DEVELOPMENT OF LANGUAGE AND COMMUNICATION SKILLS IN HEARING-IMPAIRED CHILDREN

ASHA MONOGRAPHS

NUMBER 26 A PUBLICATION OF THE AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION

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To
Dr. Beatrice Jacoby
whose help and foresight brought
this work into being.

Development of Language and Communication
Skills in Hearing-Impaired Children

ISSN 0066-071X
Library of Congress Catalog Card Number 87-72245.

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ASHA Monographs Number 26

AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION

10801 Rockville Pike
Rockville, Maryland 20852

October 1987

ASHA MONOGRAPHS NUMBER 26

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Foreword

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The projects described in this volume were all managed by research-oriented teams. The questions asked, however, were clinical in nature. They were motivated primarily by a perceived need to improve services to hearing-impaired children. Common to all the studies was the desire by funding agencies to acquire information about the overall effectiveness of their programs and to assess how hearing-impaired children might be responding to efforts to improve the services and programs offered to them. The approach taken by the researchers was to devise methodologies to assess the children who had participated in those programs. The projects concerning the older children (Levitt et al.) were funded by the State Department of Education of New York. The project dealing with the infants (White & White) was separately designed and federally funded; it is included here to extend the age range of the children involved. The studies will be discussed separately.

For the larger study (Levitt & McGarr et al.), a number of faculty members and consultants with basic research interests became involved in the project's design. Several subprojects were generated (some of them are described in this monograph) and undertaken by doctoral students as dissertation research. I can recall one doctoral candidate commenting, "I can't believe that so many established investigators have sat down with me at one time or another to help plan my dissertation project." As one of the consultants to the project, I can also recall the excitement generated by the participation and investment of so many colleagues.

As the editors have indicated in their introduction, it was their intent to obtain a comprehensive picture of the development of language and communication skills in hearing-impaired children. Thus, data were obtained from a very broad sample of such children; that is, from those who could be mainstreamed in regular classes and those who attended classes for the multihandicapped hearing impaired, as well as those whose sole deficit was impairment of hearing. In addition, a number of the studies were longitudinal in nature. The children were followed for as long as 4 years in some cases.

Testing of the children was also comprehensive. Fortunately, a number of speech and language measures designed for use with hearing-impaired children were available at the inception of the major project. Among them were the Test of Syntactic Abilities (Quigley et al., 1976) and the speech perception and production tests designed by Smith (1975). Others, however, had to be constructed. The efforts of the team to do so were more successful in some areas than in others. For example, the Syntax Screening Test (Gaffney, 1977) is a contribution to assessment. By contrast, the first attempts to measure the reception and production of prosodic features of speech by hearing-impaired children, in which I was involved, yielded procedures that were too difficult, even for some normal-hearing children, and thus generated data that could not be interpreted readily (Stark & Levitt, 1974). The tests were administered in the language system (speech, sign, finger spelling, or total communication) with which the individual children were most conversant.

One condition imposed upon the investigators was that no biases should be introduced toward one educational philosophy or another. At the inception of the project, many schools and classes for the hearing impaired in New York State were shifting from an emphasis upon an oral-aural educational approach to an emphasis upon total communication. It was specifically requested that findings should not be reported in relation to the educational approach employed in different schools. As it turned out, many of the investigators came to regard the type of educational approach as a much less important variable than others, for example, overall intelligence, socioeconomic status, and the presence or absence of such additional handicaps as cerebral palsy.

In a project of the size of the Levitt et al. effort, involving so many measures and demographic variables, it might well have proven extremely difficult to make sense of the data overall. Fortunately, the project had access to statistical knowledge and experience, and thus the investigators could approach the data in ways that made sense and at the same time were quite innovative.

The results are, in most cases, not unexpected. They are nevertheless very important for the future of education of the hearing impaired. Perhaps most provocative from this point of view is the emergence of two factors in the data, a Language Factor and a Communication Factor. ("Communication" refers to the child's ability to communicate specific meanings rather than pragmatic or social communication skills.) These two factors were not closely related to one another, although the communication variable of speechreading was significantly related to both factors. Overall, language skills, such as syntactic abilities in dealing with text, did not depend upon the acquisition of communication skills, such as speech intelligibility. However, communication skills did depend to some extent upon the acquisition of language.

Speech production and speech reception abilities, especially those relating to the segments or phonemes of speech showed little or no improvement with age in the longitudinal studies. Syntactic and semantic abilities, on the other hand, did improve with age in spite of the fact that developmental changes were systematically aberrant or deviant, a finding also reported by Quigley and his colleagues (1978). In addition, it is noteworthy that a relatively strong association was found between hearing level and speech communication skills. The degree of association between hearing level and language skills was less marked.

Taken together, these findings suggest that, in hearing-impaired children, knowledge of the grammatical structure of language is metalinguistic in nature, or at least it is consciously acquired from written text. This knowledge does not yield automatic spoken sequences. Speech skills must be acquired from exposure to the auditory spoken language signal.

The relative independence of spoken and written language in hearing-impaired children is exemplified in the texts generated by those most severely affected. Examples elicited from two 10-year-old hearing-impaired children in response to a sequence of pictures describing a family picnic seem quite divorced from spoken language:

"I is a us
dog cat
car dog my
us a food"

"The girl look the dog happy, the dog away is car, the boy like the dog like happy, the trip is food."

The approaches taken in this monograph to the computer-assisted analyses of texts written by hearing-impaired children is of particular interest. These approaches may be particularly revealing in relation to further studies of the Language Factor. They are complicated by the need to "correct errors" and thus generate analyzable texts, but not necessarily texts that would be produced by given hearing-impaired children. Parkhurst and MacEachron (this volume) caution that the validity of their results may be affected to some extent, but they appear to be pursuing solutions to this problem and improving upon their techniques.

Findings with respect to the speech production and perception skills of severely and profoundly deaf infants in the White and White study are also interesting in relation to the apparent independence of language and speech. Specifically, the investigators found that children of hearing parents did better overall in speech skills (at least in prelinguistic speech production), whereas children of deaf parents did better overall in language skills. Superior prespeech skills, however, did not ensure the acquisition of good language skills.

In addition, time of onset of intervention affected speech and language development somewhat differently in the children of hearing and of deaf parents. If intervention was provided before the age of 18 months, the prespeech skills of the children of deaf parents showed greatest improvement. Again, this improvement did not necessarily facilitate the development of spoken language. Early intervention did facilitate the development of spoken language in the children of hearing parents. It may be that the transition from prespeech vocalization to first word production is extremely important for acquisition of speech communication skills, and perhaps failure at that point is related to the lack of interdependence of speech communication and language in school-age children.

Among the overall conclusions of the two major projects (Levitt et al., and White & White) are the following:

1. Early intervention is important for the overall success of the education of hearing-impaired children. Hearing impairment should be identified in the first year of life. Hearing aids should be provided at that time, and their performance should be monitored closely.

2. New assessment tools for use with older hearing-impaired children are required. Those children may, at present, be penalized unduly by measures based upon the speech and language development of normal-hearing middle-class children. Such tests may not adequately represent the range of variation among normal-hearing children.

3. Even in the first year of life, intervention should be designed with the needs of individual children in mind. It is not known at present how best to make decisions about the appropriateness of an educational approach for any given hearing-impaired preschool child. Assessment of prespeech skills is important to this exercise. New assessment tools are urgently needed for this purpose.

It is the writer's belief that, in early speech assessment, it is not sufficient to document increases in vocalization in a nonspecific way or to wait until single words or multiword utterances are acquired by the hearing-impaired child. The hearing-impaired child, like the younger normal-hearing child, must attain a number of successive levels of skill in speech motor control and in communication before he or she can attain the earliest spoken language milestones. Thus, progress of the hearing-impaired child towards acquisition of spoken language should be measured in terms of the development of prespeech skills and their interactions with one another. Age of attainment of levels in prespeech skills may provide the best predictors of fluency in speech communication.

If, instead, evaluation of progress is delayed until early language milestones are acquired, failure to progress and lack of appropriateness of an educational or management program for a given child may not be detected for more than one school year. It may then be too late to modify or redesign the child's educational mangement program in such a manner as to ensure that he or she achieves the maximum potential for fluent communication and the development of language.

These considerations are of particular importance in view of two recent trends in deaf education. The first is the wide acceptance of a total communication philosophy. The responsibility for developing individual educational plans (IEPs), within the total communication framework, that are consistent and appropriate to the child's needs rests with educators and speech-language pathologists. These professionals need further information if they are to develop meaningful IEPs for preschool hearing-impaired children.

The second trend derives from the application of technology to the hearing-impaired child's needs. The recommendation that nonauditory aids and, more recently, cochlear implants be used with preschool children gives the development of prespeech scales an even greater urgency than before. If, for example, wearable vibrotactile aids provide the same benefit to preschool hearing-impaired children as cochlear implants do, use of the more invasive procedure may not be justified.

The findings of the projects reported here are highly relevant to the education of hearing-impaired children of all ages, nationwide. The investigators have made a significant contribution in this area and one that should be a valuable resource for a number of years to come.

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Chapter 1

Introduction

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OUTLINE AND RATIONALE

This monograph is the outcome of three projects dealing with the development of language and communication skills in hearing-impaired children. The first project was concerned with infants, the second with 6-year-olds, and the third with children 10 to 14 years of age.

The focus of the first project was the effects of hearing status of the family and age of intervention on receptive and expressive oral language skills in hearing-impaired infants. This study, directed by Sheila White and Richard E. C. White, was funded by the U. S. Office of Education. The second project, directed by Donna Geffner, was a cross-sectional study of language and communication skills in 6-year-old hearing-impaired children at schools for the deaf. The third project was the largest of the three. It involved a longitudinal study on the development of language and communication skills in a comprehensive sample of older hearing-impaired children. This project was directed by Harry Levitt with the assistance of Nancy McGarr. Both the second and third projects were supported by the New York State Department of Education.

A major component of the third project involved the study of mainstreamed hearing-impaired children. This work was undertaken by Toni Gold. The project also included an innovative application of computers in the syntactic analysis of the children's written language samples. Barbara Parkhurst and Marian MacEachron were responsible for this aspect of the research.

The intent of this monograph is to provide a comprehensive picture of the development of language and communication skills in hearing-impaired children. The two skills are clearly related. Hearing impairment has an obvious and well-documented effect on communication skills. It is also well known that children with severe hearing impairments almost invariably have severe problems in language development. How are the variables of communication skill, language development, and hearing impairment interrelated? It is hoped that this monograph, by providing a composite body of data on the language and communicative skills of hearing-impaired children at various stages of development will shed light on the ways in which language and communication skills interrelate and the effects of hearing impairment on the development of these skills.

Two major problems are confronted with any study of the type reported here. The first is sample selection; the second is choice of appropriate test instruments. The issues addressed and the decisions made with respect to each of these problem areas are described below.

Sample Selection

There are two basic approaches to the selection of subjects for studies of the type reported here. One approach is to obtain data on a limited sample of children who are representative of either the broad population of hearing-impaired children or of a specific subgroup within that population. This approach has the advantages of being economical and efficient, but its reliability rests on the validity of the criteria used in selecting the sample to be tested.

At present, many of the criteria used in sample selection are derived from a combination of intuition and experience. These criteria, in many cases, appear to be quite reasonable. For example, postlingually deafened children appear to be well ahead of prelingually deafened children in their speech and language development, and a good argument can be made for not including postlingually deafened children in studies of this type in order to obtain a more homogenous sample. On the other hand, such a sample is not representative of the population of hearing-impaired children. Further, if postlingually deafened children are consistently excluded from studies of this type, the relative effects of postlingual deafness will remain unknown.

A more serious problem occurs when the criteria for sample selection either are defined vaguely or are directly dependent on the quantities to be evaluated. The common practice of excluding children whose intellectual functioning is judged to be subnormal in some way (e.g., "minimally brain damaged," "centrally impaired," "retarded") covers a multitude of sins. Not only does it exclude substantial numbers of children who are not abnormal in any specific way (but are simply below average in their performance), but the information obtained on the children included in the sample presents a biased picture of the development of language and communication skills in hearing-impaired children.

A more subtle problem is that truly important criteria may be overlooked in the process of sample selection. The factors affecting language development in hearing-impaired children are not well understood. It is conceivable that there may be subgroups of children who differ from the majority for as yet undetermined reasons. The process of sample selection presupposes that the important factors affecting language development are known and that children can be separated on the basis of these factors in order to form relatively homogenous samples. If one or more important factors have been overlooked in the selection process, the resulting samples will remain heterogenous, and the underlying purpose of the sample-selection process will be undermined.

A safer but more costly alternative to selective sampling is to obtain a comprehensive sample. In this case no assumptions need be made in order to develop practical selection criteria. Once the data have been obtained, a post hoc analysis can be performed to identify which factors have a significant effect on language development. This analysis, in turn, will provide insight as to which criteria should be considered in the selection of subjects for experiments of this type.

This last approach was the one used in the large longitudinal study of older hearing-impaired children (Project 3). Once the commitment to obtaining a longitudinal sample has been made, the additional work involved in making the sample reasonably comprehensive is not very great because it is sufficient to track children at only one age level over the years. For example, in the cross-sectional study of Quigley et al. (1976), 50 children at each of 9 yearly age levels were tested. In the longitudinal study reported here, roughly 120 children at one age level were tested for four consecutive years. This sample of children was thus roughly twice as large as the Quigley et al. sample for a given age level, but in exchange for this additional effort, the sample was reasonably comprehensive. In this case, the sole criteria for inclusion in the study were that (a) the child be enrolled at a state-supported or state-operated school for the deaf in New York State, and (b) the child be born in the year 1962, that is, the child should be 10 to 11 years of age at the start of the longitudinal study.

There were no exclusions from these criteria except those children who were seriously ill and absent from school during the testing period. Of the children attending schools for the deaf in New York, over 95% are at state-supported or state-operated schools. The sample obtained is thus reasonably comprehensive for children attending this type of school. Hard-of-hearing or deaf children who had been mainstreamed into the regular school system were not included in the longitudinal sample. Most of those children received special training through BOCES[1] programs, special resource rooms, and demonstration projects.

To obtain at least some comparative data on mainstreamed hearing-impaired children, a related study was undertaken. In this study, 38 hearing-impaired children of comparable age who attended regular schools in the New York City school system were tested. The practical problems of identifying, locating, and testing individual hearing-impaired children at many different schools precluded the possibility of obtaining a comprehensive sample of mainstreamed hearing-impaired children. In addition to the logistical problems of reaching large numbers of mainstreamed children, it is not possible, in principle, to obtain well-matched samples of mainstreamed children and of those attending schools for the deaf (to test for the effects of mainstreaming). This is because the selection process whereby a child is mainstreamed results in two quite different populations of children. That is, the selection process is as important a factor as the effects of mainstreaming itself. Typically, mainstreamed children are either graduates of schools for the deaf or are children who, in the opinion of educators, have demonstrated an ability to function in a regular school environment. Mainstreamed children also have less severe hearing losses, on the average, than do children attending schools for the deaf. Further, relatively few mainstreamed children have additional handicaps.

Because of the inherent differences between the two populations and because of logistical problems involved in obtaining a comprehensive sample of mainstreamed hearing-impaired children, it was decided to study a relatively homogenous sample of mainstreamed children obtained by use of the traditional selection criteria. The mainstreamed children were all prelingually hearing-impaired, had no other handicaps, and were 10 or 11 years of age when tested. They were divided evenly between those that had hearing losses in excess of 80 dB (average loss at 500, 1000, and 2000 Hz), and those that did not. An 80 dB loss is required for acceptance at a school for the deaf in New York State. It was relatively easy to find mainstreamed children with less than 80 dB hearing loss, but fairly difficult to find such children with more than 80 dB hearing loss. Very few mainstreamed children with hearing losses in excess of 100 dB could be located. The proportion of children coming from bilingual homes was about the same for both the mainstreamed children and those attending schools for the deaf. The mainstreamed children were tested only once; that is, longitudinal data were not obtained.

The traditional criteria were also used in selecting the sample of 6-year-old children. These children were prelingually hearing impaired, and they had no additional handicaps other than correctible visual problems. All were attending schools for the deaf in New York State. An attempt was made to get as large a sample as possible within the constraints indicated. Of the approximately 80 6-year-old children available at schools for the deaf, only 65 were tested. The approximately 20% omitted from the project were either not available during the testing program (absent from school for any or part of the testing days) or unable to be tested (were unable to follow directions, had severe attentional and behavioral problems, or had multihandicapping conditions, including severe mental retardation). Had this group been tested, they most likely would have performed in the lower 20% (lower 2 deciles) of the population. Among the sample tested, none was known to be postlingually hearing impaired. Some had Spanish as a home language, but most were from English-speaking homes with hearing parents. Of the total sample selected, roughly 6 children from each of the 10 schools for the deaf in the state were tested, giving a total sample of 65. These children were tested only once.

The youngest group of children studied consisted of 46 prelingually hearing-impaired infants between 8 and 30

[1]BOCES is the acronym for the Board of Cooperative Educational Services.

months of age at the time of enrollment into a program for infants. The children were followed longitudinally from the time of their entry until they left the infant program for a formal preschool program at approximately 36 months of age.

For logistical reasons, data were obtained from one center only (The Infant Center at the Lexington School for the Deaf). An oral teaching philosophy is followed at that center. All of the children studied had either severe or profound hearing losses.

Choice of Test Materials

A major problem in studies of the type reported here is the choice of test material. Wherever possible, existing tests were used, but new tests covering both language and communication skills were developed as needed. The total number and types of tests that could be administered was limited by the time available for testing. Each child could be tested for a total of 5 to 6 hours spread over several school days.

Most of the tests of communication skills were developed specifically for the projects reported here. They covered both speech production and speech reception as well as speechreading (lipreading) ability. This was a major undertaking, and not all of these tests were ready in their final form for the first year of the longitudinal study. Fortunately, at the time the longitudinal study on older children was initiated, an experimental version of the Test of Syntactic Abilities (Quigley et al., 1976) was available,[2] allowing for a comprehensive body of data on the comprehension of syntactic skills to be obtained using a test battery designed specifically for hearing-impaired children. The age range covered by the Test of Syntactic Abilities is 10 through 18 years of age. For the younger children, a separate test of syntactic comprehension was developed (Gaffney, 1977). Note that the cross-sectional study on the younger children was carried out after the longitudinal study had been initiated. The two projects were staggered to allow time for developing a test of syntactic comprehension for the younger children.

The following is a summary of the tests administered to the three groups of children. Detailed information on each test is provided in the relevant chapters dealing with various aspects of the research.

TESTS USED WITH OLDER CHILDREN

Syntactic Comprehension

A wide range of syntactic forms was covered using an experimental version of the Test of Syntactic Abilities (Quigley et al., 1976). These forms included:

Negation—Two subtests were administered. One dealt with the system of modals (*do, can, will*); the other with the verbs *be* and *have*.

Question Formation—Two subtests were administered. One used an answer environment in which the subject responded to questions of various types. These included *yes/no, how, what, what*-verb, and other *wh*-questions, as well as tag, causal, and intensive question forms. The second subtest required the child to judge the grammaticality of questions involving auxiliaries and modals (*be, have, do, can*).

Verb Forms—Two subtests were administered. One dealt with the child's ability to recognize a common error type, deletion of the verb. The second covered verbal auxiliaries frequently used in English. These included the present progressive and perfect tenses and passive voice as well as confusions between *be* and *have*.

Pronominalization—Five subtests covered the use of personal pronouns, possessive pronouns, possessive adjectives, reflexive pronouns, and backwards pronominalization. The subtests on relativization also involved pronoun referents and relative pronoun deletion.

Determiners—One subtest was used to measure the child's ability to recognize common errors involving determiners. These included errors of agreement, distribution, liaison, order, and redundancy.

Conjunction—This subtest covered conjunction deletion in four common environments: conjoined subjects, objects, verb phrases, and sentences with no elements in common.

Relativization—Three subtests were administered. One measured the child's ability to process a complex sentence with an embedded relative clause. The second dealt with embedding both with and without deletion of the relative pronoun. The third measured the child's ability to determine the correct referents for relative pronouns (e.g., *who, which, whose*) in complex sentences.

Chapter 5 provides more detailed information on the specific subtests used. Further information on the experimental version of the Test of Syntactic Abilities is available in Quigley et al. (1976). See Quigley et al. (1978) for the final version of the test.

Written Language

Several samples of written language were obtained from each child during the annual testing period. Typically, the child was required to describe a story conveyed by a short sequence of pictures. The written samples were then analyzed by two or more raters who evaluated the level of syntactic complexity in each sample. The rating scale is shown in Table 1.1.

A detailed syntactic analysis of the written language samples was performed with a newly developed computer program for parsing English sentences. The analysis included such standard measures as word count, sentence count, and type-token ratio, as well as an analysis of the word classes, phrase types, and syntactic structures used. An analysis of the syntactic errors produced by the children was also provided. Chapter 6

[2]We are extremely grateful to Stephen P. Quigley for allowing us to use the experimental version of his test and for the very helpful cooperation provided by Dr. Quigley and his staff.

provides a detailed description of the method of analysis and the results obtained.

TABLE 1.1. Written language rating scale.

Rating	Category description
1	No useful output (no words related to test material)
2	Single words related to test material (i.e., labeling only, incorrect word order)
3	Some evidence of syntactic structure (i.e., words in correct word order, or use of verb. Repetitive, fixed word order is not counted)
4	Essentially complete structure, although errors may be present
5	Substantial output, essentially complete structure

Speech Reception Skills

Phoneme reception. Two tests of phoneme reception were used. The first was the phoneme recognition test developed by Smith (1975). This test was used during the first two years of the study. At the end of the first year it was discovered that the majority of children were guessing at random on the test and that useful information was obtained on only the upper third of the children. A less difficult test using gross acoustic contrasts (Children's Nonsense Syllable Test) was developed during the second year and used in the third and fourth years of the study.

The Smith (1975) test was designed for young deaf children 8 years of age or older. Each item of the test consisted of a monosyllabic word spoken by a male speaker. The child was required to identify the test word from a set of three alternatives. The set of alternatives consisted of the test word and two similar words that differed on one or more phonetic features. For example, a typical set of contrasts was *fat, sat,* and *hat,* the test word being *fat*. Five types of contrasts are covered by the test: place of articulation, manner of articulation, place and manner of articulation, voicing, and vowel contrasts.

The Children's Nonsense Syllable Test used a closed response-set format with vowels, consonant-vowel, and vowel-consonant syllables. The vowels /i/, /ɑ/, and /u/ were chosen to represent gross spectral contrasts as well as different places and manner of articulation. In the CV or VC items, the vowels were always held constant while the consonants varied. (Further information on this test is provided in Chapter 7.)

Prosodic feature reception. The test for prosodic feature reception attempted to measure the three suprasegmental features of English (stress, intonation, and pausal juncture) using only gross contrasts. A preliminary version of the test was used for the first year of the study. Prosodic contrasts were conveyed by means of simple sentences. Six basic sentences were used: two 3-syllable and two 7-syllable sentences. Each sentence appeared in several different contrasting prosodic forms; for example, statement versus question, change in stress pattern, addition of pausal juncture, and a variation of the sentence in which one or more syllables were added. Each member of the pair was formed from the same basic sentence. Half of the test pairs contained a prosodic contrast, the other half did not. The subject's task was to tell whether the two sentences sounded the same or different. Before testing began, each child was presented with practice items. Testing did not commence until the experimenter was satisfied that the child understood the procedure.

The test was modified at the end of the first year because the subjects showed a marked bias toward responding "same" on sentence pairs for which they were unsure. The revised prosodic feature reception test used a closed-response set rather than the same-different format.

Revised prosodic feature reception test. In the revised test of prosodic feature reception, the child was required to listen and to circle one of four possible choices that corresponded to the sentence heard. At first, practice items were reviewed verbally by the examiner to familiarize the child with the task. When it was felt that the child understood the concepts and test procedure, the first 10 items were presented to the child.

There were some changes in the prosodic forms used in the revised test. Change in syllable number, which is not a true prosodic feature, was omitted from the revised test. The question form was limited to short 2-syllable sentences. The number of stress and pause examples was expanded to include differences in the location of the pause or the major stress. The prosodic forms used in the test are discussed in Chapter 8. The nine basic sentences, each in four different forms, were divided evenly into sentences of 2 syllables, 3 syllables, and 5 syllables in length. The prosodic forms for the 2-syllable sentences were: primary stress early in the sentence, primary stress late in the sentence, pause, and question. The prosodic forms for the 3- and 5-syllable sentences were: primary stress early in the sentence, primary stress late in the sentence, pause early in the sentence, and pause late in the sentence.

Stress/location. For the mainstreamed children, the revised prosodic feature reception test was not difficult enough, and thus a second test was developed (see Chapter 8). This Stress/Location Test was designed to assess whether hearing-impaired children could discriminate place of stress in an utterance. The place of stress was the target element in both statement and question stimuli. In addition to stress, emphasis was used to determine whether greater intensity, duration, or pitch change would make this feature more recognizable to hearing-impaired children. There were 12 sentences: 6 questions and 6 statements. Within each set, three 3-syllable and three 5-syllable sentences were used. Each of the 12 test sentences was presented once with normal stress and once with emphasis, for a total of 24 test items. For each test item, three written choices were given that differed only in place of stress or emphasis. Stress and emphasis were not contrasted within a test item. The child was taught to associate the auditory stimulus with the written response on four practice items, then instructed to circle the sentence he or she heard on a response form provided.

Evaluation of Speech Production

Three types of test were administered to evaluate speech production: tests for evaluating articulation of the segmental characteristics of speech, tests of prosodic feature production, and ratings of overall intelligibility.

Segmental characteristics. The test for segmental characteristics was similar to standard articulation tests, but it used vocabulary that was familiar to hearing-impaired children. The test words were selected from Smith's (1975) corpus produced by a similar population of hearing-impaired children. Single words were used to assess production of vowels and, also, of consonants in the initial, medial, and final positions. Each child was presented with a printed version of the test word, and the examiner scored the production as correct or incorrect; an incorrect production was scored as an omission, substitution, distortion, or addition.

Prosodic feature production. The children were required to produce the prosodic features of stress, pausal juncture, and intonation (question vs. statement contrasts only). Because of time constraints, the children were limited to 6 basic sentences, rather than the full set of 12 sentences used in the prosodic feature reception test. Each of the 6 sentences could be read meaningfully with the characteristics of stress, pause, and question versus statement intonational contrasts, thereby producing 18 different test utterances.

The 6 basic sentences were printed on separate cards. Special symbols were used to represent prosodic features; for example, dots and capital letters. Each child was asked to read the cards aloud before the test began, to become familiar with the test vocabulary. When the examiner felt that the child understood the concept, the child was asked to read the test sentences, and the utterance was recorded. The recordings were then rated by two or more independent raters experienced in evaluating the speech of the hearing impaired. Each rater determined if a child had produced the intended prosodic form and whether the speech was intelligible or not.

Contextual prosodic production. The Contextual Prosodic Production Test was developed to test prosodic feature production by hard-of-hearing children. It was designed to evaluate the children's use of stress, pause, and question intonation in a more natural setting than the Prosodic Feature Production Test.

The target features appeared in the context of a sequential question and answer unit. Each of the three units began with a question that was answered by the second utterance in the unit. If the sentence was read properly as an answer to the question, stress had to fall on a specific syllable. For example,

What color is the apple?
The apple is *green.*
What is *green?*
The *apple* is green.

The placement of stress was thus controlled in a natural way (see Chapter 8).

A second purpose of the test was to determine the effects of training on the production of the target features. For this reason the test was administered both before and after training.

Overall intelligibility. The evaluation of overall speech intelligibility was modeled on that for written language and was adopted from the National Technical Institute for the Deaf (NTID) Rating Scale (Johnson, 1975). Each child was required to describe two or more short picture sequences. Recordings made of each child's speech were then evaluated by several raters. As in the case of the written language evaluation, a five-category rating scale was used. The rating scale is shown in Table 1.2. Averages were obtained from several raters to reduce the effects of interrater variability.

Speechreading

Myklebust and Neyhus test. In the first year of the study, speechreading skills were measured with the test developed by Myklebust and Neyhus (1970). In this test, the child was presented with a silent movie, displayed on a 10″ × 12″ viewing screen, of a talker producing each of the test items. For each test item, the child was required to identify the correct answer by pointing to one of a set of four pictures. A different set of four pictures was available for each test item. Only one picture in each set corresponded to the correct answer. In the first part of the test, the test items consisted of phrases and sentences. Because the majority of children had scores of over 90% by the second year of the study, it was clear that a more advanced speechreading test was needed, and, accordingly, a new speechreading test was developed.

LCS speechreading test. The new speechreading test was referred to as the LCS speechreading test after the acronym for this project. It was designed to tap the children's comprehension of language and not simply the discriminability of patterns of facial movements corresponding to individual words or phrases. The response format of the test was similar to that used previously; for each test item the child was required to identify one of a set of four pictures. All of the pictures in each set were related to the test item in some way so that information could be gleaned on the possible source of error when a mistake was made. For example, one test item was *a boy chases a dog.* One picture, the correct answer, depicted this scene. Another showed a boy chasing a cat, a third

TABLE 1.2. Speech intelligibility rating scale.

Rating	*Category description*
1	Speech cannot be understood
2	Speech is very difficult to understand (only isolated words or phrases are intelligible)
3	Speech is difficult to understand; however, the gist of the content can be understood
4	Speech is intelligible with the exception of a few words or phrases
5	Speech is completely intelligible

picture showed a dog chasing a boy, and in a fourth a cat was chasing a boy. Each picture thus differed from the target picture in a systematic way that depended on the content of the test sentence.

The test consisted of four sections, each covering a different error type. The four error types were: (a) subject or object reversals with the verb remaining the same, (b) subject or other changes with the verb also changing, (c) changes in qualifying phrase, and (d) subject, object, and prepositional changes.

TESTS USED WITH YOUNGER CHILDREN

In an effort to be consistent with the assessment of language and communication skills in the longitudinal study and to contribute information on a younger population, the same areas of assessment were considered with younger children. That is, a broad range of tests covering both language and communication skills was administered. The areas of language comprehension and production, speech reception and production, speechreading, and auditory skills were investigated. Because of the age of this group, written language samples were not obtainable, nor were certain tests applicable. Thus the number and type of tests administered were limited by the young age, proficiency of the children, and time available for testing. Each child was tested for a total of 3 to 4 hours spread over several school days.

Most of the tests on communication skills were developed specifically for the project, particularly where other standardized tests could not be used due to the population upon which the test was standardized or due to the severe limitations of the children for whom the test was age appropriate. Additional areas were investigated; among them, sign ability, auditory skills, and overall communicative competence.

Assessment of Language Function

Evaluation of language function was limited to the use of assessment tools available for normal-hearing children and to the few tests of this type that have been designed for hearing-impaired children. Assessment methods that were developed included tests of expressive and receptive language and tests of phonologic, syntactic, and semantic development, with modifications in test presentation, instructions, and evaluation. The evaluation procedures used to measure comprehension skills in this project included an adaptation of a test for normal-hearing children, the Assessment of Children's Language Comprehension (ACLC) by Foster, Giddan, and Stark (1974), and a test designed specifically for hearing-impaired children, the Syntax Screening Test (SST) by Gaffney (1977). Both were standardized on younger children and did not call for written skills.

Assessment of Children's Language Comprehension. The ACLC consists of 40 plates of several black silhouettes. The examiner presents the stimulus word with a carrier phrase, such as "Show me *walking.*" The subject indicates which of the silhouettes on the page corresponds to the stimulus.

The first section (A), vocabulary, includes common nouns, the present progressive form of verbs (i.e., *walking*), prepositions, and adjectives. The 50 items in this section are used commonly and contain no more than two syllables.

Section B (two critical elements), Section C (three critical elements), and Section D (four critical elements) measure the subject's ability to comprehend increasing numbers of lexical items, called critical elements. In Section B, for example, the child must identify two critical elements. The items include the following relations: agent-action (*man sitting*), attribute-agent (*happy lady*), and attribute-object (*dirty box*). In Section C, the stimuli contain three critical elements (*happy lady sleeping*), and in Section D, four critical elements (*broken boat on the table*).

The Syntax Screening Test. The receptive language skills of the subjects were also tested with a syntax screening test (Gaffney, 1977) devised specifically for the project. A test was needed that measured basic syntactic structures. In addition, the test should be short, easily administered, and appropriate for hearing-impaired children in whichever mode of communication they preferred (speech and speechreading, signed English as one dimension of total communication, or fingerspelling with speech). Furthermore, the test must not entail reading or writing. (See Chapter 3 for further information on the Syntax Screening Test.) A preliminary form of the test was used to test the language skills of 86 prelingually deaf children between the ages of 5 and 7. The test was then modified to eliminate items that were unusually difficult. The vocabulary for the test was chosen from that used in a preschool class at a New York school for the deaf.

The Syntax Screening Test consists of two sections. Section I includes 14 items, which test negation (6 items), plurality (4 items), and surface word order (4 items). The 6 items on negation include 2 each of nonexistence (*There is no cat, There is no child*), rejection (*The boy does not want a bath, The girl does not want juice*), and denial (*The boy is not asleep, The toothbrush is not broken*).

The 4 items on plurality include the singular and plural of regular nouns and singular and plural of regular verbs (*The girls can walk, The fish bites the hook*). The 4 items on surface word order include 2 active sentences in a subject-verb-object sequence, such as *Mother touches father,* and 2 passive sentences, such as *The girl is pushed by the boy.*

Section II contains 18 questions including *yes/no* and a variety of *Wh*-questions. Two of each of the following question types were asked: *yes/no* questions, *where, why, when, what,* and *who.* The child had to demonstrate comprehension of the questions by giving an appropriate verbal or manual response.

The tests were administered to each child individually in his or her preferred mode of communication.

Expressive language sample (oral and signed). To evaluate the expressive language of the children, two pictures were used to elicit spontaneous language samples: the picture sequence developed by Stuckless and Marks (1966) and the city street scene from the Peabody Pre-School Language Kit (see Chapter 3). The children tested were primarily in total communication programs and, therefore, used signs as well as speech. The examiners simultaneously rated each child for both language and oral language production. A 5-point rating scale was used for each mode of language production. The two rating scales were designed to be analogous to each other.

