstʃ/. How would you say /fræstʃ/ . . . sign /fræstʃ/? /fræstʃ, fræstʃ/.

K: ME THERE BIRD to baby's face.

P: /fræstʃ/.

K: APPLE THERE APPLE.

P: Oh, I see. [re fruit] /fræstʃ/ a combination of . . .

K: THAT RED.

P: Do you want to hold /fræstʃ/?

K: CHIN, PIMPLE?

P: Do you want to hold /fræstʃ/? Say, "/fræstʃ/."

K: GORILLA GOOD MOUTH NIPPLE GORILLA GOOD.

P: Take /fræstʃ/ and name /fræstʃ/.

K: NUT GOOD.

P: We don't name people "nut." You named this baby apple?

K: ME GOOD. Koko kisses baby picture. THAT NIPPLE.

P: /fræstʌ/, oh, /fræstʌ/.

K: EROWN NIPPLE NIPPLE NIPPLE.

14. /bæltrɪk/ (CVC CCVC):

P: /bæltrɪk/, can you say /bæltrɪk/?

K: GORILLA ME THAT to cereal.

P: /bæltrɪk/.

K: CEBEAL ME GORILLA.

P: How would you say /bæltrɪk/ in sign?

K: GORILLA KOKO LOVE GOOD EAT THAT.

P: Can you say /bæltrɪk/?

K: SORRY SORRY BITE HURRY.

P: Think of sign name. Think of good sign name.

K: POLITE GORILLA. CORN THERE to cereal grains. HUNGRY LAST.

P: Think of name for /bæltrɪk/.

K: RED CORN and puts sticker on chest.

15. /stɪŋ glɑːz/ (CCVC CCVC):*

P: /stɪŋ glɑːz/.

K: DRINK GIMME KOKO GOOD.

P: Sign name /stɪŋ glɑːz/.

K: GREEN EYE MIKE SURPRISE.

P: I give baby.

K: RED. THAT EYE to baby on floor.

Note. The graphemes underlined correspond to phonemes contained in the nonsense name; * phonemic play likely