Assessment of Speech Communication Skills

The speech of young deaf children was studied to determine their competencies for oral production, reception of speech, and level of development, with particular comparison to normal-hearing children. Assessment of speech skills was divided into two areas: speech reception and speech production.

Speech reception. The Speech Reception Rating Scale (see Chapter 4) was used to estimate the child's ability to understand "spoken" language as communicated through all modalities. This rating was given by the classroom teachers because it was felt that they were more familiar with the child's receptive ability in a variety of settings. This 5-category scale ranges from an inability to understand any speech to a complete ability to understand spoken discourse.

Speech production. To evaluate speech production, an attempt was made to obtain samples of both imitative and spontaneous speech production. Because there were no known available tests to measure the speech of deaf children with limited reading skills, three different instruments were adapted and used. They were the Imitation Syllable Test, an adaptation of the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1972), and the Speech Intelligibility Rating Scale (Johnson, 1975), which was also used with older children (Table 1.2). These measures enabled the examiner to investigate production of speech varying in length and spontaneity.

Speechreading. The Myklebust and Neyhus Diagnostic Test of Speechreading (1970) was selected because it evaluates three levels of complexity: identification of words, phrases, and sentences. The relative difficulty of the test was appropriate for this age level. The method of testing was the same as that used for the older children.

Speech reception. The speech reception training tape was developed to train and evaluate the child's ability to identify several stimuli that differed in duration and frequency components, beginning with pure tones and noise and progressing to speech sounds. The test had eight levels. Before administration of each level, the child was trained to respond appropriately.

At the first level, the child was asked to distinguish between sound and silence by identifying a pulsed 125-Hz pure tone of 260-ms duration. The child was trained to indicate each time the sound was heard. The competing signal was a 1125-Hz sawtooth noise of 540-ms duration.

At subsequent levels, speech sounds, specifically the vowels /ɑ/, /i/, and /u/, were introduced. At Level III, the presentation of the vowel /ɑ/ began. The subject was required to acknowledge hearing any sound from silence and could do so in one of three ways: by simply raising the hand, by repeating the vowel heard, or by using the dactylogic representation of the sound.

Level IV required the child to discriminate between the vowel /ɑ/ and the sawtooth noise. At Level V, two vowels were presented, /ɑ/ and /i/. The child could respond by raising the hand for /ɑ/, by repeating /ɑ/ or /i/, or by using the appropriate dactylogic representation of the sound. The task at Level IV was differentiation among three vowels: /ɑ/, /i/, and /u/. The child was required to respond to /ɑ/ in the presence of two other vowels. It was also of interest to determine if the child could differentiate among all three of the vowels.

Level VII was a preparatory set where training began for the recognition of consonant-vowel combinations. The child was asked to identify when the syllable /bɑ/ was heard by raising the hand. If the child was able to perform this task, Level VIII was presented. The subject heard a pair of syllables that combined any of the three vowels /ɑ/, /i/, /u/ with any of three consonants /m/, /g/, /s/. The child indicated if the CV pairs were the same or different (i.e., /bɑ/-/gɑ/, /sɑ/-/mɑ/, or /mɑ/-/mɑ/).

A criterion of 7 correct responses out of 10 was needed at each level in order to proceed to the next level.

Overall communication competence. A rating of overall communication competence was obtained to assess the child's ability to communicate an idea or thought; spontaneous communicative interactions that took place prior to and throughout the test situation were also taken into account. In rating the children, the examiners considered the child's primary mode of communication and evaluated each child according to that mode. It should be noted that both examiners were proficient in sign language and had an understanding of the various communication modes. A 5-point rating scale was used that ranged from an inability to communicate to ability to communicate freely without difficulty or error in word usage, structure, or meaning. A rating was given upon conferment of the examiners after the testing of each child was completed.

TESTS USED WITH INFANTS

Receptive and expressive language development was measured weekly with a modified version of the Receptive and Expressive Emergent Language (REEL) Scale (Bzoch & League, 1971). Sixty items were grouped into Receptive and Expressive categories. The categories of Receptive items were: receptive vocabulary (preliminary and advanced), understanding of requests (simple and complex), understanding of parts of speech, and understanding of semantic categories. The categories of Expressive items were: vocal play (babbling and jargon), expression and use of words, expression of parts of speech, and expression of more complex combinations of words and sounds. A detailed account of the modifications to the REEL test and its application to the measurement of emerging language in deaf infants is presented in Chapter 2.

ACKNOWLEDGMENT

The research reported in this monograph involved several related projects. Many people and organizations contributed to the success of these projects, and we are grateful to all who helped. Separate acknowledgments are made at appropriate locations in the monograph. There was, however, a small core of helpers who contributed substantially to more than one project and whose efforts we would like to acknowledge most gratefully. In particular, we would like to thank our research assistants, Cheryl Barry, Jane Carp, Sister Rosemary Gaffney, Lisa Rothman-Freeman, Everett Leiter, Adriana Oleksuik-Velez, and Susan Wurtzel for the many long hours spent in gathering, collating, and analyzing data. Their painstaking efforts were invaluable, and we hope that the quality of this monograph provides them with much satisfaction for a job well done. We are also extremely grateful to our computer experts, Harvey Stromberg and Marian MacEachron, for their extensive help in computing and analyzing the vast body of data. Our team of consultants, Professors Helen Cairns, Katherine Harris, Irving Hochberg, Mary Joe Osberger, Rachel E. Stark, and Ronnie Wilbur, provided us with much useful guidance and insight into the problems at hand.

Preparation of the final manuscript would not have been possible without the considerable administrative and secretarial help of Linda Ashour, Marilyn Halprin, and Loretta Walker. We are also grateful to Angela La Bruna and Nancy Springer for their assistance in the final organization of the data.

We are indebted to Stephen Quigley for allowing us to use his Test of Syntactic Abilities before its final publication and also for his advice and that of his staff in using and interpreting the many subcomponents of that test. We are similarly grateful to Sister Rosemary Gaffney for allowing us to use her Syntax Screening Test with the younger deaf children. The staff at the National Technical Institute for the Deaf were very helpful in allowing us to draw on their materials in developing the language-communication profile for the older children. In particular, we would like to thank Kathleen Crandall, Don Johnson, JoAnn Subtelny, and Ross Stuckless for their help in this regard.

The research reported in Chapters 3 through 9 was supported by the Cooperative Research Endeavors in the Education of the Deaf Program (CREED) supported by the New York State Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Beatrice Jacoby, Acting Chief of the Bureau at the time the research was initiated, was instrumental in getting the various projects going and provided us with encouragement and support for the duration of the work. We also received much help and encouragement from the supervisors and staff of the schools for the deaf in New York State. The participating schools were:

Bureau for Hearing Impaired Children, Manhattan
The Cleary Deaf-Child Center, Ronkonkoma
Lexington School for the Deaf, Jackson Heights
Mill Neck Manor School for the Deaf, Mill Neck
New York School for the Deaf, White Plains
New York State School for the Deaf, Rome
School for the Deaf—J.H.S. #47, Manhattan
Rochester School for the Deaf, Rochester
St. Francis de Sales School for the Deaf, Brooklyn
St. Joseph's School for the Deaf, Bronx
St. Mary's School for the Deaf, Buffalo

Finally, we extend a special thank you to the children who took part in the study.

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Chapter 2

The Effects of Hearing Status of the Family and Age of Intervention on Receptive and Expressive Oral Language Skills in Hearing-Impaired Infants

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The work presented here is a longitudinal study of emerging receptive and expressive oral language skills in hearing-impaired infants, all of whom were associated with an oral infant program. The study had two objectives. The first was to collect normative data on emerging language skills in hearing-impaired infants. The second was to lay some groundwork for developing an appropriate assessment tool. Both are relevant to the broader problem of establishing effective diagnostic and intervention programs. Unfortunately, the two objectives are more difficult to achieve than would appear at first glance, as is borne out by the lack of published studies of this type. There is information available on early sound production in hearing-impaired infants (Mavilya, 1972; Stark, 1972), but none on early oral language production. With the increasing acceptance of the manual modality as a viable communication medium (e.g., Bellugi & Klima, 1978), there has been an increasing interest in the development of early signing skills (Hoffmeister, Moores, & Best, 1974; Kantor, 1982; Maestra y Moores, 1980; and others). However, the studies are usually of children from deaf homes, and no one has yet developed systematic methods for studying gestural or facial signalling in children who come from nonsigning homes. (The work of Feldman, Goldin-Meadow, & Gleitman, 1977, should be noted here because of its apparent relevance. However, because of the problematic nature of their subject selection and interpretation of data, their work offers controversial evidence, at best.)

Given the centrality of the language problem to the hearing-impaired population, why are there so few studies of early infant language? One of the major reasons is that most prelingually deaf children are not diagnosed early enough to study. Even though techniques for early diagnosis are available (e.g., Rubin, 1978), most hearing-impaired children who are not multiply handicapped are diagnosed only because of delayed or deviant verbal output. In fact, the average age of diagnosis is usually later than that at which most normal-hearing children are already showing themselves to be capable linguists. (See, for example, references cited in Kretschmer & Kretschmer, 1978, or Liben, 1978.) Such late diagnosis is not surprising if we remember that 90% of our hearing-impaired infant population comes from hearing homes, where deafness is neither expected nor recognized.

Even with effective early diagnosis, the problem of linguistic assessment still remains unresolved. Most language scales and studies dealing with infant language follow the path laid down in 1946 by Dorothea McCarthy. She noted that, although "language" has a wide variety of meanings, emphasis is usually placed on spoken language for convenience. It is perhaps unfortunate that verbal data remain the easiest linguistic data to gather. We do not know how to assess the linguistic capacities of a child whose spoken output is severely limited, and prelingually deafened infants do not produce a large corpus of easily analyzable expressions. Neither do we know how to interpret their receptive skills. Even studies with young normal-hearing children point to difficulties in attributing understanding in a population where contextual cues are more potent than verbal cues. (See experiments quoted in Kretschmer & Kretschmer, 1978, by Huttenlocher on normal-hearing children, and by Stant, Kramer, and others on language-impaired children.) These problems account for the lack of adequate instruments to measure language functioning in a deaf infant population. They also account for the fact that previous workers have usually chosen to work with children old enough to exhibit skills that are considered "testable" (e.g., writing skills, as in Levitt et al., 1976, and Quigley, Power, & Steinkamp, 1977).

There are thus three basic problems in studying the emerging language skills of hearing-impaired infants: late diagnosis, reduced or deviant production, and lack of test instruments to assess the children. Together, these problems can seem insuperable. However, a fortunate combination of circumstances made the present study possible: availability of both a population (infants enrolled in the Infant Center Program at the Lexington School for the Deaf) and a test instrument with a history of use on this population (Greenstein, Greenstein, McConville, & Stellini, 1975). Accumulated experience allowed us to refine our techniques (see the Methods section) to make the most effective use of the language instrument. Further, the size of the sample made it possible to assess the effect of two major background variables that are known to affect the children's emerging language skills. The first variable is the hearing status of the family; the second is the age of the child at intervention.

It is generally stated that deaf children of deaf parents "do better" communicatively, socially, and emotionally than deaf children of hearing parents (e.g., Monsees, 1971; Moores, 1978; Schlessinger & Meadow, 1972). The reasons for this effect are varied. First, the etiology of deafness in children of hearing families is heterogeneous, and there may be neurophysiological complications that are not found in the genetically deaf child (Jensema & Mullins, 1974; Monsees, 1971). Second, parents who themselves are deaf are more likely to have their child's hearing diagnosed early (Schlessinger & Meadow, 1972).

The constant negative interaction with professionals experienced by so many hearing parents (e.g., Gregory, 1976; Magee, 1969; McAree, 1969) serves to undermine both parental self-confidence and the communicative relationship between parents and children (e.g., Greenstein et al., 1975; references cited in Liben, 1978; and the work of Meadow, Greenberg, Erting, & Carmichael, 1981). Third, parents who are deaf do not react as adversely and in as prolonged a manner as hearing parents to the advent of a deaf child in the family. This can have the effect of normalizing the relationship between caretaker and child. For these reasons, we could not pool the data without regard to familial hearing status (see also White, 1984).

The second factor examined was the age of intervention. Intervention age is actually a compound concept that incorporates several related events known to influence the success of remedial efforts. They include age of diagnosis (Rubin, 1978), age of onset of training of residual hearing (Graham, 1976), age of utilization of hearing aids (Bench, 1978), age of involvement of the family (Greenstein et al., 1975), age of entry into a program (Kretschmer & Kretschmer, 1978), and others. These correlated factors are well described and discussed by Graham (1976). It is likely that the age of intervention, in this compound sense, has effects on the emergence of language skills. Therefore, children in this study were classified according to whether intervention was early or late (defined as before or after 18 months of age). The study was conducted longitudinally, with assessment beginning upon entry into the Lexington Infant Center Program and continuing until the children left, at 36 months of age.

This chapter, thus, presents the results of a longitudinal study of aspects of the receptive and expressive language skills of hearing-impaired infants up to 3 years of age. The data are presented separately for children of hearing parents (HP groupings) and for children of deaf parents (DP groupings). Within these groupings, the sample is further broken down into those for whom intervention was early and those for whom intervention was late. The study focused primarily on the onset of spoken language because this was the prime focus of the program in which the children were enrolled and of the assessment instrument in use. The instrument was standardized on a normal-hearing population (Bzoch & League, 1971), and it served as a model against which to measure the progress of the children in our sample. The analysis of both the receptive and expressive data was designed to answer several basic questions:

1. What was the overall attainment of the children by the end of their third year of life relative to the attainment of normal-hearing children?
2. What was the effect on this attainment of each of the two main variables (hearing status of the family and age of intervention)?
3. What was the joint effect of the two variables?
4. When, within the first three years, were the language skills we measured attained relative to the age of attainment by normal-hearing children?

METHODS

Subjects

The subjects were 46 prelingually deaf infants with no other known handicapping conditions. The children were between 8 and 30 months old when they were enrolled into a program for infants (The Infant Center at the Lexington School for the Deaf). Only those children whose losses are classified as severe or profound are admitted to the Infant Center. The basis of the classification is an unaided audiogram that is administered as part of the normal intake procedure for every infant. The average unaided pure-tone audiograms for the children with hearing parents (HP) and for children with deaf parents (DP) are shown in Figure 2.1. Audiometric data were obtained in a binaural sound field situation using behavioral observation audiometry, visual reinforcement audiometry, or a combination of the two. These are common techniques used with younger children (Rubin, 1978).

The children were followed longitudinally from the time of their entry until the time they left the Center and entered a formal preschool program at approximately 36 months of age. A detailed breakdown of the subjects appears in Table 2.1, which also introduces the nomenclature of the groups and subgroups used throughout the paper. The four groups were:

1. DPE Group: Children of *D*eaf *P*arents for whom intervention was *E*arly
2. HPE Group: Children of *H*earing *P*arents for whom intervention was *E*arly
3. DPL Group: Children of *D*eaf *P*arents for whom intervention was *L*ate
4. HPL Group: Children of *H*earing *P*arents for whom intervention was *L*ate

Further breakdown was not undertaken because the numbers involved might compromise conclusions to be drawn from statistical analyses.

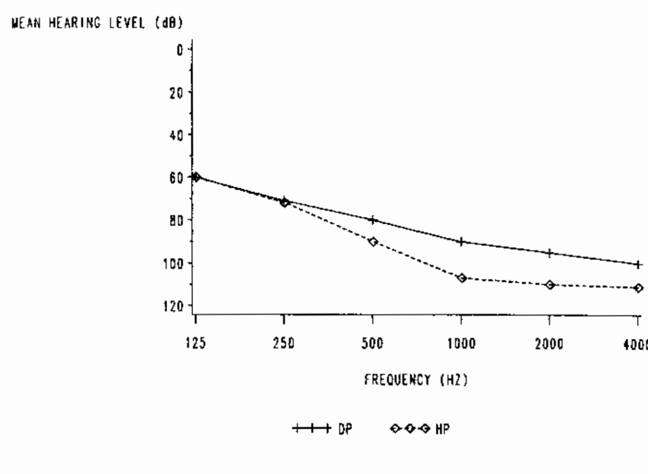

FIGURE 2.1. Average pure-tone sound-field audiograms for the DP (——) and HP (---) groups. Measures were obtained using VRA techniques (see text). The vertical bars show the standard deviations for each group at each frequency.

TABLE 2.1. Breakdown of subjects into groups by family hearing status (Deaf Parents = DP, Hearing Parents = HP) and into subgroups by age of intervention (Early = E = prior to 18 mos.; Late = L = after 18 mos.). For each subgroup the table shows the number of infants (*N*), the distribution of sexes, SES levels (see text), and home language (ME = Monolingual English; MF = Monolingual Foreign; MS = Monomodal Sign; FE = Foreign + English spoken at home; SE = Signing and English at home; SF = Signing + Foreign Language at home). The final two columns indicate the intervention ages (measured by age of diagnosis and age of entry into an infant program), and age when children were considered aided (see text).

Group	N	*Boys*	*Girls*	*SES (ed. level)*		*Home lang.*	*Average diagnosis (entry) age*	*Average age of "aiding"*
				Low	*High*			
DP group								
DPE	5	3	2	3	2	ME		
						MF	6 mos.	
						MS = 2		20.5 mos.
						FE	(9 mos.)	
						SE = 2		
						SF = 1		
DPL	4	3	1	3	1	ME = 1		
						MF = 1	11.8 mos.	
						MS = 2		31 mos.
						FE	(24 mos.)	
						SE		
						SF		
HP group								
HPE	9	6	3	4	5	ME = 7		
						MF	11.9 mos.	
						MS		28 mos.
						FE = 2	(14 mos.)	
						SE		
						SF		
HPL	28	15	13	18	10	ME = 19		
						MF = 5	19.5 mos.	
						MS		30 mos.
						FE = 3	(26 mos.)	
						SE = 1		
						SF		
Totals	46	27	19	28	18	ME = 27		
						MF = 6	–	–
						MS = 4		
						FE = 5	–	–
						SE = 3		
						SF = 1		

Table 2.1 shows the number in each group. Note that the sample proportion of deaf children of deaf parents is 20%, which appears to be higher than the usually accepted figure of 10% (e.g., Schein & Delk, 1974). This discrepancy is more apparent than real: at a 95% confidence level, the proportion (9 out of 46) is not inconsistent with a 10% figure for the population at large. Table 2.1 also shows, separately for each subgroup, the distribution of sexes and SES (socioeconomic status) levels. SES levels were based on the educational attainment of the parents. Families with educational levels of high school and below were considered as "low"; families with any amount of education above high school were classified as "high." (See White, 1977, for a discussion of the use of this measure.) The table also indicates the range of home languages used by the families, and the age of intervention. (Note that the age of intervention is based on the age of the initial diagnosis of deafness and the age of entry into a formal program.) The table also shows the average age at which the children in each subgroup were considered "aided" (i.e., actually using their hearing aids, not just fitted with them). The ages of aiding given in Table 2.1 are averages of those children who were considered "aided" by 36 months of age. The average does not include either those individuals who were not aided by the 36th month ($n = 8$, of which 7 were in the HPL group and 1 was in the HPE group) or those individuals for whom there was no definite information ($n = 9$, of which 5 were in the HPL group; the rest were equally distributed among the other subgroups).

The Language Instrument: Revised REEL Scale (WREEL)

The original REEL (Receptive and Expressive Emergent Language) Scale (Bzoch & League, 1971) covers a 3-year age range that is broken down monthly, bimonthly, and trimonthly for the first, second, and third years of life respectively. This yields 22 "milestone" ages, each of which is criterion referenced by three observable behavioral items, which provides a total of 66 items each for the receptive and expressive aspects of oral language development. The instrument was standardized on a normal-hearing population, but it has also been used extensively with deaf populations (e.g., Greenstein et al., 1975; Tonelson, 1979). Its extensive use with the deaf probably has occurred because the criterion items asked for are observable. The test is usually administered by mothers or teachers, depending on the individual program or researcher.

Modifications of the test instrument were made only after having worked with the original REEL Scale for several years. There were many problems with the original scale; the three that concerned us most are discussed here.

First, there is a bias introduced by the ordinal structure of the original test. Thus, the ordering of the behavioral items according to age of attainment leads a tester to look only at items in the age range of the child under observation. This can serve to obscure information not only about *what* items may be there, but also about *when* those items "emerge." Several investigators (e.g., Tonelson, 1979) have felt that deaf children are penalized by the ordinal structure of the original test. After comparing data coming from both the original and the revised versions, we agree with that concern.

Second, because the scale is used to assess a multidimensional skill ("language"), it is not surprising that apparently unrelated items appear together if age is the basis for their grouping. This hinders application of consistent criteria to the scoring of related items because they are separated from one another.

Third, the original scale was normed for a hearing population. Because of this, certain skills that are relevant for a hearing-impaired population were not included (e.g., the use of gestures, signs, or other significant types of nonverbal behaviors). Conversely, there is also the possibility that not all items on the original scale are relevant for a hearing-impaired population (e.g., "activity arrested when approached by sound").

The revised scale (WREEL) addressed the problems in the following ways: (a) age and order information were not included, but were asked for instead; (b) the items were organized into logical groupings, so that relations between them and between such terms as "occasionally," "usually," and "always" were made more evident; (c) items considered relevant for the population under study were added; and (d) although there was not sufficient basis for discarding any of the original items nor for changing their wordings, teachers were allowed to credit children with knowledge of words and expressions in manual as well as verbal forms. The scale now contains 94 items in each of the receptive and expressive halves.

Teachers were instructed to record the occurrence of each item by indicating the date on which it occurred and the mode in which it occurred. Teachers were also asked to indicate whether the items were partially established (analogous to the ± scoring in the original REEL) or firmly established (+ scores in the original REEL). This information was noted as part of a weekly log-keeping procedure. Thus, an incidental advantage of the new WREEL Scale was that the reduction of bias in the method of attaining age information allowed new uses that were previously not possible; the scale could be used both as a means of keeping on-going records of a child's progress and as a framework for the direction of remediation efforts.

The data for the present study come from the WREELs that were administered by teachers who worked with the mother-infant dyads at least once a week. The completed instruments were collected only after the children left the Infant Center program at 36 months of age. The dates of occurrence for each item were then converted into ages. The results reported here are based on groupings of scores of firmly established items only.

Language Measures Used in the Study

Three criteria governed the selection of items for inclusion in the analysis. These were: (a) whether the item was relevant to the age group of the infants under study, (b) whether that item could be seen as "emerging," and (c) whether the item was logically related to the milestones that psycholinguists look for in language development of normal-hearing children. The joint application of these criteria led to the use of 60 items that were then grouped into Receptive and Expressive categories. The categories of Receptive items were (1) receptive vocabulary (preliminary and advanced), (2) understanding of requests (simple and complex), (3) understanding of parts of speech, and (4) understanding of semantic categories. The groupings of Expressive items were (1) vocal play—babbling and jargon, (2) expression and utilization of words, (3) expression of parts of speech, and (4) expression of more complex combinations of words and sounds. The categories and their constituent items will be presented in Tables 2.4–2.9. Where necessary (as in Receptive categories 1 and 2), the categories were subdivided into "preliminary" and "advanced" halves on the basis of (a) the changing complexity of the items, and (b) differences in their expected ages of emergence in normal-hearing children. Ten measures were analyzed; preliminary and advanced items were counted separately.

RESULTS

The data will be presented in two parts. The first part concerns the separate effects of the main variables: family hearing status and age of intervention. The second part will look more closely at the effects of the interaction between the two main variables. The data are always presented as the percentage of attainment. Within each category, the percentage of attainment is expressed as:

$$N_{OBS} \times 100/N_{MAX}$$

where N_{OBS} = the number of items observed to be firmly established and where N_{MAX} = (total number of items in a category) × (total number of subjects in a group). For

TABLE 2.2. Main effect of hearing status of the family for each receptive and expressive category studied (Deaf Parents: DP = DPE + DPL; Hearing Parents: HP = HPE + HPL). The χ^2 figures were calculated to test the significance of the proportions of successes (observed scores) to failures (total possible minus observed). (N.S. = not significant.) The tables referred to contain the items that define the categories.

Category	*Group*	*No. observed scores*	*Total possible scores*	*% Attainment*	*(DP vs. HP)* χ^2	$p(\chi^2)$
Receptive vocab. preliminary items (Table 2.4A)	DP HP	21 74	36 148	58% 50%	0.51	N.S.
Advanced receptive vocab. (Table 2.4B)	DP HP	6 23	36 148	17% 16%	0.01	N.S.
Reception of simple requests (Table 2.5A)	DP HP	33 112	54 222	61% 50%	1.58	N.S.
Reception of complex requests (Table 2.5B)	DP HP	10 36	54 222	19% 16%	0.04	N.S.
Reception of parts of speech (Table 2.6A)	DP HP	4 12	45 185	9% 6%	0.05	N.S.
Reception of semantic categories (Table 2.6B)	DP HP	3 15	36 148	8% 10%	0.00	N.S.
Vocal play: Babble and jargon (Table 2.7)	DP HP	31 198	90 370	34% 54%	9.78	<.001
Expressive vocab. (Table 2.8)	DP HP	36 137	90 370	40% 37%	0.16	N.S.
Expression of parts of speech (Table 2.9A)	DP HP	7 9	45 185	16% 5%	4.85	.03
Expression of combinations of words and sounds (Table 2.9B)	DP HP	16 31	54 222	30% 14%	6.48	.01

the main effects, the presentation of the data is relatively straightforward, and a tabular form is used. The data for the second part (the interactive effects) are also presented as the percentage of attainment, but graphically, as histograms, and will be described below. The data presentation follows the order of the questions posed at the end of the first section of this chapter. The simple scoring of occurrence or nonoccurrence of items allows us to answer the first three questions posed. However, the longitudinal nature of the study means that information on age of occurrence is available as well. This latter information is used to answer the fourth question.

Main Effects: Hearing Status of the Parents and Age of Intervention

Table 2.2 shows the effect of family hearing status on each receptive and expressive measure. A chi-square test was used to test the significance of the proportion of successes to failures. As is shown by the numbers in the "% Attainment" column, the effect of family hearing status is usually not large. This is also reflected in the significance figures: of the 10 measures studied, only 3 were significantly affected by family hearing status. These 3 areas of difference are of interest because (a) they are all in the expressive mode and (b) the effects are not all in the same direction. The first significant effect (number 7 in Table 2.2) shows that children from hearing homes do significantly more vocalizing than do children from deaf homes. The results of the other two areas of significance (the last two items in Table 2.2) show that, although the HP group may perform better in early speech behaviors, the DPs seem to do better in areas that are considered to be more linguistic.

Table 2.3 shows the data for the effects of the age of intervention on each of the receptive and expressive measures we examined. It is immediately clear that this variable has uniformly large and consistent effects. Without exception, children in early intervention groups show greater success than do children in late intervention groups. This effect is highly significant in all but one area (area 9, expressive parts of speech), but even here there is no reversal of the trend noted above.

The results for this stage may be summarized by saying that, in overall terms, (a) early intervention has a consistently positive effect on attainment level in all the measures studied, and (b) hearing status of the family is not a major factor in the attainment of the receptive language items examined, but it seems to have an effect on the expressive language items measured. However, this summary, by itself, is too simple. Further analyses of the data

TABLE 2.3. Effects of early vs. late intervention for each receptive and expressive category studied (Early = DPE + HPE; Late = DPL + HPL). χ^2 figures were calculated in the same way as described in Table 2.2.

Category	*Group*	*No. observed*	*Total no. poss.*	*% Attainment*	*(Early vs. Late)* χ^2	$p(\chi^2)$
Receptive vocab.: Preliminary items (Table 2.4A)	Early Late	41 54	56 128	73% 42%	13.8	<.001
Advanced receptive vocab. (Table 2.4B)	Early Late	14 15	56 128	25% 12%	4.22	.04
Reception of simple requests (Table 2.5A)	Early Late	59 86	84 192	70% 45%	14.2	<.001
Reception of complex requests (Table 2.5B)	Early Late	24 22	84 192	29% 11%	11.12	<.001
Reception of parts of speech (Table 2.6A)	Early Late	9 7	70 160	13% 04%	4.18	.04
Reception of semantic categories (Table 2.6B)	Early Late	11 7	56 128	20% 05%	7.33	.01
Early vocal play: Babble and jargon (Table 2.7)	Early Late	83 146	140 320	59% 46%	6.73	.01
Expressive vocab. (Table 2.8)	Early Late	89 84	140 320	64% 26%	56.23	<.001
Expression of parts of speech (Table 2.9A)	Early Late	6 10	70 160	09% 06%	0.13	N.S.
Expression of combinations of words and sounds (Table 2.9B)	Early Late	26 21	84 192	31% 11%	15.18	<.001

show interactions between the two variables that are more subtle and interesting than the effect of either variable alone. These interactions will be discussed in the next section.

Interaction of Parental Hearing Status and Intervention Age

In this section the receptive data will be presented first, separately for each category, proceeding from the simple (vocabulary) to the most complex (semantic categories). This will be followed by a similar presentation of results for the expressive categories, also proceeding from the simplest (vocal play) to the most complex (combinations of words and sounds). Within each category, the order of presentation is designed to address the questions posed earlier. As noted previously, the data here are presented graphically, as histograms. The histograms show the actual numbers on which the percentages are based and the 95% confidence intervals for the true population percentage (Pearson & Hartley, 1958). Confidence intervals allow for a quick visual assessment of whether any two population percentages differ; nonoverlapping intervals imply a significant difference, whereas overlapping intervals usually do not.

The histograms indicate levels of performance for each of the subgroups (DPE, DPL, HPE, and HPL). Combining the subgroups numerically gives the combined group percentages (DP and HP), and combining all the numbers gives an overall average for all the subjects. Thus, the data in Figures 2.2–2.7 can answer the first three questions posed (overall level of achievement of the complete sample; the effect of family hearing status and the effect of intervention age; and the joint effect of the two variables). What cannot be inferred from the data as presented here is when the skills measured were attained (Question 4). There was usually a fairly equal spread of attainment between the second and third years. Where this is not so, it is discussed in the text. We note here, though, that in most cases attainment during the first year was practically zero. The figures for the age of attainment of the measures by normal-hearing children are based on comparing the average attainment ages observed for the items in question with those noted in the REEL Scale (Bzoch & League, 1971).

Receptive Vocabulary

Table 2.4 lists the items in the preliminary and the advanced categories for receptive vocabulary. Also noted in the table is when the items are expected to emerge in normal-hearing infants. Figure 2.2 shows the results.

Preliminary vocabulary items. Half of all the children (52%) attained the preliminary items by their third year.

TABLE 2.4. Items used to measure receptive vocabulary.

Category	Item
A. Preliminary vocabulary (See Fig. 2.2A) (Attained by normal-hearing children around the first year of life.)	Appears to recognize such words as "daddy," "bye-bye," "mama" Appears to recognize the names of some common objects when their names are spoken Appears to enjoy listening to new words Appears to understand some new words each week
B. Advanced vocabulary (See Fig. 2.2B) (Attained by normal-hearing children in their second and third years.)	Recognizes and identifies many objects or pictures of objects when they are named Recognizes new words daily at an ever increasing rate Recognizes and identifies almost all common objects and pictures of common objects when they are named Recognizes the names and pictures of most common objects

Although this overall figure reflects similar levels of performance for DPs (58%) and for HPs (50%), Fig. 2.2A allows a closer examination of the data. The data suggest that the early intervention children (DPE and HPE) performed better than did the later subgroups (DPL and HPL; as in Table 2.3). Note, however, that this effect is significant only for the HP group. (Compare the confidence interval overlaps.) Although not shown in the figure, no child in either group attained any of the items in his or her first year, and there was a relatively equal spread of attainment between the second and third years of life for both groups. For comparison, the same items are, on average, attained by normal-hearing infants during their first year.

Advanced vocabulary items. Both groups (DP and HP) attained significantly fewer of the advanced vocabulary items than of the preliminary items (compare Figures 2.2A and 2.2B). The overall attainment was only 16% by the third year, and this reflected relatively equal attainment levels for the DP (17%) and the HP (16%) groups. However, early intervention appears to be more advantageous for the HP group than for the DP group. By comparing Figures 2.2A and 2.2B, one can observe that the HPL subgroup scored significantly lower than the HPE group in both preliminary and advanced items. Almost the opposite seems to be true for the DP groups where there were no differences between early and late subgroups. Further, for the advanced items, DPLs tended to do better than DPEs. In both the DP and the HP groups, if advanced items were attained, they were attained in the children's third year.

Summary. Children in both DP and HP groups performed similarly on receptive vocabulary in two ways: (a) about half of them attained items which imply a general understanding that things have names (the "preliminary" items), and (b) very few in either group showed any clear-cut attainment of more particularized vocabulary items

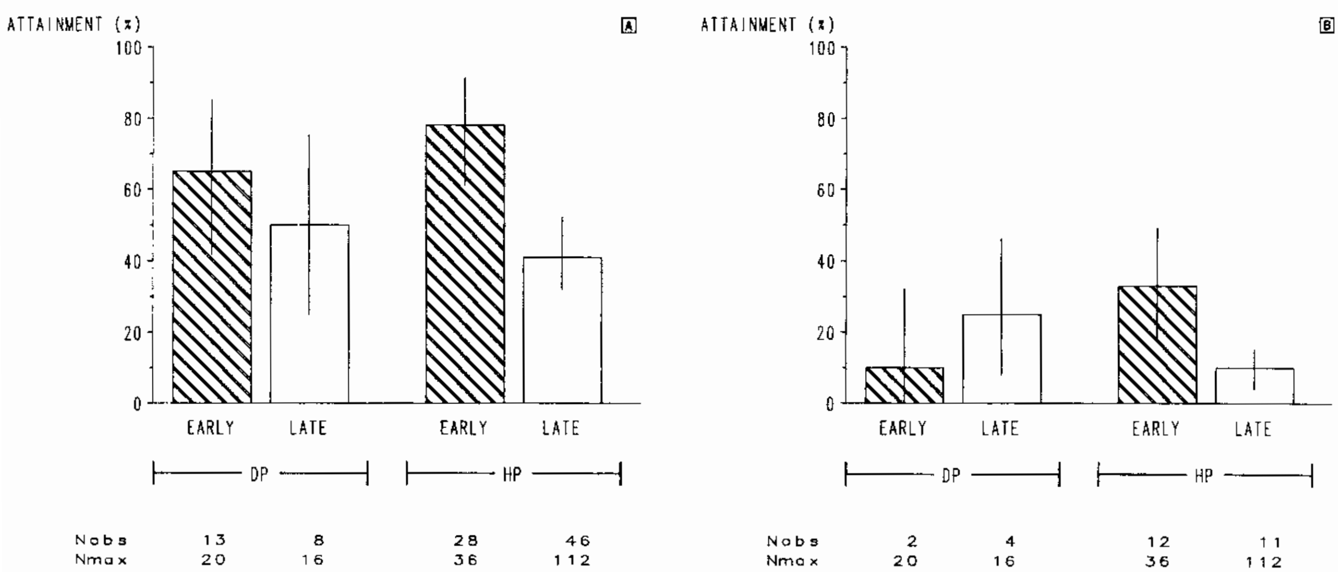

FIGURE 2.2. Receptive vocabulary. Percentage attainment of preliminary (A) and advanced (B) receptive vocabulary items for the DP and HP groups. Each group is subdivided into early or late intervention ages. The percentage of attainment figures are based on the proportions inside the columns. These indicate the ratio of observed scores to maximum possible scores (see text). The 95% confidence intervals for each percentage are indicated by vertical bars (——); nonoverlapping intervals are usually significant. (See the text for discussion of significant effects.) The items that compose each of the measures are listed in Table 2.4.

TABLE 2.5. Items used to measure reception of requests.

Category	Item
A. Simple (preliminary) requests (See Fig. 2.3A) (Attained by normal-hearing children in their first year of life.)	Responds with appropriate gestures to such words as "come," "up," "high," "bye-bye"
	Appears to understand some simple verbal requests
	Often gives toys or other objects to a parent on verbal request
	Occasionally follows simple commands like "put that down"
	Demonstrates understanding by responding with appropriate gestures to several kinds of verbal requests
	Demonstrates understanding by making appropriate verbal responses to some requests (e.g., "say bye-bye")
B. Complex (advanced) requests (See Fig. 2.3B) (Attained by normal-hearing children in their second and third years.)	Demonstrates understanding by carrying out verbal request to select and bring some familiar object from another room
	Comprehends simple questions and carries out two consecutive directions with a ball or other object
	From a single request identifies 2 or more familiar objects from a group of 4 or more familiar objects
	Demonstrates understanding by appropriate responses to such action words (verb forms) as "sit down," "come here," "stop that"
	Upon verbal request selects an item from a group of 5 or more varied items (such as comb, spoon)
	Carries out three simple verbal commands given in one long utterance

("advanced" category) by the end of their third year. The children in the DP and HP groups were different from one another in that early intervention was associated with higher scores for the HP groups, both for preliminary and for advanced items. This effect was not as clear-cut for the DP group where no intervention effect was in evidence.

Reception of Requests

Table 2.5 lists the items in the preliminary and advanced groupings of the receptive request category and indicates when they are expected to emerge in normal-hearing children. Figure 2.3 shows the percentage of attainment of the items by the different subgroups for preliminary (simple) and advanced (complex) items.

Preliminary items (simple requests). About half of all the infants (53%) showed some understanding of simple requests by the end of their third year. The difference between the DP (61%) and the HP (50%) groups was not significant. However, the effect of intervention age was significant, but for the HP group only. (Compare confidence intervals of HPE vs. HPL and DPE vs. DPL.) Attainment ages for the early groups appeared to be divided equally between the second and third years, with

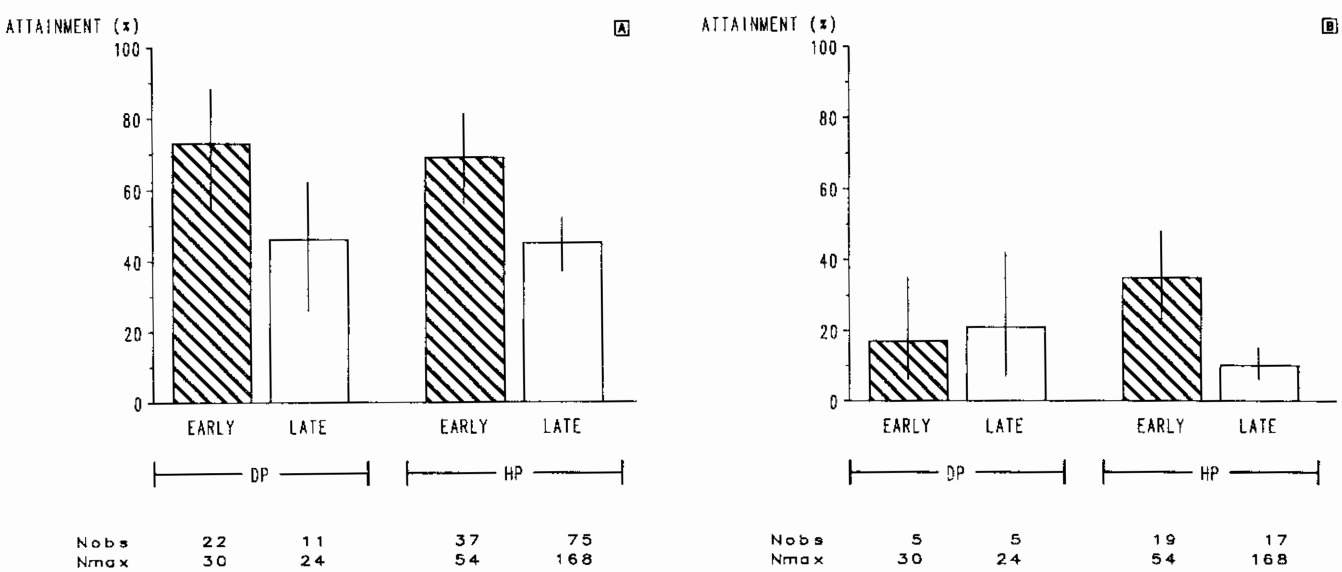

FIGURE 2.3. Reception of requests. The percentage of attainment of the comprehension of simple requests (A) and of complex requests (B) is indicated separately for each subgroup. The calculations are as described for Figure 2.2. The component items are listed in Table 2.5.

TABLE 2.6. Items used to measure other receptive skills: Parts of speech and semantic categories.

Category	*Item*
A. Understanding parts of speech (See Fig. 2.4A) (Attained by normal-hearing children during their second and third years.)	Demonstrates understanding of distinctions in personal pronouns (such as, "give it to her," "give it to me") Demonstrates an understanding of several action words (verb forms) by selecting appropriate pictures (e.g., correctly chooses which picture shows eating) Demonstrates an understanding of all common verbs Demonstrates an understanding of most common adjectives Demonstrates an understanding of prepositions (such as, on, under, front, behind)
B. Reception of semantic categories (See Fig. 2.4B) (Attained by normal-hearing children during their second and third years.)	Remembers and associates new words by categories (such as, foods, clothing, animals) Recognizes and identifies general family name categories (such as, baby, grandma, mother) Demonstrates an understanding of word association through functional identification (correctly answers such questions as "What do you eat with?" "What do you wear?") Understands size difference (correctly selects "the little doll," "the small book," "the large bowl," etc., from among a group of similar objects)

no children attaining any of the items in the first year of life. As was true for receptive vocabulary, both groups are delayed by one or two years relative to normal-hearing children in achieving understanding of simple requests.

Advanced items (complex requests). Fig. 2.3B shows the results for the understanding of more complex requests. The overall attainment level was 17%, which represents a 19% performance level for the DPs and a 16% performance level for the HPs. Again, although family hearing status did not differentiate these children, early intervention in combination with family hearing status did; early intervention was again associated with a performance advantage that is significant for the HPs but not for the DPs. Again, for the DP group there is the suggestion of a reversal that is not significant. If items were attained, it was during the third year of life in both groups, with only one or two exceptions.

Summary. About half of all the children attained an understanding of simple requests by the end of their third year of life. Those that did so were about two years behind the average for normal-hearing infants in their attainment. Understanding of more complex requests was attained by less than a fifth of the children in this sample. In an overall sense, early intervention appeared to benefit children of hearing parents, whereas the picture is different for the children of deaf parents. The pattern of results is the same as that indicated for receptive vocabulary.

Other Receptive Skills: Parts of Speech and Categorical Understanding

Two other types of general receptive skill were analyzed. The first type was labeled "parts of speech" and included items that assessed comprehension of pronouns, verbs, adjectives, and so forth. (See Table 2.6A for the list of items.) The second type of skill was labeled "categories" and included items directed at the child's understanding of how things are associated semantically (see Table 2.6B). These categories will be presented separately; the graphic presentations are in Figures 2.4A and 2.4B respectively.

Parts of speech. Very few children in either group attained any of these items by their third year, and there was an overall attainment level of only 7% for the items in this group. (Please note that the scale has been expanded in Figure 2.4.) If we look separately at the effect of family hearing status, we find no difference between total DP performance (9%) and total HP performance (6%). However, when we look at the further effect of age of intervention on attainment level (see Fig. 2.4A), the results follow the pattern that was seen with the previously analyzed receptive skills; early intervention is associated with a significantly higher attainment for the HPs but not for the DPs, who show a noticeable trend in the opposite direction. If items were attained, it was only in the third year of life.

Semantic categories. The results are no different for semantic categories than for parts of speech. There was only a 10% overall attainment, which represents 8% for the DPs and 10% for the HPs. By looking separately at the early- and late-intervention subgroups (Fig. 2.4B), we can see that early intervention significantly benefits the HP group but seems to have no effect on the DP group. Again, there is a nonsignificant difference in direction between the DP and HP groups in the intervention effect. Items were attained only during the third year of life.

Summary. Very few of the children attained either of these two receptive categories (parts of speech and semantic categories). Although not seen in the figures, the successes that did occur were ascribable to only one or two children in each group. In other words, by the end of their third year of life, with only a few exceptions, none of the children in any of the groups evidenced an under-

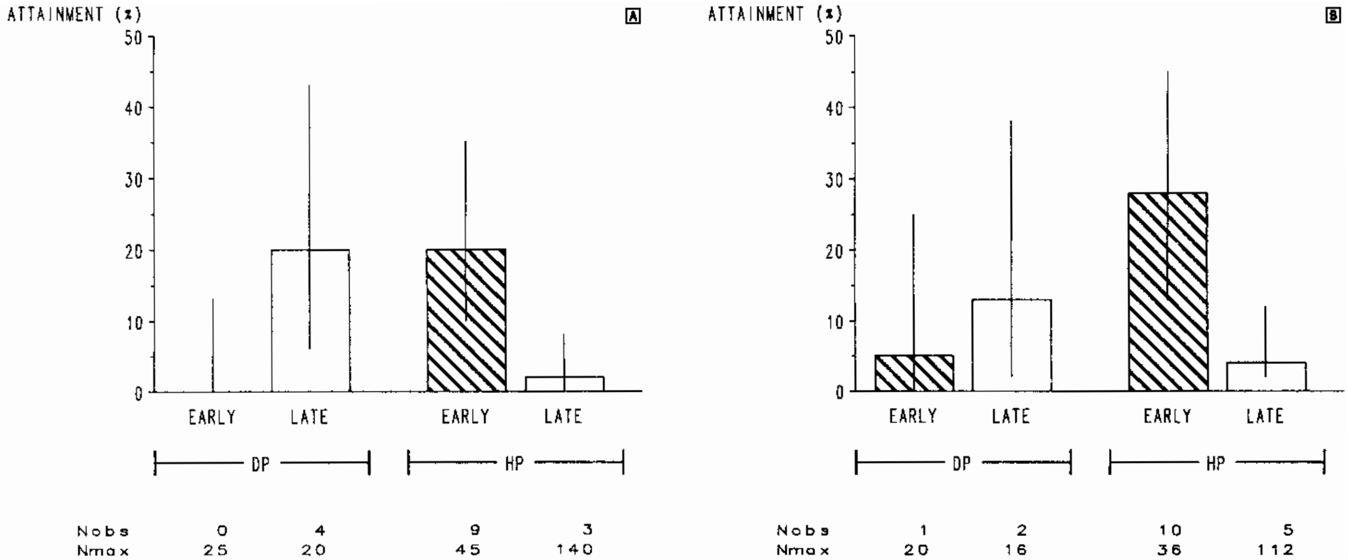

FIGURE 2.4. Other receptive categories. The percentage of attainment of the reception of parts of speech (A) and of semantic categories (B) is indicated separately for each subgroup. Although the calculations here are as described for Figure 2.2, please note that the scale has been expanded. The measures are listed in Table 2.6.

standing of the items noted in Table 2.6. However, those exceptions followed the rule established earlier: early intervention is more often significantly associated with higher levels of performance for the HPs than for the DPs.

Expressive Vocal Play: Babbling and Jargon

Table 2.7 lists the items included in the vocal play category, all of which are expected to emerge in the first year of life in normal-hearing infants. Because the results were not different for the subset that deals with babbling (the first 6 items) and for the one that deals with jargon (the last 4 items), the data have been lumped into a single vocalization category to avoid repetition. The graphic presentation of the data for the subgroups appears in Figure 2.5.

When the population is considered as a group, there was an attainment level of 49% for the items in this category. However, as noted earlier, there was a significant difference between the DP and HP groups as a whole (34% success for the DPs vs. 53% success for the HPs; $\chi^2 = 9.78$; $p < .001$; see Table 2.2). There was also a significant effect of intervention age. However, unlike

TABLE 2.7. Items used to measure vocal play: Babbling and jargon. (Attained during their first year of life in normal-hearing children. See Fig. 2.5.)

Sometimes repeats the same syllable while cooing or babbling
Often vocalizes with two or more different syllables
Babbles (regularly repeats series of same sounds), especially when alone
Occasionally vocalizes with 4 or more different syllables at one time
Plays at making sounds and noises while alone or with others
Begins some 2-syllable babbling (repeats combinations of 2 or more different sounds)
Occasionally vocalizes in sentencelike utterances without using true words
Often uses jargon (short sentencelike utterances of 4 or more syllables without true words)
Usually vocalizes in varied jargon patterns while playing alone
"Talks" to toys and people throughout the day using long verbal patterns

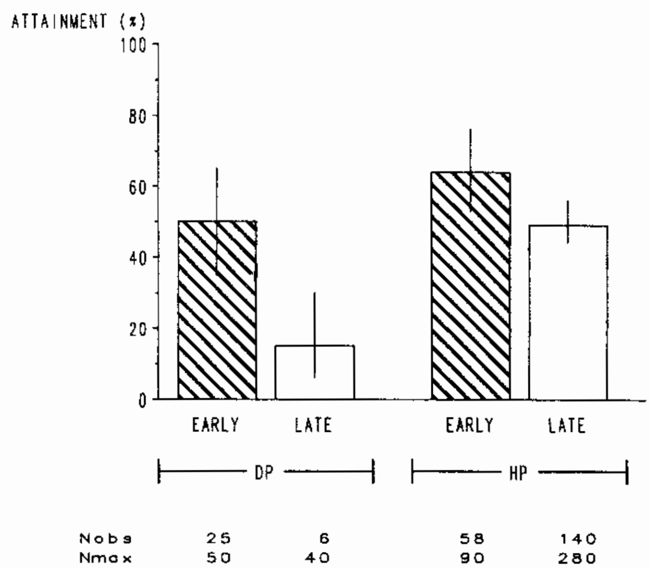

FIGURE 2.5. Vocal play. Percentage of attainment of expressive vocal play (babble and jargon) by each of the subgroups. The calculations are as described for Figure 2.2. The items that compose this measure are listed in Table 2.7.

the patterns observed previously, early intervention made a significant difference in both groups. (Compare the DPE vs. DPL and the HPE vs. HPL confidence intervals.) The difference between the HPE and HPL subgroups was significant: $\chi^2 = 5.15$, $p = .02$; that is, the apparent overlap is not real.

Examination of the confidence intervals in Fig. 2.5 yields further information: namely, that the level of vocal play shown by the DPL subgroup was significantly less than that of any of the other subgroups. In other words, vocal play is facilitated in children of deaf parents by an early oral environment, but not necessarily by a later one. This stands in contrast to deaf children of hearing parents, where even though it is true that early intervention has a significant effect, late intervention has a significant effect also.

Not illustrated in the figure is the age at which the items were attained. Here, the HPE and DPE subgroups showed some interesting differences. For the HP groups, there was an equal spread of success between the second (33%) and third (26%) years; for the DP group, attainment was concentrated more in the first two years (40%) than in the third year (10%). These differences would seem to underline the importance of early intervention for the DP group for vocalizing.

Summary. There was a higher level of performance of early vocal items (babbling and jargon) by children of hearing families than by children of deaf families. Furthermore, there were two interesting effects of age of intervention for this set of behaviors: (a) early intervention made significant differences for both groups, but (b) later intervention seemed to benefit HP children more. The DP group seems to be following more of Mavilya's (1972) pattern by showing a diminution of vocal play with age. The lack of a similar trend in the HP group may be a reflection of hearing parents' greater concern to have their children speak, which is further reinforced by programmatic efforts in that direction.

Expressive Vocabulary

Table 2.8 lists the items that jointly compose the expressive vocabulary category. Unlike for the previous categories, the conceptual dividing line between the items is not clear. Initially, the data were examined by looking separately at the first 4 items (attained by normal-hearing children during their first year of life according to the REEL Scale) and the last 6 items (attained by normal-hearing children during their second year of life). The results were the same for both halves; therefore the data are presented jointly to avoid repetition. Figure 2.6 presents the interaction effects graphically.

There was an overall performance level of 38% for the items in this category. There was no significant difference between the DP (40%) and the HP (37%) groups. Figure 2.6 shows that age of intervention appeared to affect attainment in both groups significantly. Not shown in the figure is that no child attained any of the items in the first year, and the spread of attainment was equal between the

TABLE 2.8. Items used to measure expressive vocabulary. (Attained by normal-hearing children during their first and second years of life. See Fig. 2.6.)

Uses some wordlike expressions (appears to be naming things in his own "language")
Speaks first words often ("da-da," "ma-ma," "bye-bye," or the name of a pet or a toy)
Uses 3 or more words with some consistency
Uses 5 or more true words with some consistency
Consistently uses 7 or more true words
Most communication is now accomplished by using some true words along with gestures
Begins using words rather than gestures to express wants and needs
Evidences a continual increase in speaking vocabulary
Has a speaking vocabulary of at least 10–20 words
Speaks more and more new words each week

second and third years. In other words, there was no difference between the DPs and the HPs with respect to their pattern of performance, and early intervention benefited them both.

Other Expressive Categories: Parts of Speech and Combinations of Words

Two other expressive measures were examined, and, like their counterparts in the receptive part of this paper, the categories represent groupings of items that normal-hearing children attain, on average, in their second and third years of life. The first category is labeled "parts of speech" and includes the items listed in Table 2.9A. The second category deals with complex combinations of

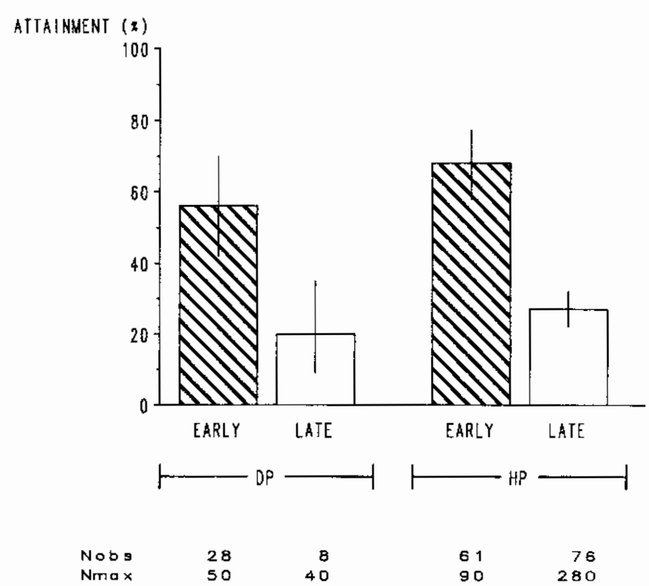

FIGURE 2.6. Expressive vocabulary. The percentage of attainment of expressive vocabulary by each of the subgroups was calculated as indicated in Figure 2.2. The items that compose this measure are listed in Table 2.8.

TABLE 2.9. Items used to measure other expressive categories: Parts of speech and combinations of words and sounds.

Category	*Item*
A. Expression of parts of speech (See Fig. 2.7A) (Attained by normal-hearing children by their third year of life.)	Begins using some pronouns but makes errors in syntax Often uses personal pronouns correctly (I, you, he, it, me, etc.) Refers to self by using a pronoun rather than his or her proper name Uses several verb forms correctly in relating what is going on in action pictures Uses some plural forms correctly in speech
B. Expression of more complex combinations of words and sounds (See Fig. 2.7B) (Attained by normal-hearing children during their second and third years of life.)	Some true words now occur in jargon utterances Begins combining words into simple sentences (like "go bye-bye," "daddy come," etc.) Attempts to tell about experiences using a combination of jargon and some true words Occasionally uses 3-word sentences (such as, "There it is," "Play with blocks") Usually uses 2-word or 3-word sentences Regularly relates experiences from the recent past (what happened while he or she was "out" or separated from parent)

words, and ranges from the ability to utter true words in a jargon framework to the ability to express more complex combinations (see Table 2.9B for a list). Figure 2.7 presents the results, separately for the DP and HP groups and separately for each category.

Parts of speech. In this category, only 7% success was exhibited by the children when the groups are combined. (Again, please note the expansion of the scale in the figure.) The DP group scored higher than the HP group (χ^2 = 4.85; p = .03; see Table 2.2), and there was no significant effect of intervention age. However, as Fig. 2.7 shows, there is a difference in the direction of the effects of intervention age between the DP and HP groups: The DPs did not seem to benefit from early intervention. If items were attained, it was in the third year of life, which is when they would be expected to emerge in normal-hearing children.

Complex expressive combinations. The overall success level of children in the sample in their attainment of the "combinations" category was 18%, but there was a significant performance difference between the two groups: 30% for the DPs and 14% for the HPs (χ^2 = 6.48, p = .01). Fig. 2.7B shows the breakdown of the interactive data for the DP and HP groups by intervention age. While early intervention seemed to favor higher attainment in both groups, the effect was only significant for the HP group. Again, if items were attained at all, it was during the third year of life.

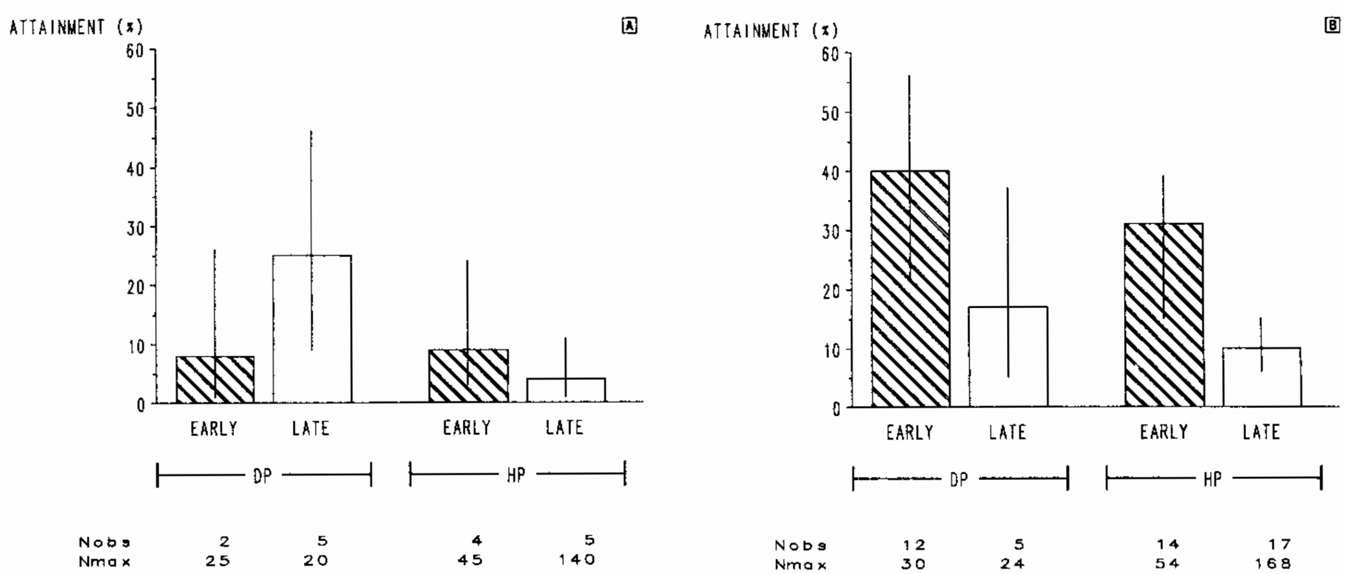

FIGURE 2.7. Other expressive categories. The percentage of attainment of the expression of parts of speech (A) and of combinations of words and sounds (B) for each of the subgroups. Although the calculations here are as defined for Figure 2.2, please note that the scale has been expanded. The items used for this measure are listed in Table 2.9.

Summary. Attainment was low for both advanced categories of expressive behavior, but children of deaf parents generally performed significantly better than children of hearing parents. Where age of intervention made a significant difference, it was for the HP group only. In fact, the HPL group (deaf children of hearing families where intervention was late) uniformly achieved the least of all the children.

DISCUSSION AND CONCLUSIONS

This study explored the effects of the hearing status of the parents and the child's age at intervention on the receptive and expressive language of a population of hearing-impaired infants up to 36 months of age. Here, we wish to expand the discussion and present the findings in their broader context; measures are not discussed separately unless they require special attention.

Several basic questions were posed. The first concerned the overall success of the total group compared to their normal-hearing peers. It was shown that (a) on average, about 50% of the deaf children attained, by 36 months of age, some command of items that normal-hearing children attain in their first year, and (b) very few of the children attained a command of items that hearing children usually attain in their second and third years. Similar delays have been found by others in studies of slightly older deaf children. (For example, see work cited in Kretschmer & Kretschmer, 1978.)

The second question concerned the overall effects of family hearing status and age of intervention. Regarding the family hearing status, children from deaf homes (DPs) performed at the same overall level as those from hearing homes (HPs) for the receptive skills measured. That is, performance was equally good for the preliminary receptive items and equally bad for the advanced receptive items. For the expressive skills, the picture is more complex. Here, the results confirm that speech skills must be separated from language skills because, in many cases, there is little correlation between performance in the two areas. In an overall sense, the DPs performed better in the language areas and the HPs performed better in the speech areas (see also Table 2.2). However, family hearing status alone does not give all the answers; the detailed picture is more interesting, particularly in the speech area. For early vocal behaviors, the poorer performance of the DP group is due solely to those children who were in the later group (DPL; see Fig. 2.5). Also, there was absolutely no difference between the performances of the DPE and either the HPE or HPL groups.

It is plausible, therefore, to conclude that (a) early exposure to an oral environment is necessary for the later oral success of deaf children coming from both hearing and deaf homes, but that (b) later exposure may not be as effective for deaf children coming from deaf homes. These findings are interesting in light of Ling's ideas (e.g., 1976 and 1981) about the importance of adequate early foundations for the successful teaching of speech skills. While the "oral" environment provided in a deaf home has been shown to be a sufficient language-learning model for hearing offspring (Schiff-Myers, 1976), it may not be a sufficient model for deaf children. Therefore, if one's goal is to be "oral," the early exposure to an oral environment is crucial, particularly for those coming from deaf homes (the DP group).

In general, early intervention had a strong positive effect on the attainment levels of both DPs and HPs. However, the richness of the findings is lost if one stays at this general level. The joint effects of the two variables account for more of the differences between the children than either variable alone, and these effects ultimately will influence the outcome of remediation efforts. The third question posed by the study addresses this issue of interaction.

By looking at the joint effect of hearing status of the family and age of intervention, we see that the effects of intervention age are different for the DP and HP groups; early intervention makes more of a consistently significant difference for the HPs. Examination of Figures 2.2 to 2.7 reveals several things. First, for the HP group, the children for whom intervention was early showed a significant advantage for 9 of the 10 possible measures. Second, there is an almost exactly opposite effect for the DP group, where for 8 of the 10 measures there were no differences between children for whom intervention was early (DPE) and those for whom it was late (DPL). The two exceptions are seen in Figures 2.5 and 2.6, which measure early vocal play behaviors and expressive vocabulary. Finally, ignoring significance levels for the moment and concentrating solely on the direction of the differences of the effects of early versus late intervention, we find that there is no exception to the rule that, for the HP group, early intervention leads to higher attainment than late intervention. However, this is not true for the DP group where, in 5 of 10 cases, early intervention effects are positive (Figures 2.2A, 2.3A, 2.5, 2.6, and 2.7B, where DPEs do better than DPLs), and in the other 5 cases the direction is actually negative (Figures 2.2B, 2.3B, 2.4A, 2.4B, and 2.7A, where DPEs do worse than DPLs). Note that the latter five figures contain data resulting from the measurement of all but one of the more advanced language categories.

We cannot yet isolate which of the related events associated with early intervention (early diagnosis, early aiding, early training, and—it is hoped—early acceptance of deafness by the family) is responsible for the consistent positive effects of early entry for the HP groups. As is usually true, all of these are likely to be important. However, the main point is that the consistency of these effects should argue strongly for the continuance of early programs for deaf children of hearing parents. This finding is in direct contradiction to the findings of Musselman, Lindsay, and Wilson (1985), where age of intervention was not shown to make a difference. For the deaf children of deaf parents (DP group), however, the anomalous results imply that there may be additional factors operating. One possibility might be that we were witnessing a "bilingual effect" in operation. Kretschmer and Kretschmer (1978), for example, argue that gestural systems have conceptual/syntactical categories that differ systematically from those used in spoken English. Deaf children who use a gestural system may thus face transition difficulties that "might in effect be second language learning" (p. 93).

Thus, deaf children of deaf parents who are identified at older chronological ages may actually be impeded in their learning of spoken English. This point should not be confused, however, with the argument made earlier about vocal skills. The results here are exactly opposite; whereas early entry seems to enhance speech skills, it appears to depress language skills in the DP group. One can make this statement because of the longitudinal nature of the data. In other words, by 36 months of age, we found that children who entered the program earlier were scored as performing lower than children who entered later. We should state, however, that the data presented here do not address the question of eventual success; they address only the performance of the children up to 36 months of age.

There is evidence in the literature on bilingual education (e.g., Mackay & Andersson, 1977) of this type of performance depression upon the introduction of a culturally dominant language form that is different from the language spoken at home. Suggestions of this type of effect in the deaf have also been made by Liben (1978), as well as by the Kretschmers (1978). If this is indeed the case, it would argue for greater programmatic flexibility, particularly in the methods used to communicate with parents who may be using a different language system. Reference to Table 2.1 will show that in all but one home, the DP group experience a manual environment, even though parents told us that they were communicating primarily in English with their children.

There is another type of effect noted in the language development literature that could be relevant here: the effect that deals with the consequences of early mismatches between mother and child in communication style on the rate of language learning. This idea was first articulated by Nelson (1973) and subsequently studied by other workers (e.g., Horgan, 1980). For the deaf, work has been done in this area by Meadow et al. (1981) and by White and White (1984). The Kretschmers (1978) note that this type of mismatching effect could become operative between deaf children and their deaf parents when they are placed in a competing language environment. Conversely, the same effect would be expected if we insist on teaching a manual mode to the deaf children of hearing parents if the parents themselves are either not involved in the learning process or regard the new language form as alien (see also Meadow, 1980).

The final question addressed the time of occurrence of the linguistic measures relative to their occurrence in normal-hearing children. As noted earlier, we found a uniform delay. For those items that are attained by normal-hearing children in their first year, very few were scored as being firmly established at that time in the deaf population; in fact, there was a fairly equal spread of attainment of those items during the second and third years. The more advanced items—those attained by normal-hearing children in their second and third years of life—were attained by very few of the children in the sample. If the advanced items were attained, it was usually in the latter half of the child's third year. It is important to note that the data, as analysed and presented in this study, address only the question of time of attainment and not the question of the quality of attainment. The difference between these issues is, of course, the difference between asking whether the children are delayed or deviant in their language skills. We cannot address the latter question in this paper because we did not attend to the patterning of the attainment of items. Also, the data do not provide enough information to know what 50% success means. Does it mean that 50% of the children attained all the items, or does it mean that 50% of the items were attained by all the children? The interpretation of the results would be different in each case. With respect to the question of delay, then, it is clear that the children in our study were delayed in both receptive and expressive areas.

Also, it is only possible to address the question of deviance or delay if we have assessment instruments available that can look at our population objectively. As Miller (1981) notes when addressing the development of a philosophy of assessment, "The first step in describing language behavior is to find an approach to assessment for the population under study that *quantifies valid indices of performance*" (p. 2, our italics). In the present study, we modified an instrument that was designed for a normal-hearing population; we consider this to be only a first step, and a halting one at that. Examination of the items listed in Tables 2.4–2.9 should leave the reader dissatisfied with the measures we used. While we had no basis for changing those measures initially, we would now recommend a more observationally oriented assessment technique. Observational techniques are a more fruitful approach to the study of emerging language skills in a population where linguistic output is likely to be highly variable, idiosyncratic, and may involve gestures whose consistent use will not be recognized by conventional techniques. We strongly believe that effective remediation starts with effective assessment, and we will not have effective assessment procedures until we begin to attend to the processes of development rather than just to its outcomes. Understanding the process is crucial. Too often we are forced to use developmental models that come from observations of normal-hearing, middle-class children who most often come from graduate student homes. The relevance of such models to a deaf population is not known.

All the children in our sample were severely to profoundly deaf. The usual prognosis for such children is bleak with respect to their eventual linguistic achievement, particularly in an oral setting. Their chances of success can be maximized by early detection and intervention, early involvement of the family, and the use of sensitive assessment instruments. Equally important is programmatic flexibility. A strong implication of this study is that there is no single approach to remediation that will benefit each child equally. This is cogently argued by White (1984). In the present work, it is suggested that remediation efforts will be more effective if they are sensitive to the hearing status and natural language of the individual family. Thus, effective remediation must rest on a three-pronged approach. It includes (a) the use of appropriate assessment instruments to measure progress, (b) the use of appropriate models to be able to understand and counteract failure, and (c) the ability to remain flexible, because this recognizes that the deaf population is heterogeneous. While these may seem like commonplace conclusions, we look forward to the day when they are in commonplace practice.

ACKNOWLEDGMENTS

The activity that is the subject of this report was supported in part by the U.S. Office of Education, Department of Health, Education, and Welfare, Grant No. G007802094. The opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education, and no official endorsement by the U.S. Office of Education should be inferred.

We would like to thank the families who participated in this study, as well as the Infant Center staff who helped both with the design of the instrument and with the collection of the data. The staff included Joan Godshalk, Margerie Held, Cissie Dietz, Betsy Kaplan, and Wendy Given. We are grateful to Leo Connor, Executive Director of the Lexington School, for permission to use the school facilities. The data gathering and coding process took many years and involved many research assistants and associates. They included Elaine LaPorte, Adrianna Oleksiuk-Velez, Diana Silber, Fran White, Ed Kenny, Barbara Richardson, Janet Mindes, and Joan Wolf. The data analysis was facilitated by the services available at the Academic Computing Center at Queens College.

The final version of this chapter was guided by comments from and discussions with Alan Lerman, Marion Blank, Rebecca Kantor, Carole Reich, and Betty Nower. We are also grateful to the editors (H.L., N. McG., & D.G.) for their encouragement, patience, and comments. Finally, special thanks for service beyond the call of duty go to Lucille Mazzoli.

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Chapter 3

The Development of Language in Young Hearing-Impaired Children

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It has been said that there is no invariant pattern of language development that differentiates children with hearing handicaps from children with normal hearing. When acoustic cues are severely limited, qualitative and quantitative deviations appear in the early utterance. But the stages of language development may or may not differentiate the child with hearing loss from a normal-hearing child. What the nature of those differences is and whether they are deviations of a qualitative nature have been investigated during recent years. We are beginning to learn that even as early as the first few months of life, vocalizations of hearing-impaired children deviate from those of the hearing infant. It was observed that hearing-impaired children evidenced a peak in quantity of vocalization that was followed by a noticeable decrement with a paucity of consonant production (Mavilya, 1972). This information provides some evidence that the "babbling stage" may differ for the hearing-impaired population. This difference may not be trivial, according to Menyuk (1977), when one considers the babbling stage to be a period during which the normal-hearing infant makes perceptual and productive categorization of the speech signal, and "these categories may be crucially important for later language development" (p. 625). During this period, the severely impaired infant may stop vocalizing spontaneously and may lose acoustic information of vital importance. Studies that attempt to systematize the development of early vocalizations beyond babbling have been limited. There are few comprehensive developmental schedules for oral language development in the hearing impaired, partly because of the lack of assessment tools for this population, but also because of the heterogeneity of speech and language skills of hearing-impaired children. The purpose of this investigation was to investigate the language skills of hearing-impaired children at a young age and to determine whether patterns of language development in older hearing-impaired children, as measured in a concurrent, longitudinal study (Chapter 5), can be traced to earlier antecedents.

Psycholinguistic research over the last 15 years has provided much information pertaining to language acquisition of normal-hearing children. Negation, plurality, and "wh-" questions appear to be among the first learned constructs. Surface word order has been observed to be an early strategy for sentence formation. Research on language acquisition by deaf children has not enjoyed the same degree of attention or proliferation until recently. Investigations of the comprehension of language have been sparse for the younger elementary age deaf child (below 7 years of age).

In accounts of language disorders in the hearing impaired, the form of the utterance has been more carefully studied than the use of content. Investigations have used written production and reading to assess language performance, thereby producing more data on written skills. Sentence length, noun phrase, and order of difficulty of syntactic structure were determined. Results of these studies show that hearing-impaired children, when compared to normal-hearing children of the same age, produce shorter sentences with a larger proportion of simple sentences and fewer compound and complex sentences; they often use a fixed form or stereotypic carrier phrase in sentences (e.g., "The boy . . ."); they use word classes with a greater proportion of nouns, verbs, and articles than adverbs, pronouns, prepositions, and wh- questions (Brannon, 1968), and they have difficulty applying morphologic rules.

Quigley and his colleagues (Quigley, Power, & Steinkamp, 1977; Quigley, Smith, & Wilbur, 1974; Quigley, Wilbur, & Montanelli, 1974; Quigley, Wilbur, Power, Montanelli, & Steinkamp, 1975; Wilbur, Quigley, & Montanelli, 1975) have carried out extensive investigations of language comprehension and production in older deaf children, 10 to 18 years of age. They tested a wide range of syntactic and morphological structures, including the use of negation and question formation and the use of the passive construction, by means of written samples and answers to multiple choice questions (see Chapter 5). Cooper (1967) tested the ability of 9- to 20-year-old deaf children to comprehend various syntactic and morphologic structures using the written modality.

Menyuk (1977) has said that comprehensive developmental schedules for oral language development in the hearing impaired do not exist. The heterogeneity in speech and language skills of hearing-impaired children render such a developmental summary a difficult task. Various stages of syntactic development have been described (Bloom & Lahey, 1978; Brown, 1973); their boundaries are defined by mean length of utterance in morphemes (MLU). With this definition of boundaries, language comprehension and production can be described within each stage, which provides an observation of sequential development of language learning behaviors. Such a systematic process can provide information on fundamental language behaviors.

Literature on MLU

Behaviors of oral language performance have been cited in the literature for younger deaf children, but only to a limited degree. Hess (1972) investigated oral language productions of a hearing-impaired and a normal-hearing boy on the basis of mean length of utterance (MLU) and found the former to evidence the same sequence of acquisition of structure as the normal-hearing child. Smith (1972) evaluated hearing-impaired and normal preschool children on the basis of MLU and placed them into one of three stages of language development. The hearing-impaired children performed in the same manner and at the same level as the normal-hearing children within each stage of language development. When equated on the basis of MLU, the two groups of children appeared to use similar comprehension strategies, with a change in strategies coincident with changes in language development. The results also indicated that children with lower MLUs focused on the semantic relationships being expressed, whereas those with higher MLUs used both semantic and syntactic information in their grammatical strings.

Literature on Semantics

Studies citing semantic proficiency in language behavior have been reported. Holmes and Green (1974) studied the semantic system of hearing-impaired subjects at ages 8.6 and 12.6 years. The younger group did not show a definite semantic structure as measured by the semantic differential task. The older children demonstrated semantic differential judgments similar to those of normal-hearing children. Koplin, Odom, Blanton, and Nunnally (1967) found that responses of hearing-impaired individuals on a word association task are comparable to those of younger children having the same reading level. They did give, however, more syntagmatic responses (different form class) than paradymatic responses (same form class). Blanton and Nunnally (1964), using a forced choice procedure with a word association task, found that the hearing impaired gave responses with more "concrete" language. Brannon (1968) used a 14-word classification system to study word classes in the spoken language of 30 normal, 15 partially hearing (PTA = 62 dB ANSI), and 15 deaf children (PTA = 92 dB ANSI). Individuals in the two hearing-impaired groups ranged in age from 8.7 to 18.5 (mean 12.6) years. Fifty spoken sentences were elicited from each child in response to colored pictures that depicted children and adults engaged in everyday activities. Sentences were tape recorded, and the hearing-impaired children wrote down each sentence after saying it. Intelligible words were sorted into each of the 14 categories. Brannon found a decrease in the number of words used with increasing hearing impairment. The partially hearing were not different from those with normal hearing for most of the classes, but they deviated in use of adverbs, pronouns, and auxiliaries, all of which were areas of deficiency for the deaf children. When the number of words used by each group in each class was expressed as a percentage of the total number of words produced, both the hearing-impaired groups showed reduced output of adverbs, pronouns, and auxiliaries, and they over-used nouns and articles. The deaf group underused prepositions, quantifiers, and indefinites. In an attempt to explain such language behavior, Griswold and Commings (1974) said that although hearing-impaired children show restricted understanding and use of noun and verb concepts, they experience even greater limitations in the acquisition of words that express relationships among other words in the context of a sentence. Function words such as prepositions, conjunctions, articles, and adjectives have few visible referrents, but rather they serve to clarify relationships among peple, objects, or events. They exist because of the choice and order of words, and they are usually short and unstressed, which explains why they are more easily obscured than nouns and verbs that have greater acoustic prominence because of duration and suprasegmental marking. Thus, because such words are often lost when portions of the speech signal are obscured, they are deficient in the vocabulary of hearing-impaired children.

In another study of vocabulary norms for deaf children, Silverman-Dresner and Guilfoyle (1972) used a typewritten vocabulary test and had the children select the most appropriate definition from among four choices. Girls scored higher than boys in mean correct response. When words were classified into parts of speech, there was an overall increase with age for all classes (nouns, adjectives, verbs, pronouns, function words, etc.). The relative gains were greatest in the early years, as expected. At the age of 16 to 17 years, 48% of the function words and 71% of the noun-related words were identified correctly. Another study of semantic skills was carried out by Sarachan-Deily and Love (1974), who used a sentence repetition task. Hearing-impaired subjects violated the syntactic integrity of the sentence by inserting words that distorted the semantic intent, thereby producing agrammatical sentences. Whereas the normal-hearing children tended to use synonyms for lexical items, the hearing-impaired-children were unable to repeat sentences that were semantically acceptable.

Literature on Syntax

Odom and Blanton (1967) discovered that when deaf children were asked to recall a series of English strings varying in grammatical correctness, grammaticality did not help them in remembering the strings; this was not the case for normal-hearing children. The authors argue that some interaction between a lack of coding in short-term memory and insufficient competence in the rule system of English affected performance. Streng, Kretschmer, and Kretschmer (1978) felt that this evidences a lack of depth in language acquisition, not deviance, which is somewhat analogous to the situation with bilingual children. Bilingual children who are tested in their non-native language experience similar performance problems. Their problems reflect a lack of mastery of the language system being tested and not a deviance in that language. The unfortunate difference, as seen by Streng et al. (1978), is that the deaf child, unlike the Spanish-dominant child, is not dominant in any language system.

It has been cited that hearing-impaired children display an overall reduction in the stability and complexity of their sentence structure (Tervoort & Verback, 1967) as well as difficulties with verb usage (Presnell, 1973), passive constructions, pronouns, questions, conjunctions, and complements (Quigley, Wilbur, & Montanelli, 1974). It has been observed that deaf children encode temporal sequences in the same way that younger hearing children do, for example, using *and* to conjoin descriptive sentences in a linear time frame (Jarvella & Lubinsky, 1975). However, when using *and* in conjunction-reduction sentences, deaf children, unlike normal-hearing children, eliminated any item in the second sentence that appeared in the first sentence, which resulted in an incorrect sentence (Quigley, Wilbur, & Power, 1976).

Evidence seems to point to the fact that syntactic structures in deaf language reflect an earlier level of development, with the rate of acquisition being slower for the deaf child than for the normal-hearing child. Gaffney (1977) tested deaf and normal-hearing children aged 5 to 7 on an oral or manually presented syntax test and found that, whereas the deaf children acquired the syntactic structures tested in much the same order as normal-hearing children, they did so at a slower rate.

Presnell (1973) studied the comprehension and production of syntax by 5- to 13-year-old deaf children using the developmental sentence scoring test (Lee, 1974) and the Northwestern Syntax Screening Test (NSST) (Lee, 1969), and reported that deaf children acquire syntax, as measured by the NSST, at a slower rate than normal-hearing children.

Do the structure and development of the language of deaf children differ from those of normal-hearing children? Only a few studies have dealt with children below the age of seven. Bench (1979), in his detailed report of British and American studies of partially hearing and deaf children, concluded that the question of whether or not the spoken language of hearing-impaired children is deviant or retarded has not yet been answered. However, on the syntactical level, poor linguistic performance may be explained on the basis of general retardation, rather than deviancy. Furthermore, he found that American studies are in agreement with the British work in that hearing loss, when severe, has marked and significant effects on several measures of spoken language.

In spite of limitations in the information concerning language structure and function in the hearing impaired, several conclusions can be drawn: (a) hearing-impaired individuals, as a group, are delayed in language learning relative to normal-hearing individuals; (b) in spite of a language delay, hearing-impaired children's sequence of acquisition may be similar to that of normal-hearing children in both comprehension and production; and (c) differences in word meaning and usage may be more closely related to the method of instruction in the classroom than to the hearing impairment, which leads one to question the method and content of language teaching within a particular educational setting when evaluating language function (Hutchinson & Smith, 1980).

The data reported in Chapter 5 of this volume indicate that, for older hearing-impaired children, the question is not whether language development in the hearing-impaired child is delayed or deviant (i.e., different) but rather, how delayed and how different? Delay and difference are not mutually exclusive; if anything, delay and difference are causally related. The longitudinal study on older children showed that both delay and difference were most noticeable among the children with the poorest language skills. In the study reported here, special attention was paid to the possibility that children with the poorest skills would be the most likely candidates to show differences in language development.

METHOD

Sixty-seven hearing-impaired children who were 6 years of age were studied. The children were selected from schools for the deaf throughout New York State. All were prelingually impaired with no additional handicapping conditions. Every attempt was made to obtain a comprehensive sample, subject to the above constraints. It is estimated that over three quarters of all 6-year-old hearing-impaired children attending schools for the deaf in the State of New York were tested in this study. The major exclusions, in addition to those noted above, were children who were absent from school at the time of testing, or children who could not be reached for logistical reasons. Problems of this type precluded the testing of children at one oral school for the deaf.

The 67 children who were tested ranged in age from 6 years to 6 years 11 months. Their mean hearing loss was 104 dB (SD = 10 dB) for the octave frequencies 250 to 4000 Hz. The mean age at which a hearing loss was first diagnosed was 1.6 years (SD = 1.1 yrs). A hearing aid was first fitted at a mean age of 2.7 years (SD = 1.2 yrs), and special education was initiated at a mean age of 3.1 years (SD = 1.4 yrs). The average IQ score was 106 (SD = 16.4). Ninety percent of the children were in total communication programs. English was the primary language spoken at home for 76%, while sign language was primary for 11%. Spanish was cited as a primary language for 13% of the parents.

The evaluation of language function is limited to the use of assessment tools that are available for normal-hearing children or to those few that have been designed for deaf children. Assessment methods developed for normal-hearing persons include tests of expressive and receptive language and tests of phonologic, morphologic, syntactic, and semantic development. To use them in assessing the hearing impaired, modification in test presentation, instructions, and evaluation is necessary. It is clear that such tests generate data that cannot be compared with normal data, but they do provide information concerning baseline behavior and intervention effects.

A variety of methods has been developed to assess language function in the hearing impaired. A sequential checklist to determine developmental progress in audition, speech, language, and communication has been developed by Ling (1977). Chalfant's (1977) communication checklist includes motor performance, speech imitation skills, gestural language, and receptive and expressive oral language arranged from preverbalization to age 5 years. Checklists, however, can not determine baseline behavior or effects of intervention. The evaluation procedures used to measure comprehension skills in this project included an adaptation of a test for normal-hearing children—the Assessment of Children's Language Comprehension (ACLC) by Foster, Giddan, and Stark (1974)—and a test designed for deaf children—the Syntax Screening Test (SST) by Gaffney (1977). Both were standardized on younger children and did not require written skills.

Tests Administered

Assessment of Children's Language Comprehension. The ACLC consists of a series of 40 plates of several black silhouettes. The examiner presents the stimulus word with a carrier phrase, such as "Show me walking." The subject indicates which of the silhouettes on the page corresponds to the stimulus.

The first section (A), vocabulary, includes common nouns, the present progressive form of verbs (e.g., *walking*), prepositions, and adjectives. The 50 items in this section are commonly used, and each contains no more than two syllables.

Sections B (two critical elements), C (three critical elements), and D (four critical elements) measure the subject's ability to comprehend increasing numbers of lexical items, which are referred to as critical elements. In Section B, for example, the child must identify two critical elements for each of 10 plates and chose one from among the four silhouettes choices placed on each plate. The items include the following relations: agent-action (e.g., *man sitting*), attribute-agent (e.g., *happy lady*), and attribute-object (e.g., *dirty box*). In Section C, the stimuli contain three critical elements, such as *happy lady sleeping*, and in Section D, four critical elements, such as *broken boat on the table*. Each section contains 10 items. The subject was required to point to one of four or five black silhouettes as a response.

The Syntax Screening Test. The receptive language skills of the subjects were also tested with a syntax screening test (Gaffney, 1977) devised specifically for young hearing-impaired children. The test had several important practical advantages. It was short, easily administered, and appropriate for hearing-impaired children in whichever mode of communication they preferred (speech and speechreading, signed English as one dimension of total communication, or fingerspelling with speech). A further advantage is that the test does not require the child to be able to read or write. The vocabulary was incorporated into the test only after it was documented as being used in a preschool class in a New York City school for the deaf. Five-year-old normal-hearing children obtain a virtually perfect score on the test.

Appendix A shows the test items making up the Syntax Screening Test. Section I contains 13 sets of 4 pictures each. The acceptable response to this section is simply pointing to the picture that corresponds to each stimulus sentence signed or spoken by the examiner. Six of the 13 test items cover three forms of negation: nonexistence, rejection, and denial (both with and without *do* support). Four of the test items cover plural forms (including regular and irregular nouns and verbs). The remaining three items test the child's processing of surface word order. One of those three items is the passive voice.

Section II of the test contains 18 questions used in conjunction with two pictures. Two of each of the following question types were asked: *yes/no, yes/no* with *do* support, *why, where, when, what* (object), *what* (subject), *who,* and *whom.* The child was required to respond to each question with verbal or manual response. Pointing to an appropriate item in the picture was not acceptable.

The test was administered to each child individually in his or her preferred mode of communication, that is, speech and speechreading, manual, fingerspelling, total communication with signed English, or any combination of these as long as it conformed to the rules of English syntax. (Ameslan could not be used because surface word order and plurals were being tested, and Ameslan follows sui generis grammatical rules). The test took approximately 15 minutes to administer. For further information on the Syntax Screening Test, see Gaffney (1977) and Geffner and Freeman (1980).

Raven Coloured Progressive Matrices Test. The Raven Coloured Progressive Matrices Test requires the child to identify geometrical patterns in a pictorial format. The test, by itself, is not a test of intelligence but rather is described by its author as a test of observation and clear thinking designed for use with people, who, for a variety of reasons, do not use spoken English as their main mode of communication (Raven, 1965). Therefore, it seemed appropriate for use with this population of hearing-impaired children.

As its name implies, the Raven Progressive Matrices is designed to present each task in a progressive scale where the early tasks are the "mother" or source of a system of thought for subsequent tasks. Training and developing the thought process necessary to solve one task should enable the subject to pursue the next task in a sequential format. The test consists of 3 sets (A, Ab, and B) of 12 problems which, according to Raven (1965, p. 3) are arranged to assess the chief cognitive processes of which children under 11 years of age "are usually capable. The three sets combined provide opportunities for a person to develop a consistent theme of thought, and the scale of 36 problems as a whole is designed to assess as accurately as possible, mental development up to intellectual maturity" (p. 3). The three sets of matrices have been constructed to assess the individual's mental development up to the point where one can accurately reason by analogy.

RESULTS

Tests for Language Comprehension

A comparison of the mean scores attained by deaf children in the present study and by normal-hearing

TABLE 3.1. Mean scores obtained on the ACLC by normal-hearing children ($N = 44$) and deaf children ($N = 65$) ages 6.0–6.11.

Section	*Mean for hearing children (%)*	*Mean for deaf children (%)*
A Vocabulary	98.2	89.0
B Two elements	99.3	85.2
C Three elements	98.2	64.5
D Four elements	92.9	44.9

Note. The data on normal-hearing children are from *Assessment of Children's Language Comprehension* (p. 18) by R. Foster, J. Giddan, and J. Stark, 1974, Palo Alto, CA: Consulting Psychologist. Copyright 1972 by Consulting Psychologists Press. Reprinted by permission. The data on deaf children are from "Assessment of Language Comprehension of 6 Year Old Deaf Children," by D. Geffner and L. Freeman, 1980, *Journal of Communication Disorders, 13,* 463. Copyright 1980 by Elsevier-North Holland. Reprinted by permission.

children in the ACLC (Foster et al., 1974) is presented in Table 3.1. Findings for deaf children are considerably below those of 6-year-old normal-hearing children.

The results are more comparable to those of normal-hearing children of younger age levels. For Section A (vocabulary), the mean score was equivalent to the mean score obtained by 4.5-year-olds. The mean for Section B (two elements) was comparable to that of children age 3.6, whereas the means for Sections C and D were below those of the minimum age level of normal-hearing children tested (3.0 years).

Further analysis was performed to investigate performance on subdivisions of the test for children at different levels of overall performance. The children were ranked according to their total scores on the ACLC and then subdivided into 10 groups, referred to as deciles. The lowest 10% of the children were grouped into Decile 1, the next lowest 10% into Decile 2, and so on.

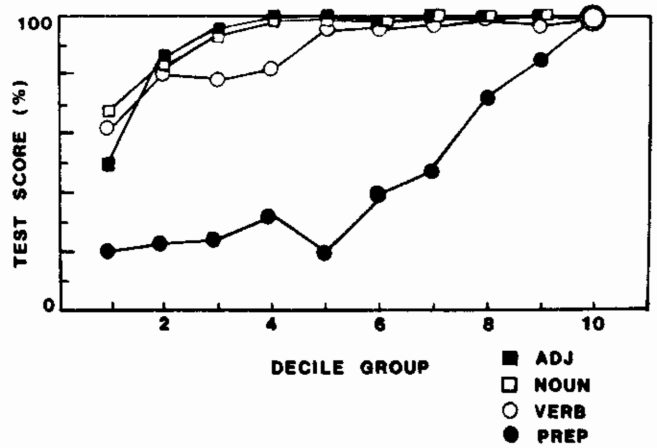

FIGURE 3.1. Relative performance by decile group on four word types (ACLC Test).

Figure 3.1 shows relative performance by the 10 decile groups on each of the four word types. The scores for nouns, verbs, and adjectives were close to the maximum for the top five decile groups. Performance for these three word classes dropped steadily for the lower decile groups. The lowest group, Decile 1, showed some evidence of a difference in relative performance in that the percentage-correct score for adjectives was lower than those for nouns and verbs. In all the other decile groups adjectives had the highest scores. The percentage-correct score for adjectives in Decile 1 is significantly lower than that for the other groups ($p < .05$), assuming a binomial distribution of test scores.

The prepositions were the most difficult word class for all decile groups. Scores for the lowest five deciles were no better than random guessing. The upper five deciles showed a rapid, systematic increase in the preposition score; children in the highest decile group obtained the maximum score for this word class.

Additional analyses were conducted to determine the

TABLE 3.2. Examples of ACLC stimuli analyzed by structure type and critical element.

Structure	*Test stimuli*	*Critical element*
Noun + verb		
subject + verb	horse standing	2
subject + verb + object	lady blowing the horn	3
subject + verb + adjective + object	clown eating the big apple	4
Adjective		
adjective + noun	dirty box	2
adjective + subject + verb	little clown jumping	3
Preposition		
noun + preposition	ball under the table	3
subject + verb + preposition	monkey sitting on the fence	4
adjective + noun + preposition	big basket under the chair	4
Compound phrase		
subject + subject + verb	bird and dog eating	3
subject + verb + subject + verb	dog eating and cat sitting	4
noun + verb + object + object	boy pulling wagon and car	4
object + adjective + subject + verb	happy little girl jumping	4
noun + noun	chair and horn	2
noun + noun + preposition	apple and shoe on the can	4

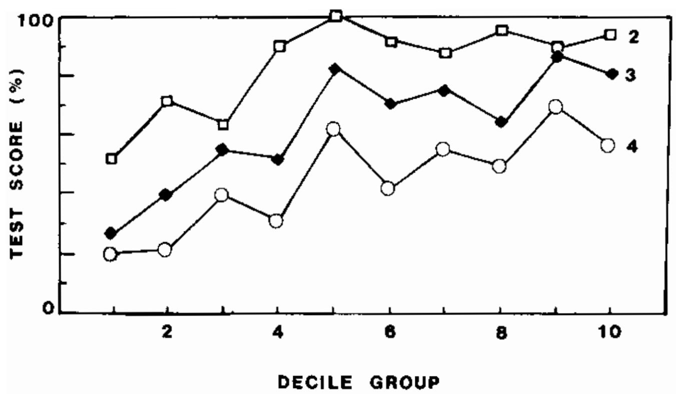

FIGURE 3.2. Relative performance on two, three, and four critical elements (ACLC Test).

nature of difficulty in comprehension of syntactic structures. In addition to the two, three, and four critical elements found in the ACLC test, each stimulus was determined to be one of the four structures (noun + verb, adjective, preposition, and compound phrase), as shown in Table 3.2. The complexity varies within each group and does not necessarily correspond to the critical element criterion.

The performance of the decile groups for two, three, and four critical elements is shown in Figure 3.2. In this case, essentially the same increase in performance with decile group was obtained for three subsections of the test; i.e., the curves were essentially parallel for two, three, and four elements.

The rank order of complexity of the structures tested is shown in Table 3.3. The data show that the noun + verb structure was the easiest to comprehend, and the noun + preposition structure was found to be most difficult.

The most difficult structures to comprehend were those containing four critical elements, for example, those with prepositions, and those with a compound form, such as compound adjectives *(happy little girl jumping)*, compound sentences *(dog eating and cat sitting)*, and compound nouns *(apple and shoe on the can)*.

The rank ordering of structures appears to be for the most part in agreement with the ACLC breakdown of the number of critical elements. Because the more difficult test items are among the longest, containing four critical elements, it cannot be determined whether it is the length of the stimulus, the structure type, or some combination of these two factors that affects comprehension of the compound form.

TABLE 3.3. Rank order of structures correctly identified by the 65 deaf children as compared to number of critical elements of ACLC stimuli.

Stimulus type	*Number of critical elements*
subject + verb	2
noun + noun	2
adjective + noun	2
subject + verb + object	3
subject + verb + adjective + object	4
adjective + subject + verb	3
noun + prepositional phrase	3
subject + subject + verb	3
subject + verb + object + object	4
adjective + noun + prepositional phrase	4
subject + verb + prepositional phrase	4
subject + verb + subject + verb	4
adjective + adjective + subject + verb	4
noun + noun + prepositional phrase	4

The Syntax Screening Test

For the Syntax Screening Test (SST), percentage-correct scores were tabulated for each syntactic structure tested. In Section I, which tested plurality, word order, and negation, plurality items were 46% correct; surface-word-order items, 52% correct for subject-verb-object order and 35% correct for passive items. This result is not surprising because the passive transformation is more difficult. In fact, Quigley, Smith, and Wilbur (1974) have found that deaf children to age 17 do not comprehend passive sentences completely.

Each child received six items dealing with negation. Those items dealing with rejection were found to be the easiest (59% correct), followed by those dealing with nonexistence (38% correct) and denial (32% correct).

Decile groups are presented in Figure 3.3. Again the lower groups were those who ranked poorest in mean scores obtained for negation, surface word order, and plurality on Part I, and for *yes/no* questions and *wh*-questions on Part II. It becomes evident that the higher decile groups performed similarly in the order of comprehension of the following items: plurality, surface word order, *yes/no* questions, negation, and *wh*-questions. The lower decile groups showed no better than random guessing for all forms except plurality. This result is very different from that obtained with children in the higher decile groups who scored relatively poorly on this form.

The *wh*-questions appear to be more easily responded to than *yes/no* questions, but the fact that all *wh*-questions were combined in this category (*who*-subject, *who*-object, *what*-subject, *what*-object, *where, when, why*) would account for the higher percentage of response.

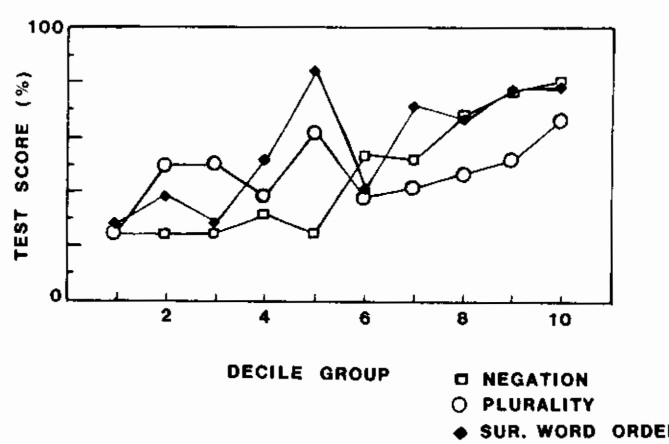

FIGURE 3.3. Relative performance on three syntactic structures (Syntax Screening Test).

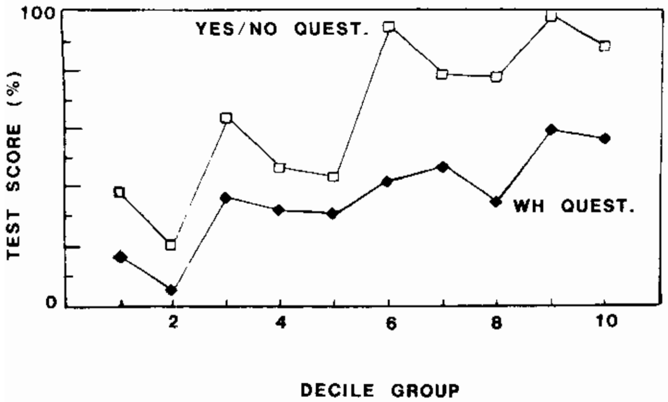

FIGURE 3.4. Relative performance on *yes/no* and *Wh*-questions (Syntax Screening Test).

In a detailed analysis of the order of comprehension of the eight question types determined by the number of correct responses (Figure 3.4), the following was indicated: *yes/no* questions were easiest, with 64% correct responses; *what*-subject and object questions received 64% and 62% correct responses respectively (mean 63%); *who*-subject and object questions were answered correctly 53% and 35% of the time respectively (mean 44%); *where* questions were answered correctly 24% of the time; *why* questions received 15% correct responses; and *when* questions were answered correctly only 5% of the time. In contrast, results for normal-hearing children of age 5 (Gaffney, 1977) indicate that all *yes/no* and 95% of the *wh*-questions were responded to correctly.

For both Section I and Section II, less than 50% of the test items were responded to accurately.

Raven Coloured Progressive Matrices Test

The overall mean percentage scores on the Raven Coloured Progressive Matrices Test were 64% on Set A, 42% on Set Ab, and 29% on Set B. Decile group performance (see Figure 3.5) indicated that Group 1, the lowest functioning group, achieved scores ranging from .15, .20, to .45; for B, Ab, and A respectively, whereas Group 10 achieved scores of .44, .65, and .85 for the B, Ab, and A sets. For all the groups, performance was clearly poorer on the B set and better on the A set. Further, all 10 decile groups showed the same ordering for the B, Ab, and A sets.

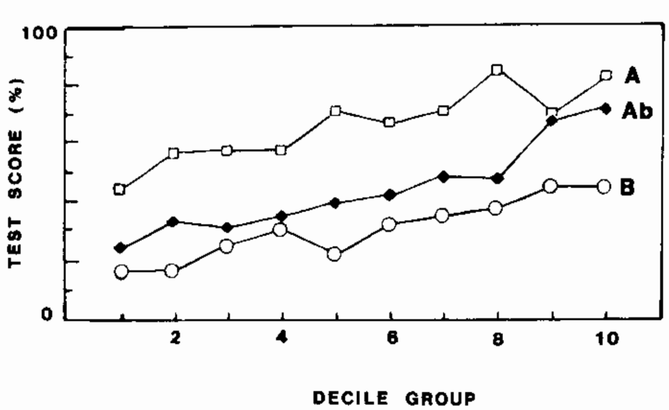

FIGURE 3.5. Relative performance on sets A, Ab, and B of the Raven Colored Progressive Matrices Test.

DISCUSSION

While the ACLC and the SST are both tests of language comprehension, they do not purport to measure the same abilities. The ACLC measures the comprehension of various word classes in different combinations of length and complexity. The SST measures ability to comprehend various syntactic relationships. In the ACLC, as the number of critical elements increases from 1 to 4 not only does the semantic complexity increase but syntactic relationships emerge that require the child to demonstrate an understanding of syntax. Further comparison can be drawn between the performance on Part D of the ACLC (four element stimuli with emerging syntax) and that on the syntax test; both results indicate responses below 50% correct. These results seem to indicate that, for 6-year-old hearing-impaired children, comprehension of syntactic relationships is more difficult than the mere comprehension of semantic units (i.e., vocabulary and two critical element stimuli).

These conclusions are supported by the observations of Bloom and Lahey (1978) implying that, while children may learn the semantic relations between words, they may not necessarily have learned the syntactic rules for representing those relationships.

Studies with normal-hearing children show that they are able to join the semantic and syntactic components of language by the second or third year of life (Bloom & Lahey, 1978). A comparison of the normative data from the ACLC to the performance of the deaf children in the present study shows that the deaf children are unable to do so, as evidenced by their performance below the minimum age level of 3 years for Parts C and D.

It appears that many young deaf children develop the ability to respond to *wh*-questions in much the same order as children with normal hearing. In fact, those 6-year-old children in the higher decile groups were already able to respond appropriately to several of these questions when asked in a mode of communication that was understandable and when concrete referents to the questions were available. However, the children in the lower decile groups did not perform in quite the same way.

Recent research shows that *what* and *who* are usually the first *wh*-questions learned and that *why* and *when* are acquired later when the cognitive concepts of causality and temporality develop (Brown, 1968; Ervin-Tripp, 1970; Lee, 1974). The deaf children in this study answered 64% of the *yes/no* questions, 53.5% of the early *wh*-questions, and 14.6% of the late *wh*-questions correctly. Nevertheless, the reader should be reminded that the percentage correct is one-half that obtained by normal-hearing children (Carrow, 1968; Gaffney, 1977).

These results indicate that while the 6-year-old prelingually deaf children who were subjects in this project are past the holophrastic and two-word utterance stages of language development (as measured by language expression tests) and appear to be in the process of acquiring syntax, they are doing so at a slower rate than their normal-hearing counterparts. It appears that for the children in the higher decile groups (Groups 7, 8, 9, and 10), those whose performances were better, their receptive skills are marked by delay, whereas those children in the lowest decile groups show not only marked delay, but differ from the normal-hearing population as well as from their superior performing hearing-impaired peers. These deaf children's failure to master linguistic skills by the age of six further accentuates their developmental lag and deviance in language development.

In comparison with group performances on the language tests, it was noted that on the ACLC, 50% of the lowest scoring children (Deciles 1–5) also scored lowest on the Raven Test (Deciles 1–5). On the Syntax Screening Test, all subjects scored below 50% on all subtests except the *wh*-questions. Many of the subjects in the lower decile groups were the same children in the low decile groups of the Raven Test. Thus, it appears that for those children in whom language comprehension is poor, perceptual nonverbal skills are also impaired. The superior performers may be those children who are using language for thinking processes and therefore are faring better in a test of intellectual capacity.

Another explanation may be that the Raven Test may be tapping linguistic skills and not only perceptual, nonverbal knowledge. Perhaps the sequential ordering of nonverbal analogies requires a language skill or knowledge of which the children in the lower decile groups are not capable. On the B subtest, which is the most difficult analogy task, all of the children obtained scores below 50% correct, and for the Ab subtest, 75% of all the groups obtained scores below 50% correct. Overall performances were poor, and decile groups 1–7 scored below 50% on the combined subtests. Wilson et al.'s (1975) study of brain-damaged and nonbrain-damaged deaf children age 7–10, found that nonbrain-damaged subjects performed as poorly on psychometrics tests, such as the Raven, as brain damaged. However, because of their good responses to other intellectual tasks, the investigators suspect that it is the lack of normally acquired language that is responsible for the poorer performances on tasks that require the mediation of normal language as a strategy for problem solving.

The deaf child's ability to learn languages is hindered by the lack of auditory input and phonological codes which the normal child uses to encode language. The hearing impaired do not have access to those codes. It is perhaps in this mode of encoding that the deaf child is at the disadvantage, not only for verbal tasks, but also for nonverbal ones that purport to measure intellectual maturity. The lack of language leads to impoverished experiences and reduction in the practice of using sequentially presented stimuli. Lack of language may result in poorer performance for tasks where normal children's language mediation provides the best strategy.

Assessment of Expressive Language

It was of interest in this project to evaluate both comprehension and production of language in an assessment battery. The hearing-impaired child's vocabulary, syntax, mean length of utterance, and intelligibility of oral productions were considered. The difficulty arose with selecting the instruments. There are few oral language tests available for the hearing impaired. One technique used for evaluating language production has been language sampling. Various sampling techniques, transcription, MLU determination, and analyses of syntactic structures can be measured as well as baseline language performance. Lehman (1970) measured syntactic complexity of oral productions from a spontaneous language sample. The Moog-Geers scales provide a more "in-depth" analysis of language samples (Moog & Geers, 1978). Kretschmer and Kretschmer (1978) developed a system for analyzing spontaneous language samples that includes such categories as preverbal behaviors, single-word and two-word combination productions, semantic classes, single-preposition productions, complex sentence productions, communication competence, and restricted form types.

Any type of assessment instrument for language behavior should serve these purposes: determining baseline behavior, describing the nature of language competence relative to the norm, and determining behavior change with given interventions.

In this project, spontaneous language samples were obtained from 50 of the 65 six-year-old deaf children in their preferred mode of communication. Analysis of the data considered mean length of utterance and frequency of occurrence of various linguistic word classes as well as the structure and meaning of the utterances. To evaluate the expressive language of the children, two pictures were used to elicit spontaneous language samples: the four-picture sequence developed by Stuckless (Stuckless & Marks, 1966) and the city street scene from the Peabody Pre-School Language Kit (Dunn & Smith, 1970). Expressive language was considered to be any oral or manual production. Data analysis produced results for mean length of utterance, linguistic word classes, and structure and semantic relationships.

Results indicated that the average mean length of utterance (MLU) was 2.0 words, which is equivalent to Brown's Stage II, occurring at the chronological age of 3 years. Only seven of the children were found to have MLUs greater than 3.0.

It was found that 64% of the utterances were nouns, 22.7% were verbs, and the remaining 12% comprised adjectives, adverbs, pronouns, prepositions, articles, and conjunctions (see Table 3.4). When these results are compared to those of normal-hearing children, they indicate an overuse of nouns and underuse of all other word

TABLE 3.4. Comparison of word classes produced by 6-year-old hearing and deaf children.

Word class	*Deaf children*	*Hearing children*
Noun	64.9	17.1
Verb	22.7	25.0
Adjective	4.2	7.6
Article	3.5	7.0
Adverb	1.8	10.0
Preposition	1.5	7.6
Pronoun	1.0	19.3
Conjunction	0.44	2.6

Note. The data on hearing children are from "Certain Language Skills in Children: Their Development and Interrelationships," by M. Templin, 1957, *Child Welfare Monographs*, No. 27, Minneapolis: University of Minnesota Press. Copyright 1957 by University of Minnesota Press. Reprinted by permission.

classes. The use of more concrete language suggests that the hearing-impaired children may be using more convergent thinking skills. They are naming or labeling objects and actions within the limits of their semantic abilities and are unable to demonstrate the divergent thinking skills that would enable them to produce a variety of statements about the objects and actions used in the test.

Structural analysis was done on those language samples with MLUs of 3.0 or more according to procedures described by Tyack and Gottlesben (1974). Of those utterances, 45.5% were N-V-N or N-V-N-N constructions indicating a trend away from simple naming to expanded agent-action relationships. Forty-nine percent of the utterances expressed the actions of an agent, object, or agent upon an object, while 20.1% expressed temporary ownership or an internal state.

SUMMARY AND CONCLUSIONS

At the completion of the project investigating communication skills of 6-year-old deaf children, tests were used to measure the lexical units and syntactic relationships.

Results indicate that as lexical units increase in order of difficulty on tests, syntactic relationships emerge and become more complex. Children in this study performed better on those test items that required semantic rather than syntactic knowledge. Thus, an immaturity can be seen in deaf children's ability to synthesize and understand the more complex syntactic and semantic relationships of language.

Those children in the higher decile groups (7, 8, 9, 10) appeared to be acquiring syntax in much the same developmental sequence as normal-hearing children, but they were doing so at a much slower rate. However, the children in the lower decile groups (1, 2, 3) showed more deviant behavior in addition to the severe delay.

For language reception, performance on the syntax test was related to intelligence. The better the understanding of negation, *yes/no* questions, the higher the I.Q. score. Understanding of negation was also positively related to the age at which deafness was diagnosed. The lack of correlations with specific variables is perhaps more noteworthy. There were no positive correlations between overall language comprehension and the age at which special education began, the age at which deafness was diagnosed, the age at which the aid was fitted, or the pure-tone average. Hearing loss and average hearing level were not directly correlated with language comprehension skills. However, findings to the contrary have been reported elsewhere. Severity and frequency region of loss have been linked reliably to structural deficiency in a child's language system (Brannon & Murray, 1966; Swisher, 1966), although some data have indicated otherwise (Curtiss, Prutting, & Lowell, 1979). It is conceivable that impairment of the peripheral auditory system may reduce the number and complexity of the form/content rules that a child learns, but such an impairment does not necessarily have to change the ways that a child tries to learn those rules. Even though a hearing-impaired child may not approach the task of rule learning with a complete set of contexts, the child will use the same strategies to extract and learn the rules of a language system that the normal-hearing child does. According to Norlin and Van Tasell (1980), functioning with inadequate sensory input affects the outcome of learning but does not alter the general characteristics of the learning process itself. Because the hearing impaired rely on similar strategies for rule learning and rule use, their language behavior resembles that of normal-hearing children who are younger. However, for the more severely language-impaired deaf child, this may not be the case. Thus, as long as hearing-impaired children have sufficient residual hearing and intact potential and facility for language development, the rules they use for comprehending and formulating oral language will resemble those used by hearing children. However, as the severity of hearing impairment increases, the children experience greater difficulty in the capacity to extract and learn the rules of an oral language system; language development may not only be seriously delayed, but it also may deviate from that of hearing peers.

Another consideration regarding the effects of hearing loss on the language system is that the acoustic configuration of the speech signal transmits multiple linguistic contexts, and those sound, word, and sentence contexts are embedded in conversations and situations. If a child is missing any information from those contexts, then other contexts will be affected. Norlin (1979) suggests that hearing loss may have an effect on the language system because any loss of context may affect the hierarchy of other contexts, not merely those which are phonetic, producing confusion into the process.

A variable to consider in language development that was not possible to measure in this project was the parent-child relationship. The child with a congenital, severe-to-profound hearing loss may experience a disruption in normal parent-child interaction (Ling, 1974). A difficult interaction between parent and child can be a deterrent in the language-learning process. Parents attempting a verbal interaction may decrease their output when it is not reinforced. Many parents correct their children on the basis of syntactic or articulatory error rather than on content. With constant corrections, the child never learns the power and value of language. The child is directed to focus on form rather than on function of language, which results in aberrant language growth.

An even more important set of variables that could not be considered involves the pragmatic aspect. There are several inherent properties of spoken language proficiency: carrying on a two-way conversation; speaking clearly enough for others to understand, which involves mastery of the phonology, semantics, and syntax of the language as well as articulation proficiency; comprehending conversational topics appropriate to one's age and culture; and knowing the ways in which conversations are entered, how new subjects are introduced, how conversations are concluded and leave-takings are made, and how to address friends and strangers. The social, pragmatic aspects of verbal skills are most difficult to measure, but they are vital in the overall competence of a communicator who is to be accepted by the community (Ling & Ling, 1978, p. 233). Such measures are yet to be developed for evaluating the deaf community. Nevertheless, assessment of language to determine the stage of language development of the hearing-impaired child in comparison with the normal-hearing child will assist in providing knowledge concerning what stages comprehension and production will take and what stages to progress to next. Such information is invaluable in program planning, intervention, and evaluation of habilitative therapies. We have learned a great deal but have much to look forward to in our continued quest for information on language development of the deaf.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of Angela La Bruna in the preparation of this manuscript. The contribution of Lisa Rothman-Freeman, a project investigator, was significant to the completion of the research. Her work should be acknowledged. Furthermore, the author wishes to thank all the teachers, staff, and administrators who made it possible for us to conduct our research in the many schools for the deaf. Without their cooperation, this project would not have been possible.

This study was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Please see the general acknowledgment in Chapter 1 for more detailed information on the many individuals and organizations who assisted and whose help is much appreciated.

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Chapter 4

Communication Skills of Young Hearing-Impaired Children

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This chapter is concerned with the development of communication skills in young hearing-impaired children. The previous chapter compared language behaviors of hearing-impaired children with those of normal-hearing children. The children considered here were the same as those discussed in the preceding chapter. Hence background data are identical, but additional information regarding the sample should be cited. Of the 67 children on whom information was available, 11 (16%) had deaf mothers, 18% had deaf fathers, and 12% had deaf siblings. English was the primary language spoken at home (73%). Eighty-three percent of the families used no sign language in the home.

One difficulty in studying communication skills is selecting instruments that are appropriate for a hearing-impaired population. For this project, a battery of tests was developed, and standard tests were modified to measure the skills of interest. Rating techniques were found to be most practical and were used to obtain a comprehensive picture of a wide range of communication skills. These included speech reception, speech production, oral language, signed language, and overall communication competence. Objective measures of speech production, speech reception, and speechreading abilities were also obtained.

A description of the tests developed and administered as well as the results obtained is presented under these headings: Speech Production, Speech Reception, Speechreading, Ratings of Communication Skills, Interrelationships Between Communication Skills, and Conclusions.

SPEECH PRODUCTION

It is known that as peripheral hearing handicap increases, so do the related speech problems. Hudgins and Numbers (1942) in an early, major study of speech production in hearing-impaired children showed that the major consonant errors were not a function of the initial consonants, voiced-voiceless confusions, or consonant cluster errors. The major vowel errors were substitutions, errors in the production of diphthongs, and neutralization. The results of this and other studies (Levitt & Stomberg, 1983; Markides, 1970; Nober, 1967; Smith, 1975) are in general agreement that the most frequent consonant errors involve incorrect production of the palatal and alveolar fricatives, the affricates, and the velar nasals. In addition, the results indicate better production of bilabials, glides, and labiodental fricatives. The most frequent vowel errors are those of neutralization (Markides, 1970; Monsen, 1976), diphthongization (Boone, 1966; Markides, 1970) and nasalization (Martony, 1965).

At the suprasegmental level, the speech of hearing-impaired children is characterized by excessive breath, slow and labored rhythm, inappropriate voice pitch, weak quality, and substitutions, omissions, and distortions of syllables (Nickerson, 1975; Nober & Nober, 1977). Syllable and pause durations are particularly prone to error (Osberger & Levitt, 1979), thereby affecting perceived stress and phrasing patterns. Coarticulation is also reduced, and there is less movement of the formants (Monsen, 1983).

The intelligibility of a hearing-impaired child's speech shows a significant correlation with his or her degree of hearing impairment. On the average, speech intelligibility decreases steadily with increasing hearing loss until a loss of about 90 dB, above that the degree of correlation is reduced (see Chapter 9 for a detailed discussion of this relationship).

Of the studies mentioned, only Nober (1967) tested children 6 years of age or younger. The children participating in the other studies ranged from 7 to 15 years of age. The test stimuli used varied from standard articulation tests, such as the Templin-Darley (1970) word-picture test, to word and sentence materials that the children were required to read. Many of the studies previously cited also measured the intelligibility of their subjects' speech. Hudgins and Numbers (1942), John and Howarth (1965), Markides (1970), Smith (1975), Gold (1978), and McGarr (1978) measured intelligibility either by percentage of words correctly understood as a function of all words produced or by percentage of complete sentences correctly understood. Other studies have used rating scales either exclusively or in conjunction with more objective measures of intelligibility, such as proportion of words produced correctly (Geffner, 1980; Gold, 1978; Markides, 1970; Smith, 1975). Attempts have also been made to develop objective indices of intelligibility using acoustic measurements (Monsen, 1978).

To evaluate speech production in our sample, an attempt was made to obtain samples of both imitative and spontaneous speech production. Because there were no known available tests to measure the speech of deaf children with limited reading skills, different instruments were adapted and used. They were the Imitation Syllable Test (IST), an adaptation of the Goldman-Fristoe Test of Articulation (1972), and ratings of overall intelligibility for continuous speech. These measures enabled the examiner to investigate production of speech varying in length and spontaneity.

Imitative Production at the Syllable Level

Because syllable imitation is an elementary phonological skill that is precursory to spontaneous speech production, it was felt that requiring the children to imitate the examiner's production would determine whether or not the children were stimulable for various consonants and vowels in a CV cluster. The Syllable Imitation Test consisted of 36 CV syllables containing the consonant /b/ plus the vowels /ɑ/, /u/, /æ/, /ɔ/, /ɪ/, /o/ and the diphthongs /eɪ/, /aʊ/, /oʊ/, /aɪ/, /ɔɪ/. The consonant /b/ was selected because it was both more easily produced and more easily heard by the children. The remainder of the test included CV syllables in which the initial consonant varied but the vowel remained constant. All consonants were used. In addition, /b/ was placed in the medial (VbV) and final (bVb) positions of a syllable to determine what effect position might have on production. The examiner produced the target syllable and asked the child to repeat it. The children's responses were scored as correct or incorrect.

The data obtained with the Syllable Imitation Test showed patterns of articulatory errors similar in form to those reported for speech elicited by other means, for example, pictures or reading. The frequency of correct productions was greatest for vowels (77.2%), not quite as high for diphthongs (72.7%), and substantially lower for consonants (23.9%). Consonantal errors were least on those for which the place of articulation is at the front of the mouth. Those sounds are also visible to the hearing-impaired child during the imitation task. Consonants produced with a place of articulation farther back in the mouth elicited a greater frequency of error. The error rate typically increased with decreasing visibility of the sound. The most difficult sounds were those that were not visible and also required especially precise control of the articulators, such as the affricates /dʒ/ and /tʃ/ and the fricatives /z/, /ʃ/, and /s/.

The position of the consonant in the syllable also had a major effect on the error rate. Errors were most frequent for consonants in the final position and not as great for the medial (VCV) position. Relatively few errors were obtained for consonants in initial position. These findings are consistent with the general pattern of errors reported for older hearing-impaired children (Levitt & Stromberg, 1983).

Production at the Word Level

An adaptation of the Goldman-Fristoe Test of Articulation (1972) was used to measure the child's speech production in response to picture stimuli. Those words not occurring in the known vocabulary of 6-year-old hearing-impaired children were taken out and supplanted with words that were known to exist in the children's vocabulary (Central Institute for the Deaf, 1950). The relevant articulatory features of each child's productions were evaluated. For the vowels, features of frontness, height, rounding, tenseness, and visibility were considered. For consonants, features of place (front, medial, back), manner (nasal, affricate, plosive), and voice (voice, voiceless) were evaluated in addition to visibility. Diphthongs were analyzed by formant change, from small to large change in second formant, and by visibility. Details of this analysis are described in Geffner (1980), and only a brief summary of major findings is reported here.

As in the case of syllable imitation, vowels and diphthongs were produced correctly substantially more often than consonants (71.4 and 23.7% correct, respectively). Consonantal errors were found to be linked closely to place of articulation, the lowest error rate occurring with the bilabial and labiodental consonants (46 to 47% correct). The percentage of correct productions decreased systematically with place of articulation in the following order: glottal (28%), linguadental (22%), alveolar (19%), and velar (4%). The degree of variation was almost as great for manner of production, starting with a high of 36% correct for the lateral, followed by the glides (30%), stops (27%), fricatives (24%), nasals (17%), and ending with a low of 4% correct for the affricates.

Comparisons Between Tests

Of particular interest is the degree of similarity between the results for the syllable-imitation and the picture-elicited word tests. Figure 4.1 shows the percentage of correct productions for all of the phonemes covered by

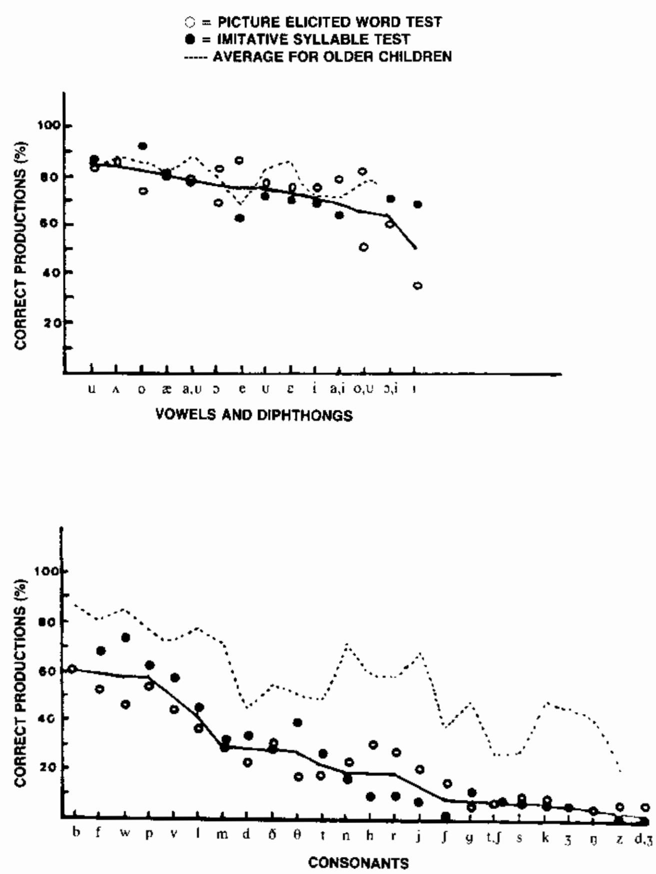

FIGURE 4.1 Percentage of correct phoneme productions on two speech production tests.

the two tests. The upper half of the diagram shows vowels and diphthongs; the lower half shows consonants. The phonemes have been ordered according to their mean score averaged over both tests. The solid line shows the mean score, the open circles represent data from the picture-elicited word test (i.e., the modified Goldman-Fristoe test), and the solid discs represent the results of the Syllable Imitation Test. The dashed line represents mean phoneme scores for older hearing-impaired children and is discussed later.

The two tests show very similar patterns of performance, but with several noteworthy differences. The children scored significantly higher on the back vowels for the Syllable Imitation Test. (These differences were statistically significant for the vowels /ɑ/ and /ɔ/ and for the diphthong /oʊ/ ($p < .05$). The differences for /u/ and /ɔɪ/ were also in the same direction, but were not statistically significant.) In contrast, the children scored higher on the picture-elicited word test for most, but not all, of the front and central vowels. The reasons for this difference are not obvious. The back vowels require less extensive movements of the articulators and are easier to produce correctly, on the average. As will be noted, there is some evidence that the children did relatively well on the easier items on the Syllable Imitation Test.

The differences between the syllable-imitation and picture-elicited word tests show a clearer pattern for the consonantal sounds. The children obtained consistently higher scores on the Syllable Imitation Test for the bilabial and labiodental consonants /b, p, m, w, f, y/. These are the most visible of the consonants. Visibility of articulatory movements is a useful additional source of information in syllable imitation but not in picture-elicited stimuli. The bilabial and labiodental consonants are also easier to produce than other consonants. With few exceptions, the children scored higher on the Syllable Imitation Test for easier test items and lower on the more difficult items (relative to the same items on the picture-elicited word test). For example, phoneme scores on the Syllable Imitation Test were usually lower than those for the picture-elicited word test in cases where the average phoneme scores were less than about 20%.

Aside from the above-mentioned differences, which are small, the two tests yielded essentially similar results. A relatively high correlation was obtained between the two sets of test scores ($p = .82$). A reasonably good correlation was also obtained between these test scores and ratings of overall intelligibility ($p = .71$). The rating data will be discussed in a separate section.

Comparisons between the data obtained in this study and results reported for older children show similar patterns of performance. Data obtained by Smith (1975) on 20 8- to 10-year-old and 20 13- to 15-year-old children at an oral school for the deaf, by Gold (see Chapter 8) on 38 10- to 12-year-old mainstreamed hearing-impaired children, and by McGarr (see Chapter 7) on 120 10- to 14-year-old children at various schools for the deaf all show similar patterns.

The dashed line in Figure 4.1 shows the average percentage of correct phoneme productions obtained from those three studies. With a few exceptions, such as the vowels /ɛ/, /oʊ/, and /ɪ/, relative performance on vowels and diphthongs was much the same for the 6-year-old children of this study as for the older hearing-impaired children. The similarity is quite striking considering the differences in age and educational background among the children, and the different types of test materials used.

Similar patterns of performance were also obtained with consonant production, although in this case the degree of similarity is not as great. The dashed line in the lower half of Figure 4.1 is higher than the solid line, indicating that the older children had higher average phoneme scores. The two lines, however, have a similar overall shape. For both the younger and the older hearing-impaired children, the highest scores were obtained with the labial and labiodental consonants, shown on the left side of the horizontal axis, and low scores were obtained for the affricates /tʃ/ and /dʒ/ and the fricatives /z/, /s/, and /ʃ/.

Notable exceptions from a common trend are the relatively high scores obtained by the older hearing-impaired children (or, alternatively, the relatively low scores obtained by the 6-year-old children in this study) on the nasals /n/ and /ŋ/, the stops /k/ and /g/, and the glide /j/. Were it not for the differences in relative score obtained for these five consonants, the two curves would be roughly parallel.

The similarities among the various sets of speech production data can be expressed another way. Table 4.1 shows the product-moment correlations between phoneme scores among the five sets of data. The correlations are uniformly high, indicating that despite the differences in age, educational background, and types of test material, the speech of hearing-impaired children shows very similar patterns, at least at the phoneme level. The lowest correlations in Table 4.1 were obtained between the mainstreamed children and the younger children considered in this study ($\rho = .67$ and $.69$). These two groups of children show the largest differences in speech production skills, yet, apart from a substantial difference in average test scores, both groups show similar error patterns in their speech.

SPEECH RECEPTION

An objective evaluation of speech reception skills in young hearing-impaired children is not an easy task. The child is in the process of learning the sounds of speech, and measurements obtained with any conventional speech recognition test are likely to be confounded with learning effects. To circumvent this problem, at least with respect to short-term learning effects, the Speech Reception Training Test was developed. In this test, the child is trained to identify simple stimuli, beginning with tones and noise, and then the child progresses gradually to more complex stimuli, such as single vowels, vowel complexes, and then monosyllabic nonsense syllables.

TABLE 4.1. Correlations between phoneme scores for several sets of speech production data.

Test	IST	MGF	Smith	Gold	McGarr
Imitative syllable test, IST Population: 67 6-year-old children at schools for the deaf Source: This study	—	.88	.82	.67	.79
Modified Goldman-Fristoe, MGF (picture-elicited word test) Population: 67 6-year-old children at schools for the deaf Source: This study	.88	—	.73	.69	.90
Phonetic transcriptions of read sentences Population: 20 8- to 10-year-old and 20 13- to 15-year-old children at an oral school for the deaf Source: Smith (1975)	.82	.73	—	.85	.92
Phonetic transcriptions of read sentences Population: 38 mainstreamed children, 10 to 12 years of age Source: Gold, Chapter 8	.67	.69	.85	—	.83
Picture-elicited articulation tests Population: 120 10- to 14-year-old children at schools for the deaf Source: McGarr, Chapter 7	.79	.90	.92	.83	—

The test consisted of eight levels, as shown in Table 4.2. Prior to the administration of each level, the child was trained to respond appropriately. A criterion of 7 correct responses out of 10 was used to determine if the child had acquired the necessary skill before proceeding to the next level. The results of the test indicated the level reached by the child after a specified amount of training.

Ideally, extensive training should be provided until short-term learning effects have saturated. In this way, speech reception ability over the long term can be ascribed to the child learning the test. These learning effects are not of direct interest. Long-term learning effects, taking place over many test sessions, can be ascribed to the effects of auditory training and are of great interest. For the purpose of this study, speech reception ability was measured after saturation of short-term learning effects.

TABLE 4.2. Speech reception training test.

Level	Stimuli
I	125-Hz pure tone plus silence
II	125-Hz pure tone plus sawtooth noise
III	/ɑ/ plus silence
IV	/ɑ/ plus noise
V	/ɑ/ plus /i/
VI	/ɑ/ /i/ /u/
VII	/bɑ/ plus silence
VIII	/sɑ/ — /gɑ/ /mɑ/ — /sɑ/ /gɑ/ — /gɑ/

At the first level of the Speech Reception Training Test, the child was asked to distinguish between sound and silence by identifying a pulsed 125-Hz pure tone of 260 ms duration (see Table 4.2). The child was trained to indicate each time the sound was heard. At the second level, the child was required to identify the tone against a background of noise. The competing signal was a 125-Hz sawtooth noise of 540 ms duration.

At subsequent levels, speech sounds were introduced. At Level III, the vowel /ɑ/ was presented without background noise. It was decided to begin with /ɑ/ because it is acoustically one of the most powerful vowels and therefore more likely to be heard by this population. The child was required to acknowledge hearing any sound from silence and could do so in one of three ways: by simply raising the hand, by repeating the vowel heard, or by using the dactylogic representation of the sound.

Level IV required the child to discriminate between the vowel /ɑ/ and the sawtooth noise. At Level V, two vowels were presented, /ɑ/ and /i/. The child could respond by raising the hand for /ɑ/, by repeating /ɑ/ or /i/, or by using the appropriate dactylogic representation of the sound. The task of Level VI was the differentiation among three vowels: /ɑ/, /i/, and /u/. The child was required to respond to /ɑ/ in the presence of two other vowels. It was also of interest to determine if the child could differentiate among all three of the vowels.

Level VII introduced the first consonant-vowel combination. The child was asked to identify when the syllable /bɑ/ was heard by raising the hand. At Level VIII it was necessary to distinguish between pairs of nonsense syllables. For example, the child would be required to indicate whether pairs of nonsense syllables, such as /mɑ/-/gɑ/, /sɑ/-/mɑ/, or /mɑ/-/mɑ/, were the same or different. The nonsense syllables were CV pairs consisting of the consonants /m/, /g/, or /s/ paired with a common vowel which could be either /ɑ/, /u/, or /i/.

Figure 4.2 shows the proportion of children failing the test at each level. The distribution appears to be bimodal, with one large group of children failing the test at Level I and a second large group failing at Level V. Children failing at Level I have clearly not yet learned the test, because all of these children should be able to respond to a 125-Hz tone either auditorially or by feeling the associated acoustic vibrations. Children who failed at this level were also difficult to test audiologically. Note that the criterion for passing Level I on the Speech Reception Training Test was stricter than that used in obtaining a measurable response when recording the audiogram.

The relatively large number of failures at Level V indicates that many children can distinguish between speech and noise but have difficulty in identifying speech sounds; that is, they can distinguish between /ɑ/ and a sawtooth noise but not between /ɑ/ and /i/. Because the sawtooth noise is periodic with a harmonic structure not that different from a synthetic vowel, it would appear that the limitations to performance are cognitive rather than the result of an impairment to the peripheral auditory system. Intensive auditory training should produce substantial improvements in speech recognition performance with these children.

An analysis of the children's audiograms and performance on the various levels of the Speech Reception Training Test showed significant negative correlations (p = .25) between performance on the first three levels of the test and low-frequency (≤500 Hz) auditory thresholds. Negative correlations are to be expected because performance decreases with increasing auditory thresholds. Performance on Levels IV and VI of the test showed significant correlations ($p = -.5$) with pure-tone thresholds of 1000 Hz or higher. No significant correlations were observed between pure-tone thresholds and performance at Level V of the test. This observation supports the view that the difficulties experienced by many of the children at Level V were cognitive rather than auditory. Too few children reached Levels VII and VIII to allow for statistically significant correlations to be made.

In addition to the Speech Reception Training Test, ratings of total speech reception ability were also obtained. Their results are discussed later in the section dealing specifically with rating data.

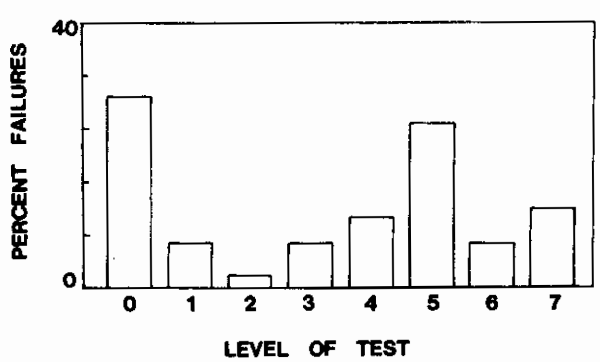

FIGURE 4.2 Percentage of failures at each level of the speech reception training test.

SPEECHREADING

Speechreading is a vital aspect of oral communication. Even normal-hearing persons make substantial use of visual cues in face-to-face communication. For the hearing-impaired, these cues are critically important. The Myklebust and Neyhus Diagnostic Test of Speechreading (1970) was used to measure this skill. That test was selected because normative data are available and also because it evaluates three levels of complexity: identification of words, phrases, and sentences. There is also recurrence of stimulus items in different sections of the test. The word *boot*, for example, appears in the word section of the test, as well as in the phrase *(ten black boots)* and sentence sections *(the girl has new boots)*.

The child is presented with a silent movie on a 10″ by 12″ viewing screen, with a talker producing each of the test items. For each test item, the child is required to identify the correct answer by pointing to one of a set of four pictures in a booklet. The mean percentage of correct scores obtained by our sample for each subtest of the speechreading test is presented in Table 4.3 with comparisons to the original data obtained by Myklebust and Neyhus (1970).

The data indicate that the mean score obtained on the word subtest was higher than on other subtests, which is in agreement with the data of Myklebust and Neyhus (1970). It would thus appear that hearing-impaired children are more successful in speechreading when the message is of short rather than long duration. One explanation may be that for 6-year-old deaf children, visual sequential memory may not be sufficiently developed for them to be able to comprehend visually phrases or sentences of any length. Another explanation is that vocabulary and language limitations render the task too difficult. Furthermore, hearing-impaired children may not be able to take advantage of the grammatical cues that string the words together because of limited syntactic skill.

The scores obtained by the hearing-impaired children in this study are comparable to those obtained by the poor

TABLE 4.3. Comparison of speechreading scores.

Test items		*Present study* (N = 67)	*Myklebust-Neyhus study* *Good speechreaders* (N = 10)	*Poor speechreaders* (N = 10)
Words	Mean	49.3	85.5	45.4
	SD	20.1	7.9	21.0
Phrases	Mean	28.1	65.0	28.0
	SD	17.1	22.1	16.6
Sentences	Mean	32.0	63.0	27.5
	SD	15.7	14.2	8.4
Total	Mean	41.6	75.5	37.5
	SD	14.9	10.7	14.3

speechreaders in the Myklebust-Neyhus study. However, the mean percentage correct score of the 10 highest scoring children in the present study was 83%, a score similar to that obtained by the good speechreaders in the Myklebust-Neyhus study. Standard deviations are large, indicating a wide variation in speechreading ability among the children tested.

Green, Green, and Holmes (1980) found that their 6.3-year-old hearing-impaired subjects on the Myklebust-Neyhus Test performed significantly better on word stimuli than on either phrase or sentence stimuli. Because words used in the word section reappear in other sections, results imply that words successfully speechread in isolation were not necessarily identified when they appeared in phrases and sentences. Erber and McMahan (1976) suggest that coarticulatory effects make the visual identification of word boundaries difficult, as well as altering the visual appearance of key words in context.

The performance on word stimuli appeared to reflect language abilities. Green et al. (1980) reported that responses to the word test on the Myklebust-Neyhus Test seemed to parallel expressive performance. Six words were correctly identified by at least two-thirds of the children. A comparison of the words correctly identified with those not identified revealed that the former were all concrete nouns *(house, boat),* whereas the latter were a combination of verbs *(turn off, drink)*, adjectives *(ten)*, and abstract nouns *(January)*. The identified words were more familiar to the hearing-impaired children and could be categorized as concrete or tangible, whereas the less identifiable words seemed to require a greater degree of conceptualization. Furthermore, the more easily identified words were not necessarily more visible. Visible initial consonants appeared in the less identified list, thereby suggesting that linguistic aspects of words, rather than visibility, may be the primary determinants of the ease with which words are speechread by hearing-impaired children.

Correlations between speechreading performance and subject variables indicate that children with higher IQs obtained better scores on the speechreading test than the older children within the sample studied. For those children fitted with hearing aids early in life, speechreading performance was superior ($p < .01$). Similarly, the earlier the age at which special education was initiated, the better the speechreading and other communication skills.

A small but statistically significant correlation ($p = .44$) was also observed between speech production and speechreading skills. The better the articulation skill, the higher the speechreading score. Correlations with other tests in the battery showed a positive relationship between receptive language skills, as measured by the Syntax Screening Test (Geffner & Freeman, 1980), and overall speechreading ability. Apparently, the better the language comprehension, the better the speechreading ability, particularly for phrases and sentences. These observations, together with the data of Green et al. (1980), strongly support the view that good speechreading ability is reflective of both good language and good communication skills. See Chapter 9 for further discussion of this issue.

RATINGS OF COMMUNICATION SKILLS

A rapid and efficient method of assessing communication and language skills is to have an experienced evaluator or teacher rate the child's performance. A 5-category rating scale has been found to be practical for this purpose and has been used extensively in deriving profiles of communication skills for large groups of hearing-impaired persons (Johnson, 1975).

Two problems with the use of subjective ratings are the high test-retest variability and poor interrater reliability. Both problems stem from uncontrolled or random variations in the criteria used by the raters. Several techniques can be used to reduce criterion variability. One is to train a select group of raters to evaluate all the children on a well-defined, fixed set of criteria. Another is to use several raters or several ratings on each child to obtain an average rating. A variation is to have the raters confer with each other before assigning a rating.

The rating procedure, with the precautions noted above, was used to obtain a broad profile of each child's communication skills. Trained evaluators were used to obtain ratings of speech intelligibility (SPI), spoken language ability (LSP), signed language ability (SLI), and overall communication competence (OCC). In addition, teacher's ratings of speech intelligibility (SPI), spoken language ability (LSP), and total speech reception skills (TSR) were obtained. The latter group of ratings was of interest since classroom teachers are often asked to make these types of evaluations. Practical constraints prevented a separate rating of total speech reception skills (TSR) from being obtained by the skilled evaluators.

The categories used in defining each of the rating scales are summarized in Table 4.4. Analogous sets of categories were chosen, as far as possible, so that the rating scales were reasonably comparable to each other. The Speech Intelligibility Rating Scale developed by Johnson (1975) was used as a model for the other rating scales. For further information on the rationale and development of these scales see Johnson (1975) and Geffner, Levitt, Freeman, and Gaffney (1978).

Figure 4.3 shows how the classroom teachers and the trained evaluators differed in their ratings of speech intelligibility (SPI) and spoken language (LSP). The data are plotted in cumulative form. The horizontal axis shows the rating category, beginning with the highest level of performance. The vertical axis shows the cumulative percentage of children who have reached each level of performance. The curves thus begin at a relatively low value, indicating the percentage of children who have reached the highest level of performance (Category 5), and then increase systematically showing the cumulative percentage of children who have reached each of the lower categories. Because all of the children perform at or

TABLE 4.4. Summary of rating scales.

Communication skill	*Rating scale*
Speech intelligibility (SPI)[a]	1. Speech cannot be understood 2. Speech is very difficult to understand with only isolated words or phrases intelligible 3. Speech is difficult to understand; however, the gist of the content can be understood. 2- to 3-word utterances are intelligible 4. Speech is intelligible with the exception of a few words or phrases 5. Speech is completely intelligible
Spoken language ability (LSP)[b]	1. No measurable language 2. Some language—isolated words; 1-word utterances; holophrastic utterances 3. Some language—use of phrases; 2- to 3-word utterances, including nouns, verbs, and other linguistic forms 4. Language consisting of simple sentence structure 3 to 4 words in length, including nouns, verbs, and other linguistic forms. Some errors—not complete thought 5. Substantial output and essentially complete structure
Sign language ability (LSI)[c]	1. No useful output 2. Isolated signs related to context 3. Pairings of signs; groupings of 2 signs—sometimes 3 signs 4. Longer sequence of signs; not complete in thought; some errors 5. Complete sequence of signs conveying a thought
Total speech reception skills (TSR)[c]	1. No understanding of speech 2. Unable to understand speech except for a few spoken words 3. Able to understand 2- to 3-word utterances 4. Able to understand sequences of words and simple sentences. Errors in comprehension apparent 5. Complete understanding of connected discourse with no apparent errors
Overall communication competence (OCC)[c]	1. Not able to communicate 2. Just able to communicate at minimum level of proficiency. Makes basic needs known 3. Interaction for social and basic needs with a minimum of at least 2 social interactions 4. Communicates spontaneously and freely with error or difficulty 5. Communicates freely and without error

[a]See Johnson, 1975. [b]See Geffner, 1980. [c]See Geffner, et al., 1978.

better than the lowest level of performance, each curve must terminate at 100% for Category 1.

The figure shows that the teachers gave consistently higher ratings than the trained evaluators gave. On the average, the teachers' ratings were a little more than one-half a category higher than those of the trained evaluators. The reason for the difference is presumably the teachers' familiarity with the children. As a consequence, the teachers are better able to understand the child's speech and therefore rate it more highly. It is important to bear this difference in mind when comparing subjective evaluations obtained by teachers who know the children well with evaluations obtained by trained outside observers who are not familiar with the children.

Figure 4.4 shows the relative performance of the children on speech intelligibility (SPI), spoken language (LSP), signed language ability (LSI) and overall communication competence (OCC), as rated by the trained evaluators. The children did least well on speech intelligibility (SPI), slightly better on spoken language ability (LSP), and relatively well on signed language ability (LSI) and overall communication competence (OCC). In rating communication competence, the evaluators took into account the child's primary mode of communication (manual, oral, or total) and evaluated each child accordingly.

A disconcerting aspect of the data is the relatively low percentage of children who are functioning at or above the middle category. Category 3 corresponds to a minimal level of performance for practical communication. Less than one-third of the children are functioning at this level for their best mode of communication.

Figure 4.5 shows relative performance on the communication skills rated by the classroom teachers. As before, the children did least well on speech intelligibility (SPI), somewhat better on spoken language ability (LSP), and relatively well on total speech reception (TSR). The last rating measured the child's ability to understand speech using all modes of communication (auditory, visual, manual). Over 95% of the children were enrolled in total programs, and there was no difficulty in evaluating the children in this way.

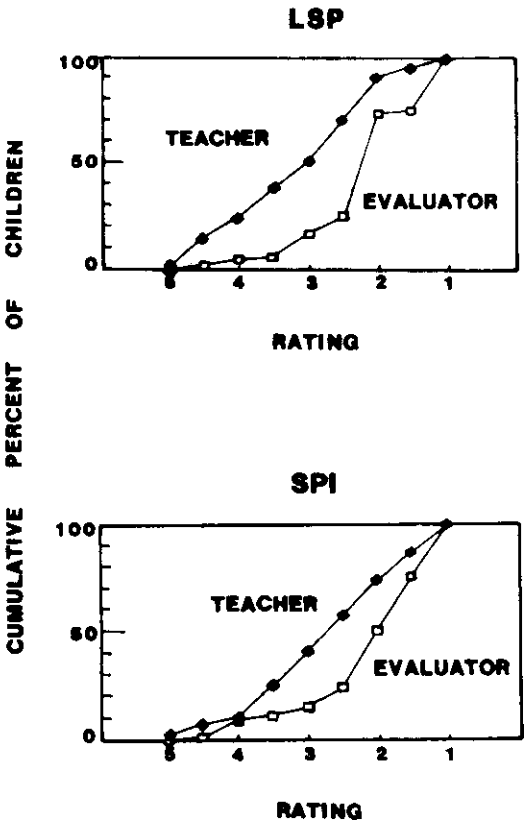

FIGURE 4.3 Ratings by classroom teachers and trained evaluators on spoken language (LSP) and speech intelligibility (SPI).

The data shown in Figure 4.5 provide a more optimistic picture of the children's communication skills. According to the teachers' ratings, well over half of the children are able to communicate at the minimal practical level (Category 3) for both total speech reception (TSR) and signed language ability (LSI). The ratings may be relatively high because of the teachers' familiarity with the children, but in many communicative situations both participants know each other well (e.g., parent-child). The ratings shown in

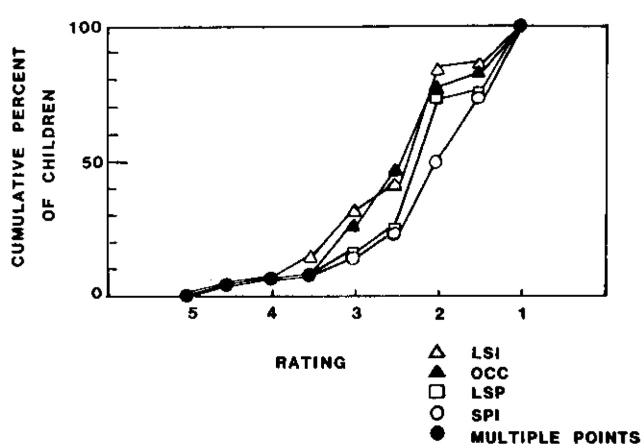

FIGURE 4.4 Ratings of signed language ability (LSI), overall communication competence (OCC), spoken language ability (LSP), and speech intelligibility (SPI) by trained evaluators.

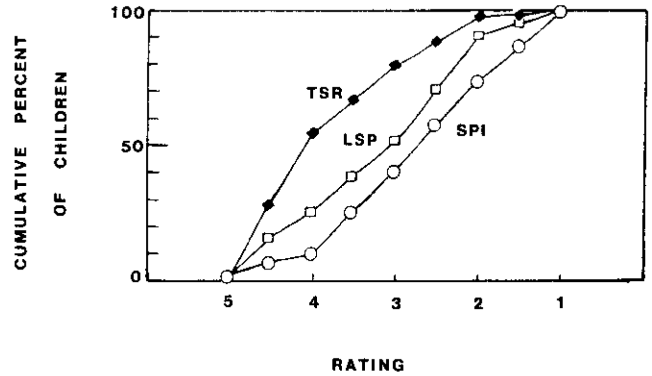

FIGURE 4.5 Ratings of total speech reception (TSR), spoken language ability (LSP), and speech intelligibility (SPI) by classroom teachers.

Figure 4.5 should thus not be regarded as overly optimistic, but rather as typical of communicative situations where talker and listener are familiar with each other.

INTERRELATIONSHIP AMONG COMMUNICATION SKILLS

A factor analysis was performed on all of the rating data. The results are shown in Figure 4.6. Two factors account for over 76% of the variance. The first factor, shown on the horizontal axis, shows high correlations with all of the language-oriented ratings and is identified in the diagram as the Language Factor. The second factor, shown on the vertical axis, shows high correlations for the speech-oriented tests and is identified in the diagram as the Speech Factor.

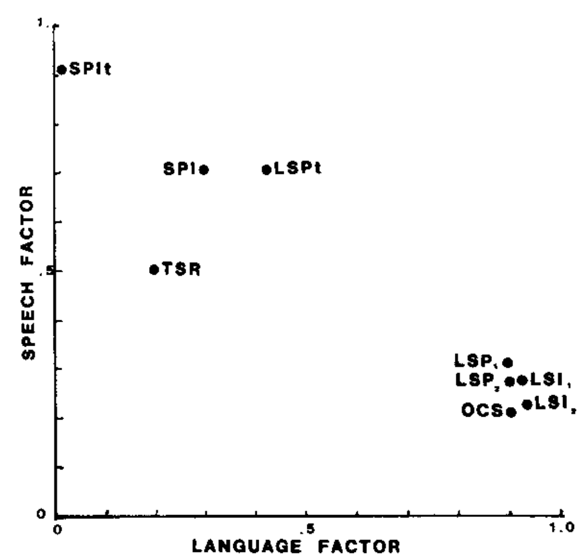

FIGURE 4.6 Results of factor analysis on rating data. SPI = speech intelligibility, LSP = spoken language ability, TSR = total speech reception, LSI = signed language ability, and OCC = overall communication competence. The t indicates rating by classroom teacher. The subscripts 1 and 2 indicate which of two samples was used for the ratings. Note that two language samples were obtained for the LSP and LSI ratings.

Both the spoken language and the sign language ratings show a high correlation with the language factor and a low correlation with the speech factor. This result is not surprising for the signed language ratings (LSI), but it does indicate that the ratings of spoken language were based primarily on language ability and not on the mechanics of speech production.

Note that two separate samples of spoken and signed language were obtained and that separate points were used to represent each sample (i.e., LSP_1 and LSP_2 represent the two spoken language samples, and LSI_1 and LSI_2 represent the two sign language samples). The ratings obtained for the paired samples were very similar, and the points representing each pair of samples occupy virtually identical locations in the factor diagram. The closeness of these points is indicative of the reliability of the ratings for these measures.

Overall communication competence (OCC), which has a strong sign language component for the large majority of the children, also shows a substantial correlation with the Language Factor and relatively little correlation with the Speech Factor. In contrast, the teachers' ratings of speech intelligibility (SPIt) show a high correlation with the Speech Factor and a negligible correlation with the Language Factor. The ratings of speech intelligibility by the trained evaluators also show a correlation with the Speech Factor, but in this case the correlation with the Language Factor is not negligible. Similarly, the ratings of spoken language by the teachers (LSPt) show a moderately high correlation with both the Speech and Language Factors.

These results indicate that the teachers' ratings and those of trained evaluators differ by more than their differences in average rating. The teachers' judgments of spoken language (LSP) appear to be correlated in part with the intelligibility of the child's speech, and the evaluators' judgments of speech intelligibility appear to be correlated in part with the child's language skills.

A communication skill that is correlated with both the Speech and Language Factors is that of total speech reception (TSR). This result was expected since TSR involves auditory speech reception, speechreading, and signing (i.e., the total mode of communication); thus some degree of correlation with both speech and language ability is to be expected. A similar result is reported for speechreading alone in Chapter 9.

It was of interest to test whether hearing-impaired children who signed at home had better speech or language skills than their peers. The correlations between this variable and each of the ratings obtained in this study are listed in Table 4.5. The results showed highly significant correlations ($p < .005$) with ratings of signed language ability and overall communication competence, which also involves signing. Relatively low correlations bordering on statistical significance ($p \approx .05$) were obtained for the ratings of spoken language ability (LSP) by the trained evaluators. The teachers' ratings of spoken language ability (LSPt), however, did show a significant correlation with the use of sign at home. None of the other ratings showed significant correlations with this variable.

In one respect, the findings are obvious. It is to be expected that children who sign at home will have better sign language ability. Of much greater importance is whether improved sign language ability carries over to improved language skills in general. The close correspondence between the spoken language (LSP) and sign language (LSI) ratings in the factor analysis suggest that this might be the case. The correlations shown in Table 4.5 support this view to a limited extent. The correlations between the use of sign language in the home and ratings of spoken language were barely significant. On the other hand, the sample of children was small. Only 11 of the 67 children studied used sign language at home.

CONCLUSIONS

The speech production data showed very similar patterns of performance both between tests and between the young hearing-impaired children considered in this study and the older hearing-impaired children considered in related studies. The differences in relative performance that were observed between imitation and picture-elicited word tests were quite subtle. The data suggest that

TABLE 4.5. Correlations between use of sign language at home and ratings of communication skills.

Communication skill	*Symbol*	*Correlation coefficient*	*Signif. level*
Signed language rating			
Sample 1 (Stuckless Picture Sequence)	LSI_1	0.33	.004
Sample 2 (Peabody Picture)	LSI_2	0.31	.006
Spoken language rating			
Sample 1 (Stuckless Picture Sequence)	LSP_1	0.22	.04
Sample 2 (Peabody Picture)	LSP_2	0.20	.06
Teacher ratings	LSP_t	0.33	.004
Overall communication competence	OCC	0.003	
Total speech reception			
Teacher ratings	TSR_t	0.001	—
Speech intelligibility rating			
Outside evaluators	SPI	0.12	—
Teacher ratings	SPI_t	0.06	—

the children made better use of visual cues in the imitation test and also had greater relative difficulty with the harder, nonvisible consonantal sounds. There are few practical test procedures that can be used with young hearing-impaired children. Syllable imitation is one such procedure. In using imitative tests, it is important to know how the child's performance is likely to differ from performance on other, more conventional test procedures used with older children. The data reported here provide such a guide.

The differences between the data obtained in this study on young hearing-impaired children and those obtained elsewhere on older hearing-impaired children (see Chapters 7 and 8) have important practical implications for the development of more effective speech-training programs. The largest difference observed in speech production test scores between the younger and older hearing-impaired children related to the overall percentage of correct productions, the older children scoring substantially higher on the consonantal sounds and moderately higher on the vowels and diphthongs.

In addition to this one major difference, several smaller differences in relative performance on various consonantal sounds were observed. The older children, on the average, showed better relative performance on the nasals and on the glides and stops produced at the back of the mouth. These findings are consistent with the model of articulatory error patterns in the speech of the hearing-impaired proposed by Levitt and Stromberg (1983). A key element of this model is that there is a common pattern of segmental errors in the speech of hearing-impaired children, and the major difference among children (considering segmental errors) is the overall frequency of error. There are exceptions to this general trend, such as children with extremely poor speech who demonstrate an overlay of additional errors or children who have had the benefit of an extremely good speech training program. On the average, however, the large majority of hearing-impaired children show similar segmental error patterns. Those patterns will vary to some extent with age as the child's repertoire of sounds increases. The similarities in suprasegmental (prosodic) error patterns are not as marked.

The few differences in relative performance that were observed between the younger and older hearing-impaired children suggest that the vowel system of the 6-year-old hearing-impaired children is relatively well developed (compared to older hearing-impaired children) and that further development will involve the consonants primarily. The front sounds are also fairly well developed in young hearing-impaired children, and thus it is not surprising to find that the older hearing-impaired children showed more of an improvement on those consonants produced farther back in the mouth.

The direction of future growth is a crucial consideration in the development of more effective speech-training programs. The findings reported here provide detailed information on expected levels of performance for young hearing-impaired children, at least at the segmental level, and identify areas in which future growth is likely to be substantial. This information should be of value in planning individualized speech-training curricula for the young hearing-impaired child.

The results obtained with the Speech Reception Training Test indicate that the majority of the hearing-impaired children considered in this study are in need of auditory training. The difficulties experienced by the children reflected poor recognition of sounds rather than limitations imposed by the impaired auditory system. It should be remembered that although the children exhibited poor recognition of speech sounds received auditorially, their total speech reception skills (including visual and manual cues) were relatively good, on the average. An effective auditory training program should produce substantial improvements on speech recognition ability with concomitant improvements in other communication skills.

The children's speechreading skills were roughly appropriate for their age. Comparisons with the results obtained on the same test with older hearing-impaired children (see Chapter 7) showed substantial improvements in overall performance with age. As reported in Chapter 7, most of the 10-year-old hearing-impaired children scored at or close to 100% on the Myklebust-Neyhus speechreading test. Of the various communication skills considered in these investigations, speechreading showed the largest improvement between younger and older hearing-impaired children. Improvements in language skills were also large, and it may be that because speechreading involves language to a large degree, speechreading ability increases concomitantly with age-related improvements in language skills.

The use of subjective ratings in evaluating communication and language skills was found to be efficient and practical. A set of rating scales, modeled on those of Johnson (1975), was developed and found to be particularly useful. It is important, however, to bear in mind the limitations of subjective ratings. In addition to random variations in judgmental criteria, which may result in high test-retest variability and poor interrater reliability, there is also the possibility of fixed differences among raters that reflect a judgmental bias. The classroom teachers in this study, for example, gave consistently higher ratings than did the outside evaluators. This difference was presumably due to the teachers' familiarity with the children, but it may also be that the teachers were less strict in their criteria. Fortunately, the rating differences between the teachers and the outside evaluators were consistent, and it is possible to compensate for the differences in interpreting the data. It is important, however, to bear in mind that such differences exist.

The use of the rating-scale technique allowed a large body of data to be gathered on a range of communication and language skills. A factor analysis of the ratings showed that language and speech skills fell on two orthogonal factors. Whereas the language-oriented skills (spoken language ability and signed language ability) showed a high correlation with the language factor and a low correlation with the speech factor, most of the other communication skills, other than speech intelligibility per se, showed some correlation on both factors. Speechreading or total speech reception ability showed a moderate correlation with both the speech and language factors. A similar finding was obtained in the concurrent study of older hearing-impaired children.

The role of background variables (e.g., educational history, familial factors) is particularly important in evaluating young hearing-impaired children and planning their educational programs. Children who had the benefit of early intervention showed superior language and communication skills. Special education of high quality, beginning early in life, is a key ingredient in the prescription for success.

A small proportion of the children used sign language at home, and it was of interest to determine if the use of signing at home was correlated with better communication and language skills. As expected, a statistically significant correlation was found between the use of sign language at home and ratings of signed language ability. A significant correlation was also obtained with ratings of overall communication competence, the latter skill also being heavily dependent on the use of signs in this particular population of children. A small correlation that just reached statistical significance (p = .05 to .06) was found between ratings of spoken language ability and the use of sign language at home. It is important to remember that this finding is correlational rather than causal. Children who use sign language at home usually have a deaf parent. Several studies have shown that deaf children of deaf parents have slightly better language skills, on the average, than do children whose parents have normal hearing. Whether this can be attributed to the early use of sign language or whether hereditory forms of deafness affect primarily the peripheral auditory system and have a less deleterious effect on central processing functions remains an important, but as yet unresolved, question.

ACKNOWLEDGMENTS

This study was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Please see the acknowledgments in Chapters 1 and 3 for more detailed information on the many individuals and organizations who assisted in this project and whose help is much appreciated.

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Chapter 5

Development of Syntactic Comprehension

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This chapter is concerned with the development of syntactic comprehension in hearing-impaired children. Two sets of data are considered: 4 consecutive years of longitudinal data on children at schools for the deaf (10 to 13.9 years of age) and 1 year of data for hearing-impaired children, roughly 10 years of age, who have been mainstreamed into the regular school system. The method of sampling the two groups of children was described in Chapter 1. The most important difference between the two groups (aside from the parameter of direct interest, mainstreamed vs. children at schools for the deaf) is that the mainstreamed group is typical of prelingually hearing-impaired children without additional handicaps, whereas the longitudinal group is a comprehensive sample of all children of a given age attending schools for the deaf in New York State. As noted earlier, a feature of the longitudinal study is that it includes children who, in other studies of this type, would typically be excluded on the grounds of having additional problems; that is, the usual methods of sample selection effectively screen out poor performers, the children for whom we should have a special concern. Also included in the longitudinal sample are a few postlingually deafened children. The effects of these additional variables are analyzed at a later stage (see Chapter 9).

Both groups of children received the same battery of tests, the Test of Syntactic Abilities (experimental edition, Quigley, Wilbur, Power, Montanelli, & Steinkamp, 1976). These tests are designed to measure the deaf child's comprehension of basic syntactic forms. Unlike other tests of this type, they are designed specifically for hearing-impaired children and cover syntactic forms appropriate for such children between 10 and 18 years of age. The tests also measure error types that are common to hearing-impaired children within this age range.

The syntactic forms and error types covered by the battery of tests used in this study included: negation, question formation, verb deletion, verbal auxiliaries, pronominalization, determiners, conjunction, and relativization (reduction and embedding of sentences). Several variations of each syntactic form were considered. A brief description of the specific forms tested is provided in the sections that follow. A detailed description of the tests used and the rationale underlying their development is provided by Quigley, Wilbur, Power et al. (1976). The experimental edition of the Test of Syntactic Abilities has since been modified, and the final version is now generally available (Quigley, Steinkamp, Power, & Jones, 1978). The differences between the test's final version and that used in this study are not substantive.

Two basic test formats were used. In the first, the child had to judge the grammaticality of a sentence. This was done by having the child check off each test sentence as being either *Right* or *Wrong*. An example of this type of test item is shown in the upper half of Figure 5.1. The second type of test used a multiple-choice format. In this case the child had to choose one set of possible answers as being the correct one. An example of such a test item is shown in the lower half of Figure 5.1. Quigley, Wilbur, Power et al. (1976) also used a format requiring the rewriting of sentences, but that was not used in our study because of difficulties in scoring the rewritten sentences and because some of the children attempted to avoid the rewriting task.

A summary of the syntactic forms tested by the subtests of the Test of Syntactic Abilities is provided in Table 5.1. The subtests are grouped according to syntactic form and, with one exception (conjunction), are listed in order of average score for each group. Note that the average score for a subtest, or group of subtests, provides only a rough indication of the relative difficulty of the syntactic form(s) being tested. Each subtest contains items that are rela-

Right-Wrong Format

The boy didn't be sick.

Check ☑ ONE box. The question is:

Right: ☐

Wrong: ☐

The above example is from the subtest on negation (modals).

Multiple-Choice Format

Write ONE word to make a good sentence

A man broke ______ arm

Write ONE of: it
he
his
him

FIGURE 5.1. Examples of test items.

TABLE 5.1. Grouping of subtests.

Subtest	*Symbol*	*Number of response alternatives*	*Average score unadjusted*	*Average score adjusted for guessing*	*Number of test items*	*Average group score weighted*
Negation						
modals	Nm	2	65.9	31.8	52	30.5
be/have	Nbh	2	64.5	29.0	45	
Questions						
answer environment	Qae	4	48.1	30.8	78	25.1
modals/auxiliaries	Qma	5	51.5	3.0	20	
Verbs						
deletion	Vd	2	70.9	41.8	16	20.7
auxiliaries	Va	2	54.3	8.6	28	
Pronominalization						
possessive adjectives	Pa	4	50.8	34.4	14	19.4
backwards pronominalization	Pb	3	52.7	29.1	10	
personal pronouns	Pp	3	49.3	24.0	28	
reflexive pronouns	Pr	5	28.5	10.6	36	
possessive pronouns	Ps	4	32.1	9.5	12	
Determiners	D	2	58.5	17.0	32	17.0
Conjunction	C	2	62.7	25.4	16	25.4
Relativization						
processing of sentences	Rps	7	23.7	11.0	36	
relative pron. referents	Rrpr	2	67.8	35.6	18	12.0
embedding + relative pronoun deletion	Repd	2	48.8	−2.4	58	−2.4

tively easy as well as difficult items, and the score for a subtest is thus a reflection of both the composition of the test and the syntactic forms being tested. The subtest on conjunction, for example, has a high proportion of relatively easy test items, and hence the average score for this subtest is comparatively high. Had this test included many of the more difficult syntactic forms involving conjunction, the average score would have been much lower.

Table 5.1 provides a useful framework for summarizing the experimental results obtained on the various subtests of the Test of Syntactic Abilities. The subsequent sections of this chapter present data according to the subtest grouping shown in the table. For the reader's convenience, the sections that follow have a common format. Each section begins with a brief description of the syntactic forms tested and the structure of the subtest(s) used. The data from the longitudinal study are then summarized, followed by an analysis of the specific syntactic forms covered by the subtest. Comparisons are then drawn between the mainstreamed children and those of comparable age attending schools for the deaf. Each section concludes with comments on the overall pattern of the data and its implications.

The same method of analysis was used on the data obtained for each subtest. The first step in the analysis was to subdivide the children into 10 groups according to their relative performance in the first year of the study. These groups are referred to as *deciles*. Decile 1 contains those children whose test scores were in the top 10%. Decile 2 contains those children whose test scores made up the second 10%, and so on. The subdivision of the children into decile groups was done separately for each subtest and for each of the two groups of children (children at schools for the deaf and mainstreamed children).

For the longitudinal study of children at schools for the deaf, each decile group consisted of the same set of children for each year of the study. The decile analysis in this case was thus restricted to children who completed all 4 years of the study. No significant differences were found in the distributions of average test scores between the children who completed all 4 years of the study and those who did not. This was checked by means of the chi-square test of independence using two-way contingency tables (average test scores vs. the two groups of children). In the large majority of cases, the reasons for a child's not completing all 4 years of the study were unrelated to the child's speech or language skills. For example, the most common reason for a child not completing all 4 years of testing was a change in residence.

The average scores by decile group are shown in the first diagram appearing in each section. Only even-numbered deciles are shown in Figure 5.2 and subsequent figures in order not to clutter the diagrams; odd-numbered deciles are only shown in cases involving very important or exceptional between-decile differences. Scores below the chance level of performance are not shown because they are primarily a result of random guessing. For these cases, the chance level of performance is as good an estimate of performance as any, and is the estimate shown.

The diagrams showing relative performance by decile all have a common format (Figures 5.2 through 5.17). The decile scores for the 10-year-old mainstreamed children are shown on the left side followed by the decile scores for the 4 consecutive years of the longitudinal study. The mainstreamed children were of comparable age (within ± 1 year) to the children attending schools for the deaf during the first year of the longitudinal study.

Accompanying each decile diagram is a table that shows the average scores obtained on each syntactic form covered by the subtest. The left column shows the average scores for the mainstreamed children. The next four columns show average scores for each year of the longitudinal study. As before, the data for the mainstreamed children should be compared to those for the first year of the longitudinal study.

A feature of the decile analysis is that it separates out the effect of relative level of performance and how this factor interacts with other factors, such as syntactic form or child's age. By maintaining the same set of children within each decile group, very sensitive statistical tests are available for examining developmental trends because between-subject differences are separated out. Comparisons between mainstreamed childern and those at schools for the deaf are necessarily confounded with between-subject differences.

Two types of statistical analysis were used. Developmental trends were analyzed using a three-factor, fixed-effects analysis of variance. The factors were: age of child, decile group, and syntactic form. Because the data are in the form of percentages, an arc-sine transformation was used to stabilize the error variance (Brownlee, 1965). Mean scores obtained from the analysis of variance have been converted back to percentages to simplify the plotting of the data. In the vast majority of cases, all three main effects were found to be statistically significant, as were the interactions between decile and syntactic form and between age of child and decile. The significance level was typically less than 0.001. Details of the analysis of variance are only mentioned in the sections that follow when the significant effects differ from the pattern described above.

The differences between the mainstreamed children and those at schools for the deaf were analyzed using t tests between specific decile groups of interest. As before, the arc-sine transformation was used to stabilize the error variance.

The raw subtest scores were used in all of the analyses. An adjustment for random guessing was made only in those cases when comparisons among subtests were necessary (as in Table 5.1). The adjustment for random guessing was avoided when not essential because there are several ways in which this adjustment can be made, and difficulties can occur with each method depending on the underlying assumptions. For example, when test scores are at, or close to, the chance level, there is a high probability that one or more of the adjusted scores will result in a negative percentage, creating difficulties for subsequent statistical analyses.

An item analysis was used routinely to identify any test items that generated unusually high or low scores, or that were idiosyncratic in some way. The results of the item analysis are not reported except in those cases involving important idiosyncracies affecting the interpretation of the data.

NEGATION

General Comments

Negation appears very early in normal language development (Brown, 1973). The two subtests on negation cover forms that are acquired early as well as several common error forms that have been observed in emerging language. The first subtest deals with the system of modals *(do, can, will)*, the other with the verbs *be* and *have*.

The *Right/Wrong* format was used for each of the two subtests. Both correct and incorrect forms were presented to the child, who was required to indicate whether the sentence was *Right* or *Wrong*. Because there were two response alternatives, the expected score for random guessing was 50%.

Subtest on modal forms (Nm). Nine modal forms were tested: *no* form with *did*, *not* form with *did*, *no* form with *can*, *not* form with *can*, *no* form with *will*, *not* form with *will*, and Redundancy. Within each of these categories, several sentences were used; each of them occurred in several versions according to developmental forms observed by Klima (1964) and Klima and Bellugi-Klima (1966). For example, *no* forms with *did* included the following items: *No the boy go home*, *The boy go home no*, *The boy no did go home*, *The boy did not go home*, and *The boy didn't go home*, as well as variations such as *The boy no go to school* and *The boy did not go to school*. The negative forms used in the Redundancy category were of this type: *The boy didn't be sick*, *The boy didn't was sick*, and *The boy wasn't sick*.

Figure 5.2 shows that all of the children in the longitudinal study improved steadily over the 4-year period. The rate of improvement was greatest for the children in the middle deciles (2 through 8). Those in Decile 10 showed a smaller rate of improvement because their test scores were already close to the maximum, and there was little room for measuring further improvement. Those children were presumably in the process of acquiring more advanced negative forms not covered by the subtest. The children in the lowest two deciles showed no evidence of understanding the modal forms covered by the subtest (i.e., their scores were at or below the random-guessing level) until the second year of the study (i.e., until age 11).

The modal forms that were tested (see Table 5.2) showed only small differences in average score, and those differences remained much the same over the 4-year period of the study. The scores for the *not* forms were slightly higher than those for the *no* forms with *am* and *will*. The reverse was true for *no* and *not* forms with *did*. The lowest score was obtained for Redundancy, which is a fairly common error form in the language of hearing-

TABLE 5.2. Negation—Modal forms.*

Type number	Description	Mainstreamed	Age of child 10–11	11–12	12–13	13–14
i	*No* form with *did*	68.4	60.2	71.2	75.1	81.0
ii	*Not* form with *did*	61.2	55.4	64.8	70.6	72.7
iii	*No* form with *can*	70.0	69.3	74.0	76.6	78.1
iv	*Not* form with *can*	65.5	71.6	65.8	77.6	79.5
v	*No* form with *am*	63.7	65.7	70.7	78.3	80.9
vi	*Not* form with *am*	71.7	71.4	76.8	77.9	84.0
vii	*No* form with *will*	67.8	65.3	70.2	75.3	81.2
viii	*Not* form with *will*	73.0	76.0	81.7	81.9	86.9
ix	Redundancy	35.3	54.3	55.1	61.8	61.5

*All entries are average score in percentage correct.

impaired children. An example of a redundancy error appears in Figure 5.1.

The mainstreamed children showed much the same pattern of performance as the children at schools for the deaf (see the left side of Figure 5.2 and Table 5.2). The ranking of average scores for the forms tested was essentially the same for both groups of children, except that the mainstreamed children showed slightly higher scores for both *no* and *not* forms with *did.* The mainstreamed children did not show any significant differences in average score with children of comparable age at schools for the deaf. The comparison was done decile by decile, as shown by the connecting lines in Figure 5.2.

Be/have/forms. Four negative forms involving *be* and *have* were tested. They were *no* forms with *be, not* forms with *be, no* forms with *have,* and *not* forms with *have.* Each of these four categories contained several sentences, with several versions of each sentence. For example, *no* forms with *be* included the following items: *No the baby is happy, The baby is happy no, The baby is not happy,* as well as such variations as *Teacher no is sick today* and *Teacher is no sick today.* The test contained between 10 and 12 items for each of the 4 negative forms tested, yielding a total of 46 test items.

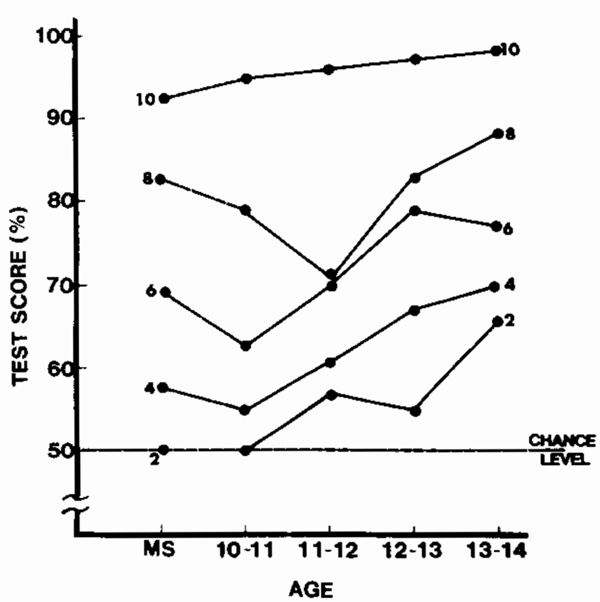

FIGURE 5.2. Mainstreamed and longitudinal data by decile: Negation, modal forms, Nm.

As before, the longitudinal data (Figure 5.3) showed steady improvements with increasing age for children in the middle deciles (2 through 8). The children in the lowest two deciles scored at chance level at age 10, but showed some evidence of understanding the forms tested in their 11th year. The children in the highest decile were already close to the maximum score at age 10, and for this group there was no room for any measurable increase in test score over the years. The average scores for this decile showed a regression in the second and third years of the study, which is believed to be the result of chance variations in the measured test scores.

Table 5.3 shows no significant differences in average score between the syntactic forms tested. This was the only subtest for which this main effect was not significant. There was, however, a significant difference in average score between the mainstreamed children and children of comparable age at schools for the deaf. (t = 5.86, p < .001). In this case, contrary to the usual pattern, the mainstreamed children did less well, on the average.

Summary. The data are striking in the wide range of scores within the two groups of children and the relatively small differences between the two groups. For both the mainstreamed children and those of comparable age at schools for the deaf, test scores ranged from random guessing (Deciles 1 and 2) to close to the maximum score of 100% (Decile 10). That is, there were quite a few children in both groups who could not handle the syntactic forms tested, while others in both groups could handle virtually all of the forms tested.

A second striking aspect of the data was the slow average rate of improvement. Even after 4 years, only an additional 20% of the children (Deciles 8 and 9) approached the maximum score. The average improvement was less than 15 percentage points, or roughly one-third of the range from random guessing to the maximum score. At this rate of progress, it is estimated that another 4 years would be required before children at an average level of performance (i.e., children in Deciles 5 and 6) would show mastery of the syntactic forms tested.

TABLE 5.3. Negation—*Be/have* forms.*

Type number	*Description*	*Main-streamed*	*Age of child* 10–11	11–12	12–13	13–14
i	*No* forms with *be*	64.4	64.7	74.4	75.2	78.0
ii	*Not* forms with *be*	61.4	67.0	70.8	75.3	78.2
iii	*No* forms with *have*	60.5	62.6	72.0	74.1	73.5
iv	*Not* forms with *have*	57.1	68.3	73.5	72.3	72.6

*All entries are average score in percentage correct.

On the positive side, children in the lowest deciles showed some evidence of understanding the forms being tested (and of being able to handle the test format) by the second year of the study, and that steady, albeit slow, progress was observed in subsequent years. This indicates that even the weakest children in the longitudinal study, including those who are often labeled as "learning disabled" or "minimally brain damaged" or even "retarded," are acquiring these syntactic forms.

QUESTION FORMATION

The question form is one of the earliest forms to be acquired. This is true for both normal-hearing and hearing-impaired children. Because questions are not frequently encountered in the written language of deaf children (and hence it is difficult to assess the development of question forms from written language samples), it is doubly important that effective tests of question formation be included in tests of syntactic comprehension. The nature of questions is such that, fortunately, very effective tests of question comprehension can be developed. Difficult test formats, such as judging the grammaticality of test sentences, can be avoided. Instead, test formats can be developed in which the child responds to a well-designed set of questions. This technique was used effectively in developing a test of syntactic comprehension in very young hearing-impaired children (Gaffney 1977; Geffner & Rothman-Freeman, 1980; see also Chapter 3) and was also used in the main subtest dealing with question forms. Data were also obtained on a second subtest using the *Right/Wrong* format. In the latter case, questions involving modals and auxiliary verb forms were tested.

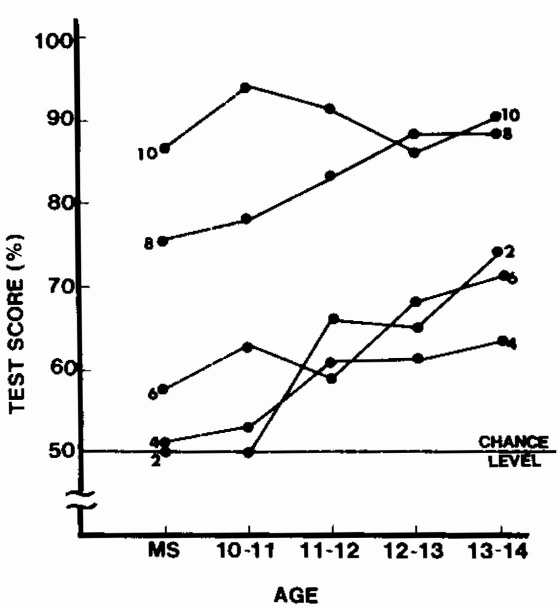

FIGURE 5.3. Mainstreamed and longitudinal data by decile: Negation, *be/have* forms, Nbh.

Question Forms Tested in an Answer Environment

A multiple-choice answer environment was used. The format for each test item consisted of a question accompanied by a set of possible answers. For example, a typical test item was of the form:

Who gave the boys ice cream?
a. Mother
b. At the shop
c. A party
d. Yesterday

The child was required to indicate which of the four alternatives was the correct answer to the question. The test included 39 question forms. There were two test items for each question form, with four alternative answers for each item. The 39 question forms were classified into 8 basic question types. These were:

i. *Yes/No* questions (3 forms)	*Is? Do?* and *Can?* (Aux/Modal questions with *Yes/No* answers)
ii. Tag questions (8 forms)	*Wasn't? Can't/Can? Hasn't?* and *Didn't?* (with answer of the form *Yes/No, I think so, I don't know*, and *PRO did*)
iii. *What* questions (3 forms)	*What shape? What colour?* and *What size?*
iv. *What*-V questions (5 forms)	*What did NP do? What did NP Verb? What does NP mean? What happened to?* and *What kind of?*
v. *Wh-* questions (other than *what*) (7 forms)	*Who? Where? When? Whose? With whom? Which?* (with descriptive answer, e.g., *The big one*), and *Which?* (with possessive answer, e.g., *John's*)

TABLE 5.4. Questions, answer environment.*

Type number	*Description*	*Main-streamed*	*Age of child* 10–11	11–12	12–13	13–14
i	Yes/No questions	73.0	47.0	57.3	66.7	74.3
ii	Tag questions	67.3	39.7	50.9	55.5	58.1
iii	What questions	71.7	57.9	71.3	78.1	78.8
iv	What-V questions	72.8	54.5	63.0	65.6	73.4
v	Wh-questions	59.4	47.6	55.0	64.0	69.8
vi	How questions	65.8	48.7	59.6	67.2	74.4
vii	Causal questions	57.2	38.0	42.3	46.2	49.2
viii	Intensive questions	36.0	12.8	22.6	28.3	28.0

*All entries are average score in percentage correct.

vi. *How* questions (6 forms)	*How many? How often? How much? How old? How far?* and *How Aux NP-V?*
vii. Causal questions (5 forms)	*Why?* (with answers of the form, *Because ----, for ----, so that ----*) *What did NP-V-NP for?*
viii. Intensive questions (2 forms)	*How scared? How happy?*

Note that the question forms are listed in pairs. The first two are paired because they both require a *yes/no* answer. The two versions of *what* questions are similarly paired. The *wh-* and *how* questions are estimated to be of roughly equal difficulty and are paired for convenience. The remaining two question forms were by far the most difficult and are also paired for convenience.

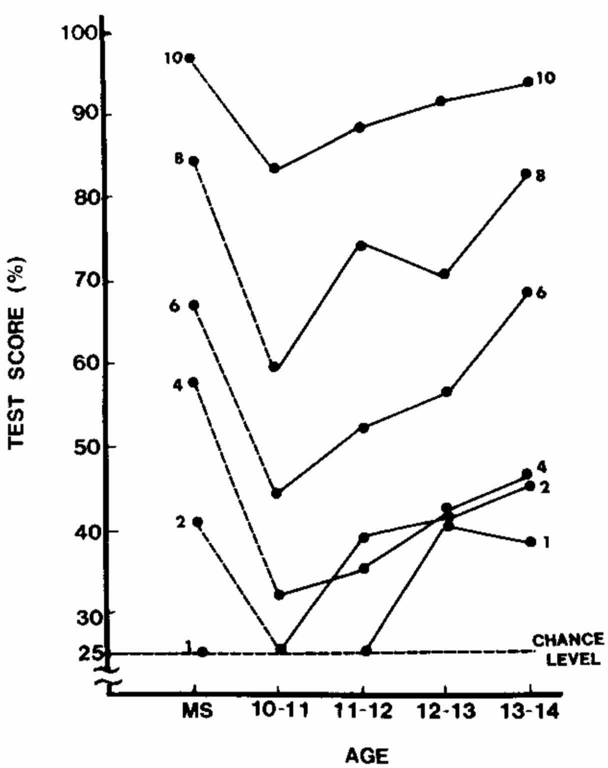

FIGURE 5.4. Mainstreamed and longitudinal data by decile: Questions, answer environment, Qae.

The longitudinal data, summarized in Figure 5.4, show a steady improvement over the years for children at all levels of performance. While children in the highest decile showed an improvement in average score of about 10 percentage points, bringing them close to the maximum possible score at age 14, the children in the lowest decile progressed from the chance level of performance to just under 15 percentage points above the chance level.

Very large differences in average performance were observed among the various question forms. The magnitude of these differences varied between the two groups of children. The data in Table 5.4 show that the mainstreamed children did particularly well on *yes/no* and tag questions, but that children at schools for the deaf did relatively poorly on the tag questions and showed mixed results on the *yes/no* questions. The average test score for the latter question form was quite low in the first year of the study, but improved steadily to a relatively high score by the fourth year. Both groups of children did very well on *what* and *what*-V questions, moderately well on *how* and *wh-* questions (other than *what*), and relatively poorly on causal questions. In all of these cases, the mainstreamed children showed significantly higher scores. The lowest scores of all, for all of the children, were obtained on the intensive questions.

The analysis of variance showed a significant interaction between age and syntactic form ($p < .04$). This was one of the few subtests in which a significant interaction of this type was observed. Because of its importance, the nature of this interaction is considered in greater detail in the following section.

Developmental and Between-Group Differences for Specific Question Forms

Figure 5.4(A-H) shows longitudinal data for each of the question forms considered in this subtest. Also shown, for comparative purposes, are corresponding data for mainstreamed children. The diagrams are grouped in pairs following the format described earlier (e.g., the uppermost pair of diagrams show the two question forms requiring a *yes/no* answer). The diagrams are also ordered

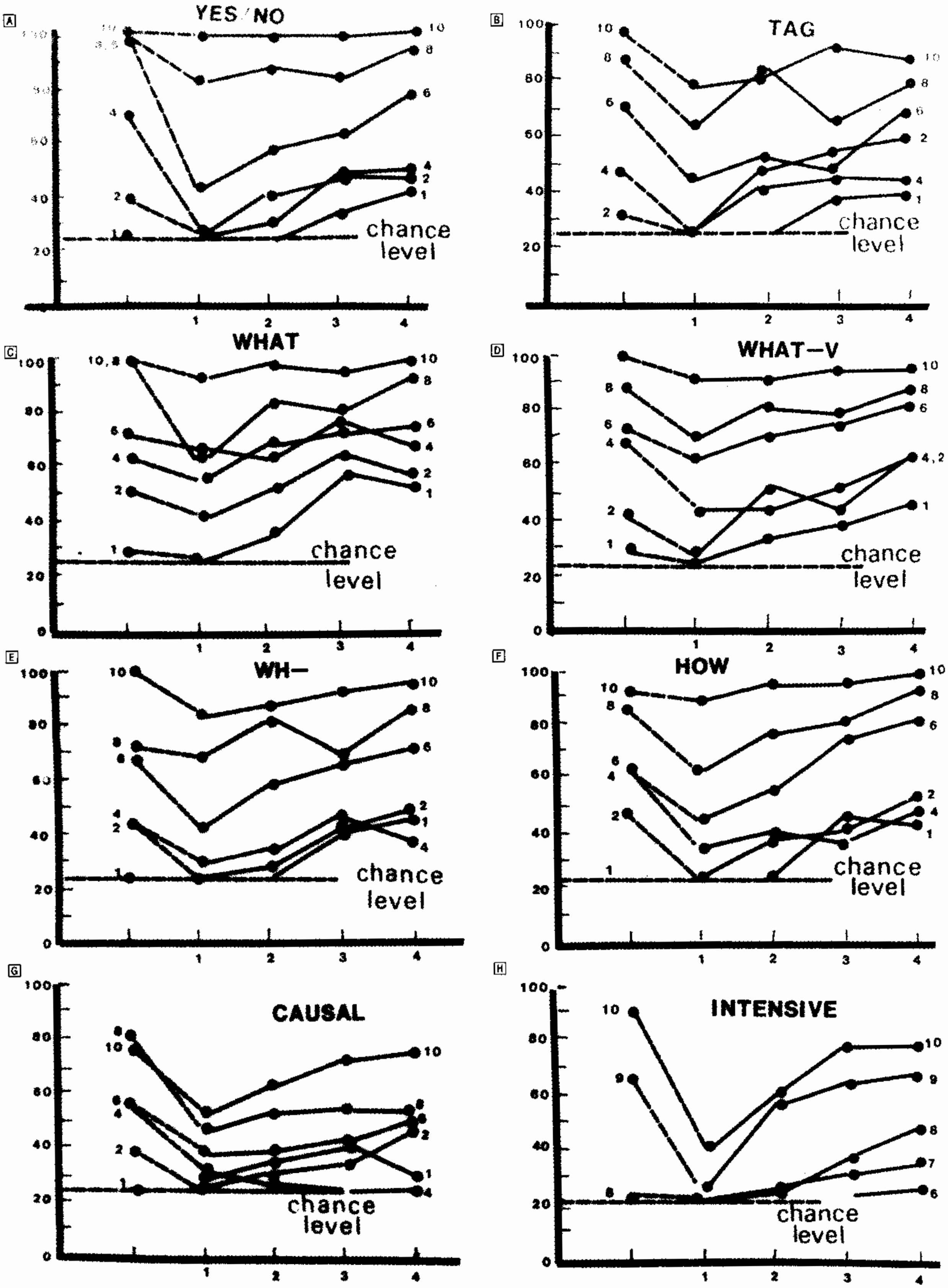

FIGURE 5.4(A-H). Subsections of question test, answer environment.

roughly according to average score; (e.g., the question form yielding the lowest scores, on the average, appears in the bottom right corner).

The diagrams show significant differences in the rate of improvement for the various question forms considered. For example, the average rate of improvement for the *yes/no* questions is fairly high, whereas that for the causal questions is relatively small. There are also important differences between the question forms in two other respects, *saturation* and *bottoming-out*. By bottoming out is meant the average test score is not significantly different from the chance level of performance. Saturation refers to the corresponding effect at the opposite end of the scale, when the average test score is at or very close to 100%. Bottoming out and saturation effects are of great importance in evaluating developmental changes.

The bottoming-out effect makes it possible to track developmental changes by noting the first evidence that children within a given decile group understand a specific form. For example, the data for *yes/no* questions show that during the first year of the longitudinal study, the children in the lowest decile were essentially guessing at random for all of the question forms tested. By the second year (age 11), the children in this decile showed some evidence of understanding the *what* and *what*-V questions. By age 12, these children also showed better than chance performance on *yes/no,* tag, *wh*-, and *how* questions. The rate of improvement, although measurable, was very slow. By the fourth year of the study, performance on the *what* and *what*-V question forms was still only moderately above the chance level for these children.

The bottoming out effect was quite substantial for the more difficult question forms (causal, intensive) and, as a result, inferences on the acquisition of these forms is necessarily restricted to children in the higher deciles. For example, only the top 20% of the children showed any significant evidence of understanding intensive questions in the first year of the study. By the fourth year, the number of children showing some evidence of understanding this question form had increased to just over 40%. Very little can be inferred about the remaining 60% of the children other than that this particular form was too difficult for them over all 4 years of the longitudinal study.

The saturation effect allows one to track developmental changes indicated by the children's mastery of the syntactic form being tested. Saturation occurred for only about half of the question forms tested, and only the children in the highest decile demonstrated this effect. In short, only a small proportion of the children mastered the easier question forms. None of the children mastered the more difficult forms (causal, intensive), although by age 14 the children in the highest decile were approaching the maximum score for the tag and *wh*- questions.

The data on the causal questions show very little change for all decile groups. An unexpected aspect of these data is that children in the lowest decile scored above the chance level in all 4 years of the study. This result is believed to be artifactual due to a lack of homogeneity among the test items within this subtest. This particular problem has since been rectified in the final version of the test.

Because of the great sensitivity and wide range of performance levels covered by this subtest, it is possible to identify several important differences between the mainstreamed children and those attending schools for the deaf. Although a small proportion of children at schools for the deaf scored well on the *yes/no* questions, nearly half of the mainstreamed children obtained the maximum score on this subtest. Roughly one in five of these children also obtained the maximum score on tag questions, which also involve a *yes/no* response. In addition, a substantial proportion of mainstreamed children obtained the maximum score on the *what* and *what*-V question forms (roughly 30% and 20% of these children, respectively).

These data indicate that many more mainstreamed children than children at schools for the deaf show an ability to handle common question forms. This is particularly true of questions involving responses of a *yes/no* type and may reflect differences in the communicative environment encountered by these two groups of children.

In marked contrast to the relative superiority of the more advanced mainstreamed children, those in the lower deciles were only modestly better than their low-scoring counterparts at schools for the deaf. For example, even for those question forms on which the more advanced mainstreamed children did especially well, the mainstreamed children in the lowest two deciles scored at or just above the chance level. Their scores are only slightly better than those obtained by children in the lowest two deciles at schools for the deaf.

This finding has important implications from both a pedagogical and a theoretical viewpoint. It seems that those mainstreamed children who do well, do very well. Whether or not this can be attributed to the effects of mainstreaming is a question that cannot be answered by the existing data. (This is because of major confounding effects, e.g., the mainstreamed children are often children who already have demonstrated superior communication and language skills and do not require the additional special attention they would receive at a school for the deaf.) At the same time, it also seems that mainstreamed children who do not do well, do rather badly. Their scores are only marginally above those for the lowest scoring children at schools for the deaf. Bearing in mind that a substantial proportion of these low-scoring children at schools for the deaf have additional handicaps, the level of performance of the poorer mainstreamed children (who typically do not have additional handicaps) is indeed low. These mainstreamed children clearly need additional special attention.

Auxiliaries and Modals

This subtest was concerned with the ordering of constituents in questions. The rules for subject-auxiliary inversion and *do*-support were tested using the

TABLE 5.5. Questions, modals/auxiliaries.*

Type number	Description	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	*Do* E.g., Did you buy a new car?	60.1	54.3	62.4	64.3	71.9
ii	*Have* E.g., Did the man have a hat?	58.6	51.3	55.6	55.3	61.6
iii	*Be* E.g., Is the dog brown?	52.0	42.1	44.4	47.1	53.3
iv	*Can* E.g., Can all the boys run?	54.3	51.2	53.0	56.3	61.5

*All entries are average score in percentage correct.

Right/Wrong format. Four verb types were covered: *do, have, be,* and *can.* The test items included examples of both correct and incorrect word order. Error forms included subject-verb inversions (e.g., *Bought you a new car?*) as well as the lack of a subject-auxiliary inversion (e.g., *Children played in the park?*).

The data are summarized in Figure 5.5 and Table 5.5. Scores were relatively low, on the average, particularly in comparison with the subtest on question forms in an answer environment. The longitudinal data show that the majority of the children had great difficulty with this test and that it was only in the last year of the study (age 13–14) that substantial numbers of children scored above the chance level. The scores for the mainstreamed children were similar in that only the upper third of the children scored significantly above the chance level.

Small but consistent differences were observed among the scores for the different verb types. The highest scores were obtained for the question forms involving *do* and the lowest scores for the forms involving *be.* In the latter case, the children had particular difficulty in identifying the ordering of the constituents appropriate to a question (e.g. *Is the dog brown?* vs. *The dog is brown?*). Much of the difficulty can be traced to the fact that the latter form is acceptable under certain conditions. Many of the children consistently identified this particular form as being *Right,* thereby bringing the test scores below the chance level, as shown in Table 5.5, Type iii. If the ambiguous test items are omitted, the test scores are increased by 10 to 20 percentage points, on the average. Even with this adjustment, however, the children did considerably less well on this subtest than on the preceding subtest involving questions in an answer environment.

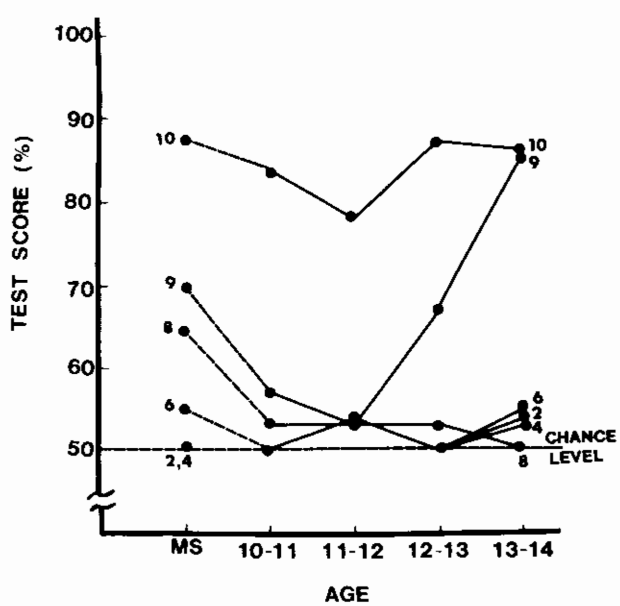

FIGURE 5.5. Mainstreamed and longitudinal data by decile: Questions, modals, and auxiliaries, Qma.

VERB FORMS

Verb Deletion

A common error in the written language of deaf children is omission of the verb. The relative frequency of this error depends on the type of sentence. Omission of the verb appears to be most frequent in sentences containing a locative phrase, such as *The cat under the chair.* Other fairly common cases involve forms of the verbs *be* and *have* in simple declarative sentences. These types of sentences are shown in Table 5.6. In the verb deletion test, both correct and incorrect (i.e., verb deleted) forms were presented to the child, who was required to indicate whether the sentence was *Right* or *Wrong.* There were 4 test items for each of the 4 sentence forms shown in Table 5.6. The test thus consisted of 16 items, of which 8 were syntactically correct, and 8 had the verb deleted. The longitudinal data are shown in Figure 5.6. Systematic improvements in test scores are evident over the 4-year period of the study. The children in the highest decile were already at or very close to the maximum score at the start of the study. In contrast, the children in the lowest decile only showed an above-chance level of performance at age 12.

Table 5.6 provides a breakdown of the average scores according to syntactic form and year of testing. Of the four sentence forms considered, those involving a locative phrase showed lower scores, on the average. The other

TABLE 5.6. Verb deletion.*

Type number	*Description*	*Main-streamed*	*Age of child* 10–11	11–12	12–13	13–14
i	Subject + verb + locative phrase E.g., The cat (hid) under the chair.	54.4	66.2	68.1	73.0	78.3
ii	Subject + verb + object + locative phrase E.g., The boy (threw) the ball over the fence.	74.7	71.4	76.9	81.2	86.1
iii	Subject + *be* + predicate adjective E.g., The girl (is) sick.	60.9	75.0	83.8	86.3	93.3
iv	Subject + *have* + object E.g., The man (has) a coat.	79.5	75.2	75.9	82.4	84.3

*All entries are average score in percentage correct.

sentence forms showed much the same level of performance at the start of the longitudinal study, although scores for the sentence form involving the verb *to be* showed a greater rate of improvement.

The scores for the mainstreamed children were very similar to those for children at schools for the deaf when analyzed by decile (Figure 5.6), but a systematic difference was observed for the comparison by syntactic form (Table 5.6). In this case the mainstreamed children did less well on the sentence forms involving a locative phrase and those involving the verb *to be*.

Several important conclusions can be drawn from the test of verb deletion. First, substantial improvements in performance were observed over the 4-year period of the study. Thus, although deletion of the verb is a common error in spoken and written language of hearing-impaired children, it is an error that such children can learn to recognize.

Verb deletion is not simply a common error; it is one that is particularly deleterious to understanding. In a study evaluating the relative effect of common errors in the written language of deaf children, it was found that

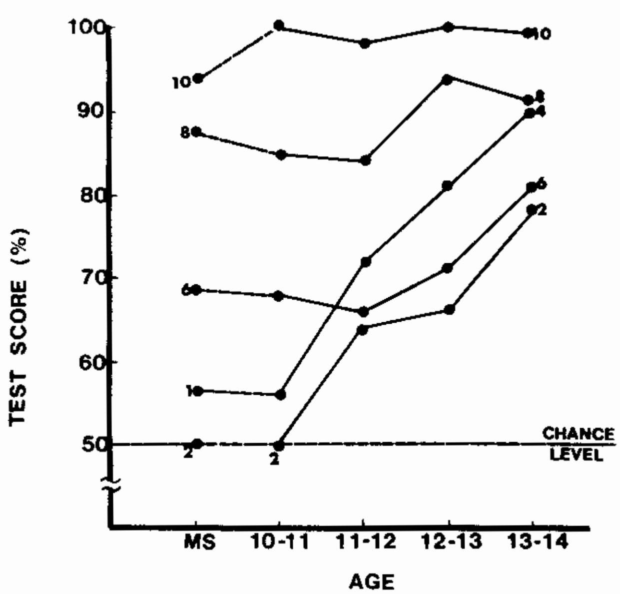

FIGURE 5.6. Mainstreamed and longitudinal data by decile: Verb deletion, Vd.

errors of verb deletion and other major errors of omission were by far the most deleterious (Levitt, Stromberg, McGarr, & Carp, 1974).

A particularly gratifying aspect of the data was the substantial improvement in performance shown by the large majority of children. Only the children in the lowest decile showed a relatively low rate of progress. Those children might well have had difficulty with the test format (i.e., judging grammaticality) as well as with the syntactic form being tested.

Verbal Auxiliaries

Deaf children are particularly prone to errors in their use of verbal auxiliaries. As noted by Quigley and Power (1971), the most frequent uses of auxiliaries in English are with the present progressive and perfect tenses and the passive voice. The test on verbal auxiliaries covered these three cases as well as confusions between *be* and *have*. As in the previous case, the test consisted of a set of sentences, roughly half of which were syntactically correct; the remaining sentences contained errors in the use of verbal auxiliaries. The child was required to indicate whether each sentence was *Right* or *Wrong*. The sentence types covered by the test are shown in Table 5.7. The longitudinal data (Figure 5.7) show that well over half of the children (up to and including the 7th decile) did not perform significantly above the chance level. Of the children scoring above the chance level, only those in the highest decile showed any improvement over the years.

An analysis of the syntactic forms tested (Table 5.7) showed that the *be/have* confusion exhibited the highest scores, whereas the scores for the other forms tested (progressive tense, passive voice, and perfect tense) were lower and did not differ significantly from each other. Progress was relatively slow for all of the forms tested.

The data for the mainstreamed children showed similar patterns. Only those children in the three highest deciles showed scores significantly above the chance level of performance. Similarly, the scores for the *be/have* confusion were significantly higher than those for the other forms tested. For those cases where better than chance performance was obtained, the scores for the main-

TABLE 5.7. Verbal auxiliaries.*

Type number	Description	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	Progressive tense E.g., The boy is kick (is kicking) the ball.	47.1	45.1	55.9	54.9	57.6
ii	Passive voice E.g., The ball kicked (was kicked) by the boy.	55.6	52.7	56.5	58.2	58.3
iii	Perfect tense E.g., The boy has kick (kicked) the ball.	52.0	53.8	49.7	47.6	55.4
iv	*Be/have* confusion E.g., The man is (has) a coat. The girl has (is) sick.	73.3	60.3	64.6	67.7	69.4

*All entries are average score in percentage correct.

streamed children were higher than those for children at schools for the deaf.

In short, the test on verbal auxiliaries was much more difficult than that on verb deletion. Only a small proportion of the children performed above the chance level and even fewer showed evidence of learning over the 4-year period. Of the four forms tested, the highest scores were obtained for the *be/have* confusion. This test form is not, strictly speaking, a test of verbal auxiliaries but rather a test of a common error type.

PRONOMINALIZATION

General Comments

The term *pronominalization* is used to describe the process of pronoun formation. The English pronoun system is fairly complex and a source of difficulty for both hearing and deaf children. The tests in this battery cover five of the most common pronoun forms: personal pronouns, possessive pronouns, possessive adjectives, backwards pronominalization, and reflexive pronouns. Other syntactic forms involving pronouns are covered by the tests on relativization. The tests used in this section were of the multiple-choice format. This type of format is useful not only in providing a performance measure of the percentage of items correct, but also in providing information on the types of error made by the children. Because the patterns exhibited by the data are similar for the five pronoun subtests, the summary and discussion of the results are presented in a separate subsection. Each of the five subsections that follow describes one of the pronoun subtests and the data obtained for that subtest. The subtests are described in order of decreasing score (see Table 5.1). The last subsection contains a summary of the findings, including a discussion of longitudinal trends.

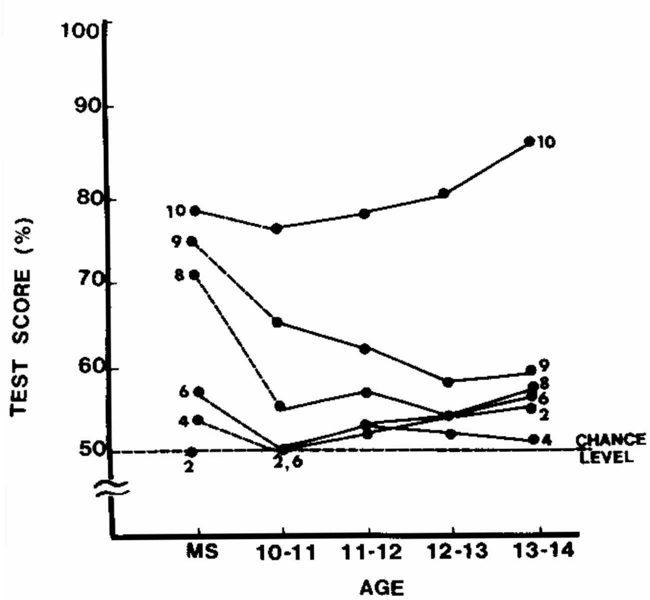

FIGURE 5.7. Mainstreamed and longitudinal data by decile: Verbal auxiliaries, Va.

Possessive Adjectives

This test covers the seven possessive adjectives: *my, your, his, her, its, our,* and *their.* There were two test items for each form of the possessive adjective, and the total number of items in the test was 14. A 4-alternative multiple-choice test format was used. The chance level of performance was therefore 25%. Table 5.8 lists the seven forms of possessive adjective covered by the test and the average scores obtained for each form. Also shown in the table are examples from each subdivision of the test and, in parentheses, the four alternatives available to the child.

Backwards Pronominalization

This test deals with the child's ability to use the proper pronoun before the referent noun or noun phrase occurs in the sentence. There were five subdivisions to the test, three involving personal pronouns and two involving possessive adjectives. There were two test items for each subdivision of the test. The forms tested are listed in

TABLE 5.8. Possessive adjectives.*

Type number	Description	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	First person, singular E.g., John found ______ book. (I, mine, my, me)	70.7	55.5	71.2	69.6	76.3
ii	Second person E.g., This is ______ dog. (it, your, yours, you)	82.4	56.7	54.6	58.3	70.2
iii	Third person, singular, masculine E.g., Bill washed ______ face. (his, him, it, he)	68.5	56.6	60.4	71.9	69.1
iv	Third person, singular, feminine E.g., Mary lost ______ hat. (her, hers, she, it)	80.3	63.1	63.9	63.9	64.5
v	Third person, singular, neuter E.g., A cat loves ______ kittens. (it, its, she, they)	32.4	33.4	29.2	34.2	32.9
vi	First person, plural E.g., The boys came to ______ house. (ours, our, we, us)	65.3	34.8	37.9	44.0	43.0
vii	Third person, plural E.g., The girls liked ______ dresses. (theirs, them, their, they)	50.0	25.2	32.2	39.2	42.9

*All entries are average score in percentage correct.

Table 5.9. A multiple-choice format with three alternatives was used; the chance level of performance was therefore 33.3%. The response alternatives available to the child are shown in parentheses.

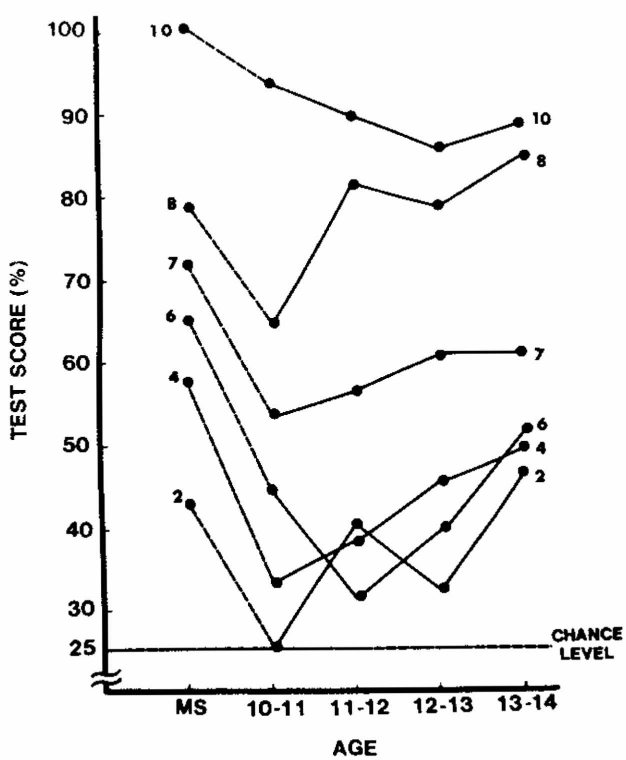

FIGURE 5.8. Mainstreamed and longitudinal data by decile: Possessive adjectives, Pa.

Personal Pronouns

In this test, the child was required to pronominalize a second identical occurrence of a noun phrase (NP). The alternatives available to the child were: the original NP, the subject form of the appropriate pronoun, and the object form of the appropriate pronoun. For example, a typical test item for the first person, singular, subject position is:

My name is John. ______ am a boy.
(John, I, me)

The test also includes items on the pronoun as object of a preposition. Both singular and plural forms are covered. For example,

Teacher saw the children. Teacher told a story to ______ .
(them, they, the children)

Three response alternatives were available for each test item. The chance level of performance was thus 33.3%. Fourteen pronoun forms were considered, as indicated in Table 5.10. There were two test items for each pronoun form for a total of 28 test items.

Reflexive Pronouns

Deaf children seldom use reflexive pronouns in their written language (Quigley and Power, 1971). It is thus not possible to determine the acquisition of reflexive pronouns in deaf children from samples of written language. This test was designed by Quigley and his associates to determine the pattern of emergence of this type of pronoun.

Both pronoun and noun-subject forms were covered by

TABLE 5.9. Backwards pronominalization.*

Type number	Description	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	Personal pronoun, third person, singular, masculine E.g., From where ______ sat, the boy could see the car. (him, he, his)	70.3	67.7	67.5	72.9	77.7
ii	Personal pronoun, third person, singular, neuter E.g., Because ______ was hungry, the dog ate some meat. (its, it, his)	35.6	45.1	56.1	53.7	48.0
iii	Personal pronoun, third person, plural E.g., When ______ came home, the girls ate lunch. (they, them, their)	69.4	58.3	66.4	71.5	79.0
iv	Possessive adjective, third person, plural E.g., After ______ ball broke the window, the girls ran away. (they, their, them)	51.4	34.8	47.9	46.0	43.4
v	Possessive adjective, third person, singular, feminine E.g., When ______ father went away, Mary cried. (she, her, hers)	73.6	45.0	60.1	58.8	60.0

*All entries are average score in percentage correct.

the test, as shown in Table 5.11. A multiple-choice format was used, but unlike other tests in the battery, this one used pictures on some items. This was done to avoid ambiguity among the alternatives and was generally used with the third-person form.

The number of alternative choices available to the child on each test item depended on the pronoun form being tested. In general, the available alternatives included:

a. the appropriate reflexive pronoun, e.g., *myself*
b. the subject form of the cognate personal pronoun, e.g., *I*

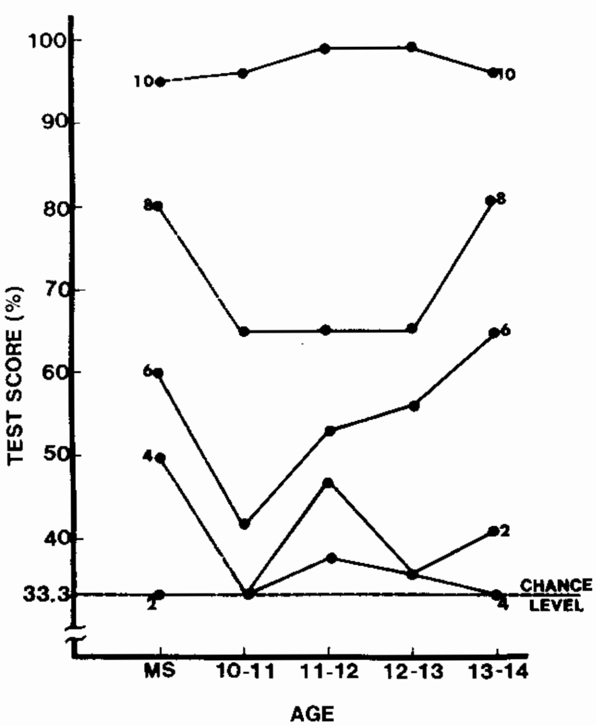

FIGURE 5.9. Mainstreamed and longitudinal data by decile: Backwards pronominalization, Pb.

c. the object form of the cognate personal pronoun, e.g., *me*
d. an irregular form obtained by adding the reflexive morpheme-*self* to (b), e.g., *I self*
e. an irregular form obtained by adding the reflexive morpheme-*self* to (c), e.g., *me self*

For the plural forms, the number of possible alternatives was increased to 12 because two possible plural endings—*selfs* and *selves*—could be used as could a singular ending added to the plural pronoun—*usself*. To accommodate all of these alternatives in a convenient framework, additional test items were used with balanced sets of four to six alternatives per test item. For each of the singular forms, which were relatively straightforward, two test items were used. For the more complex plural forms involving several sets of alternatives, six test items were used for each form. The total number of items on the test was 36. The number of alternatives for each test item varied between 4 and 6, and the expected score for random guessing on the test was just over 20%.

Possessive Pronouns

The test covers the six forms of the possessive pronoun (*mine, yours, his, hers, ours,* and *theirs*). There are 2 items for each pronoun form for a total of 12 items in the test. The six pronoun forms are listed in Table 5.12 together with the average scores for each year of testing. Also shown in the table, in parentheses, are the four alternatives available to the child on the respective test items. The chance level for this test was 25% correct.

Summary

The decile diagrams for the five pronoun subtests are shown in Figures 5.8 through 5.12. The diagrams are ordered according to average score, the highest scores being obtained for the possessive adjectives and the

TABLE 5.10. Personal pronouns.*

Type number	Pronoun form	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	First, singular, subject (I)	65.8	65.5	63.6	63.7	77.6
ii	First, singular, object (me)	80.0	69.9	69.2	70.4	79.6
iii	Second, singular (you)	80.3	61.8	59.5	64.5	66.3
iv	Third, singular, masculine, subject (he)	63.2	56.9	62.5	64.8	71.9
v	Third, singular, masculine, object (him)	67.1	55.6	58.1	62.1	65.6
vi	Third, singular, feminine, subject (she)	54.0	48.8	56.0	58.1	61.3
vii	Third, singular, feminine, object (her)	54.0	36.5	46.5	58.3	62.5
viii	Third, singular, neuter (it)	46.1	39.9	43.8	53.1	54.4
ix	First, plural, subject (we)	80.3	67.0	69.8	72.2	68.2
x	First, plural, object (us)	67.1	47.7	48.9	56.4	63.7
xi	Third, plural, subject (they)	44.0	22.6	36.0	38.7	40.6
xii	Third, plural object (them)	40.8	23.7	32.5	37.6	37.2
xiii	Third, singular, object of preposition (her)	42.1	37.6	39.3	44.7	44.5
xiv	Third, plural, object of preposition (them)	35.5	18.4	29.3	34.6	38.9

*All entries are average score in percentage correct.

lowest scores for the possessive pronouns. Essentially the same developmental trends are evident for the three pronoun forms showing relatively high scores (possessive adjectives, backwards pronominalization, and personal pronouns). In each case, the majority of children showed slow but steady progress over the years. The children in the highest decile showed no systematic improvements. This was understandable for the case of backward pronominalization (where scores close to 100% were obtained), but not for possessive adjectives and personal pronouns, where the highest scores were well below the maximum. An item analysis showed that even the best children in the group were having difficulty with several of the plural forms and that there was no improvement on those forms over the years. This problem presumably could be remedied by appropriate modification of the language curriculum for such good students.

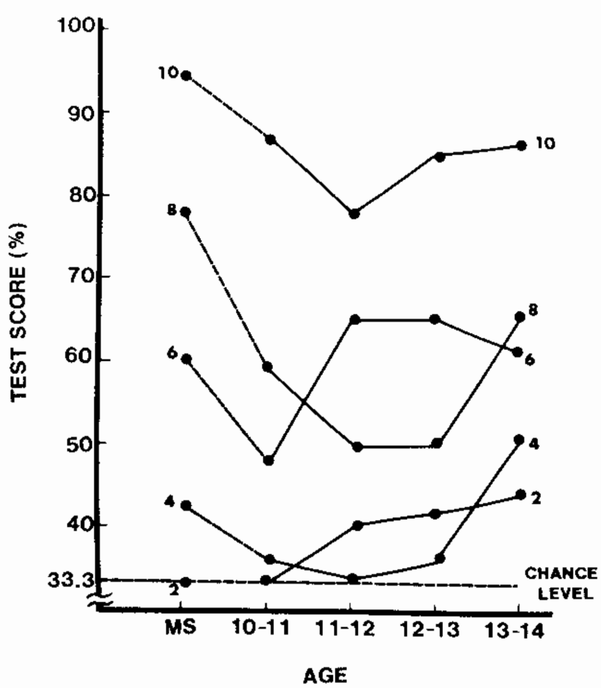

FIGURE 5.10. Mainstreamed and longitudinal data by decile: Personal pronouns, Pp.

The children in the lowest decile showed some understanding (i.e., better than chance performance) of possessive adjective forms, but did not perform well or show evidence of improvement on personal pronouns or backwards pronominalization. The proportion of children who did not score above the chance level was substantially higher for the two most difficult pronoun forms (reflexive and possessive pronouns). For the few decile groups that scored above the chance level, the improvements shown over the years were mixed; some children improved significantly, but others did not.

Similar patterns were observed for the pronoun forms within each subtest; that is, higher scores were obtained consistently for the singular as opposed to the plural forms, for the first person as opposed to the second or third person, and for the masculine or feminine gender as compared to the neuter gender. A few differences in the pattern of scores were observed among different pronoun types, but the differences were small and were usually linked to irregular forms (e.g., the second person). There was some evidence of regression in the longitudinal data, which is a fairly common occurrence when dealing with irregular forms.

The mainstreamed children showed higher scores than children of comparable age at schools for the deaf. The differences were largest on those pronoun forms that are more frequently used in spoken, interpersonal communication (e.g., first person forms, reflexive pronouns).

DETERMINERS

The English determiner system is quite complex and is generally a source of difficulty for deaf children. The test

TABLE 5.11. Reflexive pronouns.*

Type number	Pronoun form	Mainstreamed	Age of child 10–11	11–12	12–13	13–14
i	First person, singular E.g., I saw _____ in the mirror. (me, myself, itself, I, myself)	79.7	44.2	50.2	58.1	64.9
ii	Second person, singular E.g., You saw _____ in the mirror. (you, yourself, youself, your)	57.8	25.2	32.2	41.4	48.4
iii	Third person, singular, masculine, pronoun subject E.g., He saw _____ in the mirror. (him, heself, he, himself, hisself)	38.2	21.0	31.0	28.8	42.4
iv	Third person, singular, masculine, noun subject E.g., A boy saw _____ in the mirror. (him, heself, he, himself, hisself)	54.7	23.9	28.4	38.2	46.3
v	Third person, singular, feminine, pronoun subject E.g., She saw _____ in the mirror. (herself, she, sheself, her)	70.7	31.9	38.4	50.0	54.3
vi	Third person, singular, feminine, noun subject E.g., A girl saw _____ in the mirror. (herself, she, sheself, her)	65.8	21.1	42.1	39.9	53.6
vii	Third person, singular, neuter, pronoun subject E.g., It saw _____ in the mirror. (itself, its, itsself, it)	50.7	32.0	43.3	47.0	48.4
viii	Third person, singular, neuter, noun subject E.g., A dog saw _____ in the mirror. (itself, its, itsself, it)	53.3	33.9	51.0	46.5	47.3
ix	First person plural** E.g., We saw _____ in the mirror. (usself, ourselves, us, we, weself, ourself) (we, usselfs, us, ourselves, weselfs, ourselfs) (usselves, we weselves, ourselves, us)	35.6	16.8	26.5	31.6	41.1
x	Second person, plural E.g., You saw _____ in the mirror. (your, yourselves, youselfs, yourselfs, youselves)	18.3	13.5	17.0	21.8	24.5
xi	Third person, plural, pronoun subject** E.g., They saw _____ in the mirror. (theyself, they, themselves, them, themself, theirself) (theirselfs, themselfs, theyselfs, themselves, they, them) (they, them, themselves, theirselves)	29.4	14.7	23.3	23.2	35.5
xii	Third person, plural, noun subject** E.g., The men saw _____ in the mirror. (theyself, they, themselves, them, themself, theirself) (theirselfs, themselfs, theyselfs, themselves, they, them) (they, them, themselves, theirselves)	23.7	15.6	21.4	27.5	36.0

*All entries are average score in percentage correct.
**Three sets of alternatives were used. No significant differences in performance were obtained between sets of alternatives after correcting for the number of alternatives in a set.

used here covered some of the more common determiner errors made by deaf children. These included aspects of distribution, redundancy, agreement, liaison, and order. Examples of each type of error covered by the test are given in Table 5.13. For certain subdivisions of the test, specifically distribution, redundancy, and agreement, two types of error were included, and examples of both are given in the table. Between 4 and 8 items were allocated to each subdivision of the test, providing a total of 30 test items. The test was of the *Right/Wrong* format. Half of the test items were syntactically correct, the other half contained errors of the type listed in Table 5.13.

Of the error forms considered, the children handled liaison errors (e.g., *a apple is red*) least well, on the average. This was true of both the mainstreamed children and those attending schools for the deaf. This error form also showed the least improvement in the longitudinal portion of the study. Slightly better performance, and greater rates of improvement, were shown on agreement errors (e.g., *a boys are sick*) and distribution errors (e.g., *some the girls found a book*).

The highest scores, on the average, were obtained on redundancy errors (e.g., *The a boy went home*) and order errors (e.g., *I have a big a car*). The rates of improvement for the longitudinal data were also greater for these error forms. The mainstreamed children also obtained relatively high scores on these two subdivisions of the test.

Figure 5.13 shows rates of improvement by decile for the longitudinal data. Relatively low rates of improvement are shown by all of the decile groups. Neither saturation nor bottoming out effects are shown. Scores for children in the highest decile are still well below 100%

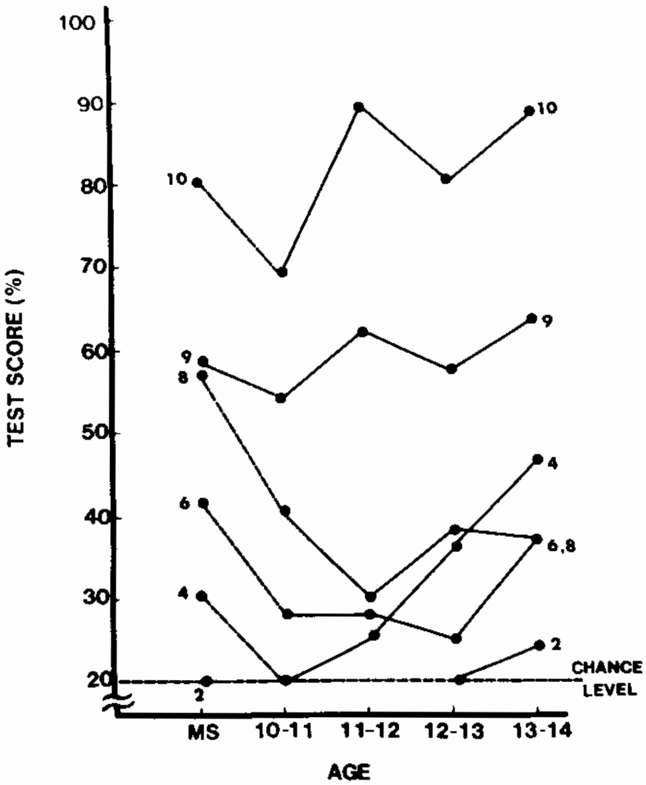

FIGURE 5.11. Mainstreamed and longitudinal data by decile: Reflexive pronouns, Pr.

even after 4 years of improvement, and children in the lowest decile are showing small but consistent improvement above the chance level of performance.

In short, all of the children performed relatively poorly on the determiner subtest and showed very slow rates of improvement over the years. This is not surprising because the determiner system in English (as in many other languages) is very difficult and, in addition, hearing-impaired children typically have little experience in the use of determiners because they tend to use telegraphic language in communicating with others.

COMBINING OF SENTENCES: CONJUNCTION

There are three ways in which sentences are combined in English: conjunction, relativization, and complementation. Simple forms of conjunction were found to be the easiest, relativization much more difficult, and complementation the most difficult. The subtest on complementation, in fact, was found to be so difficult that it was not administered beyond the first year of the longitudinal study, the scores for that year being no better than random guessing.

Many hearing-impaired children often combine sentences in a trivial way by simply stringing them together with the conjunction *and*. This method of combining sentences involves no processing of the constituent parts. Sentence length is a useful and practical measure of linguistic proficiency, but only if care is taken to separate out longer sentences that involve no more than the concatenation of shorter sentences using *and*. This problem is discussed in Chapter 6 by Parkhurst and McEachron.

Deletion of the conjunction is a common error in the written language of deaf children. The subtest used here covered conjunction deletion in four common environments: conjoined subjects, conjoined objects, conjoined verb phrases, and conjoined sentences with no elements in common. The test format was of the *Right/Wrong* type. Examples of each form, together with the average scores obtained in each year of testing, are shown in Table 5.14. In the examples given, the conjunction is shown in parentheses, indicating that it was deleted on some tests. The test consisted of 16 test items, 4 for each of the 4 forms considered. Half of the test items contained syntactally correct sentences, the other half contained sentences with the conjunction deleted. The expected score for random guessing on this test was 50%.

There was evidence of a gradual improvement in overall score with increasing age, as shown in Figure 5.14. The improvement varied substantially with decile group. The children in the highest deciles (9–10) showed little or no improvement over the years, although scores were well below the maximum possible. (Note that a relatively high average score was obtained by the children in Decile 1 during the first year of the study, but this one-time high score is believed to be the result of statistical fluctuations and not a real effect.) In contrast to the slow progress made by the children in the higher deciles, the children in the upper middle deciles showed good steady progress over the years, and those in Deciles 2 through 6 showed inconsistent patterns of progress with good to moderate overall gains. The children in the lowest decile, however, did not score above the chance level of performance at any time during the 4-year period of the study.

As shown in Table 5.14, the children did best of all at age 10 on the conjoined-objects form and slightly less well on conjoined subjects, conjoined verb phrases, and conjoined sentences that had no common elements. By age 14, the children performed roughly equally well on all of the forms tested. The mainstreamed children showed larger differences between the forms tested as compared to children of comparable age at schools for the deaf. Test scores for the mainstreamed children were higher for conjoined objects and conjoined verb phrases, but below those for their peers at schools for the deaf on conjoined subjects.

There was also some evidence of different patterns of learning among decile groups. An analysis of the data by syntactic form and decile group showed that children in the higher deciles (Decile 10 excluded) progressed relatively rapidly on the more difficult forms (e.g., conjoined verb phrase) whereas children in the lower deciles (Decile 1 excluded) showed greater relative progress on the simpler forms (e.g., conjoined objects). There was also

TABLE 5.12. Possessive pronouns.*

Type number	Pronoun	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	First person, singular E.g., This book is ______ . (my, me, mine, I)	44.7	45.1	49.6	50.2	64.5
ii	Second person E.g., This cat is ______ . (you, yours, my, your)	34.2	17.2	24.6	20.8	27.2
iii	Third person, singular, masculine E.g., This car is ______ . (he, she, his, him)	60.5	40.1	50.0	50.8	45.7
iv	Third person, singular, feminine E.g., This apple is ______ . (she, her, hers, he)	41.9	24.2	30.0	30.6	35.9
v	First person, plural E.g., This story is ______ . (ours, our, we, us)	44.7	24.8	29.6	30.8	32.2
vi	Third person, plural E.g., This ball is ______ . (he, theirs, they, their)	36.8	20.8	21.8	22.4	32.3

*All entries are average score in percentage correct.

evidence of some regression by the more advanced children in later years.

The battery of tests developed by Quigley, Wilbur, Power et al. (1976) contained two other tests on conjunction, but those tests, which required some written output from the children, were found to be extremely difficult by most of the children tested. They were not administered after the first pilot trials.

In summary, performance on the conjunction subtest spanned the entire range, from no progress at the chance level of performance to saturation at a relatively high (but not the maximum) level of performance. For children within these two extremes, moderate to good progress was made over the years. These data indicate that although the trivial use of conjunction (i.e., simply stringing sentences together by using the conjunction *and*) is commonplace in the written language of hearing-impaired children, the use of conjunction that involves processing of the constituent parts is poorly understood. Even the best children did not achieve scores of 100%, and the poorest children showed no evidence of learning these more advanced forms. In addition to the very wide range of scores, there was also evidence of different learning patterns between the better-than-average and poorer-than-average children.

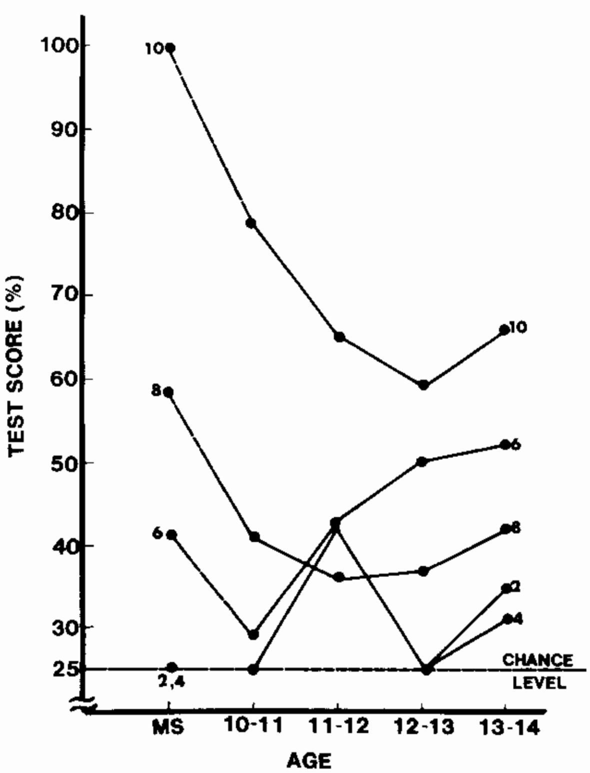

FIGURE 5.12. Mainstreamed and longitudinal data by decile: possessive pronouns, Ps.

COMBINING OF SENTENCES: RELATIVIZATION

General Comments

The process of embedding one sentence within another is poorly handled by hearing-impaired children. The function of the relative pronouns (*who, which, whose,* etc.) appears to be poorly understood by most hearing-impaired children. The three tests used in this subdivision of the test battery attempted to measure the hearing-impaired child's comprehension of the embedding process and the function of the relative pronoun in this process. The tests deal with:

a. processing of a complex sentence containing an embedded relative clause

TABLE 5.13. Determiners.*

Type number	Error form	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	Distribution E.g., Some (of) the girls found a book Five (of) the cats were black.	59.9	54.4	57.4	63.2	62.7
ii	Redundancy E.g., A the boy went home. The a boy went home.	65.9	65.9	69.2	73.7	78.9
iii	Agreement E.g., A boys are sick. Some boy played ball.	55.6	55.0	57.3	59.0	64.7
iv	Liaison E.g., A apple is red.	51.3	56.1	61.1	58.3	61.8
v	Order E.g., I have big a car.	65.6	58.0	63.1	69.6	72.7

*All entries are average score in percentage correct.

b. determining the correct referents for the relative pronouns (*who, which, whose,* etc.)
c. embedding one sentence inside another and concomitant deletion of a relative pronoun

A fourth test developed by Quigley, Wilbur, Power et al. (1976) for investigating processing of relative clauses and the copying phenomenon was not included after initial trials showed that scores on this test were close to random guessing for the age group to be considered.

Relativization—Processing of an Embedded Sentence

In this test, a sentence containing an embedded relative clause was presented to the child followed by a set of simple sentences. The child was required to indicate whether or not the content of each of the simple sentences was true of the embedded sentence. The test differs from most of the others in the test battery in that it was designed to tap the child's understanding of the meaning of the exemplar sentence, and hence the child's ability to handle the syntactic relationships involved.

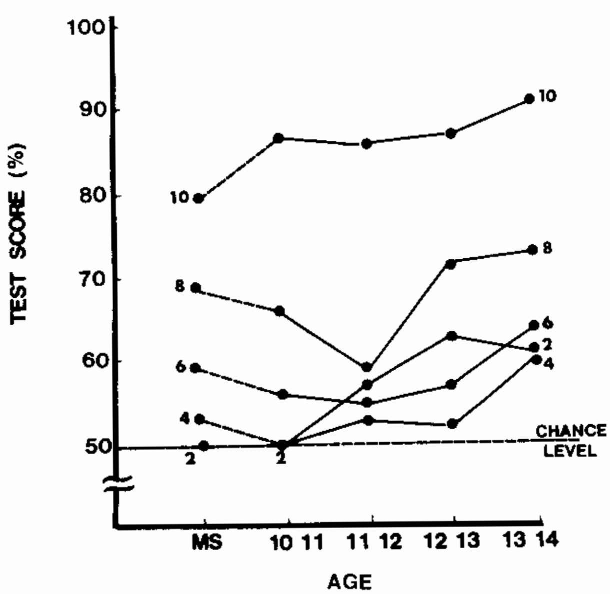

FIGURE 5.13. Mainstreamed and longitudinal data by decile: Determiners, D.

Five forms of embedded relative clause were covered by the test: final placement of the clause with relatives moved from the subject and from the object position, medial placement of the clause with relatives moved from the subject and from the object position, and preposition-fronted clauses. These five forms are shown in Table 5.15 together with the average scores obtained in each year of testing. The table includes an example of each type of embedded sentence and the associated set of simple sentences. The test contained two embedded sentences for each of the five clause types. For each of these embedded sentences a set of three or four simple sentences was provided, leading to a total of 36 binary-choice items on the test.

Developmental changes by decile group are shown in Figure 5.15. The children did relatively well on this test, and with few exceptions, each decile group showed significant improvements in test score over the years. One exception involved Decile 10. For reasons that are not clear, the children in this decile showed a reduction in test score over the 4-year period. This is believed to be a result of unusual chance fluctuations rather than a real effect.

Table 5.15 shows relative performance on the various syntactic forms tested. The highest scores were obtained for the clause in final placement with the relative from the object position. Average scores on other forms involving final placement were also comparatively good (i.e., relative from subject position and preposition-fronted clause). A small improvement over the years was also observed on these forms. In contrast, the children had considerable difficulty with medial placement of the relative clause. In particular, the average score for medial placement with the relative from the object position was

TABLE 5.14. Conjunction deletion.*

Type number	*Conjunction*	*Main-streamed*	*Age of child* 10–11	11–12	12–13	13–14
i	Conjoined subjects E.g., A boy (and) a girl went home.	55.6	60.9	56.5	57.7	71.0
ii	Conjoined objects E.g., A boy broke a cup (and) a glass.	73.7	65.8	69.4	70.7	73.8
iii	Conjoined verb phrases E.g., A girl bought an apple (and) ate it.	65.8	60.1	64.0	61.3	72.0
iv	Conjoined sentences with no common elements E.g., The girls went home (and) the boys played at the park.	61.2	61.9	68.5	66.6	72.8

*All entries are average score in percentage correct.

only slightly above the chance level of performance for all 4 years of the longitudinal study.

The scores for the mainstreamed children did not differ significantly from those for children of comparable ages at schools for the deaf. This was true both for the analysis by decile group and for the analysis by syntactic form.

Relativization—Relative Pronoun Referents

This test was designed to determine the child's mastery of the correct referents for the relative pronouns. The child was presented with an embedded sentence with the referent missing and required to select the correct referent from a set of seven alternatives: *who, which, what, that, when, where,* and *whose.* In some cases there could be more than one correct alternative (e.g., *which, that*). Nine referent forms were considered. They are listed in Table 5.16. There were 2 items on the test for each referent form, leading to a total of 18 multiple choice

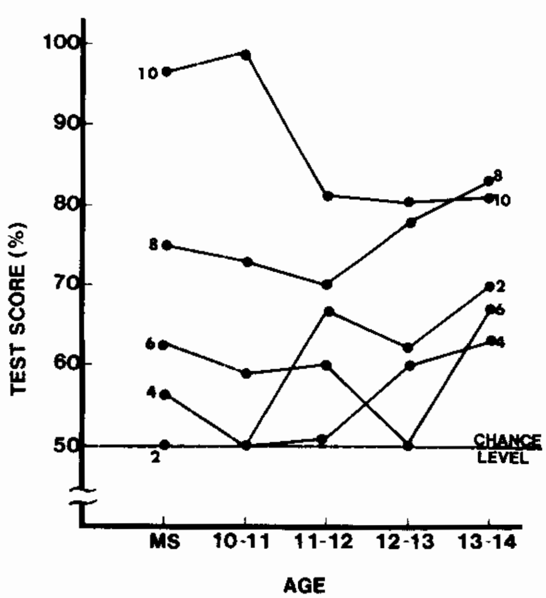

FIGURE 5.14. Mainstreamed and longitudinal data by decile: Conjunction, C.

items. The order of items and alternatives for each item were randomized as usual. The expected score for random guessing on this test was approximately 14%.

Figure 5.16 shows some evidence of learning over the 4-year period. The learning effects were small but steady for children in the lower deciles, whereas erratic learning patterns were observed for children in the higher deciles. The children in the three highest deciles initially showed some regression followed by substantial improvements in performance towards the end of the 4-year longitudinal study.

The analysis by syntactic form is shown in Table 5.16. As is evident from the table, the children performed relatively well on only one of the forms tested: *who* from the subject position. The next highest scores, which were substantially lower, involved *when* (in initial and in final position), *what* (as a free relative), and *who* from the object position. The scores for the remaining forms (*which, where,* and *whose*) were at about the chance level. A more detailed analysis of the data showed that children in the lower deciles improved on only the simpler forms, whereas those in the higher deciles showed improvements on all of the forms tested.

Different patterns of performance were observed between the mainstreamed children and those at schools for the deaf. In some cases, the mainstreamed children scored higher (e.g., *which* from object position, *where* and *when* forms), but they were consistently lower on other forms (e.g., *who* from object position, *whose,* and the free relatives). In the case of *whose,* the mainstreamed children scored significantly below the chance level, indicating some degree of processing of this form. The processing may be incomplete or incorrect according to the normal rules of English, but there is nevertheless some comprehension of this particular form.

Relativization—Embedding and Relative Pronoun Deletion

The purpose of this test was to examine the child's acceptance of the process of embedding by means of a relative clause. Irregular deletion of the relative pronoun (and sometimes also part of the verb *to be*) has been

TABLE 5.15. Processing of an embedded sentence.*

Type number	Relative clause	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	Final placement from subject position E.g., The girl saw the boy who kicked the cat. The girl saw the boy. The boy kicked the cat. The girl kicked the cat.	69.0	68.5	71.1	72.4	76.1
ii	Final placement from object position E.g., The woman loved the man she saw. The woman loved the man. The man saw the woman. The woman saw the man.	81.2	81.3	81.8	84.3	86.5
iii	Medial placement from subject position E.g., The girl who hit the boy went home. The girl hit the boy. The boy hit the girl. The boy went home. The girl went home.	54.9	58.5	53.8	58.9	52.7
iv	Medial placement from object position E.g., The girl who the boy hit went home. The girl hit the boy. The boy hit the girl. The boy went home. The girl went home.	55.9	53.7	50.7	54.3	53.0
v	Preposition-fronted E.g., The woman liked the boy she gave an apple to. The woman liked the boy. The boy gave an apple to the woman. The woman gave an apple to the boy.	67.6	79.0	82.5	79.9	86.4

*All entries are average score in percentage correct.

observed in the written language of deaf children (Quigley and Power, 1971), and a second aim of this test was to determine the extent to which correct and incorrect forms of relative pronoun deletion are judged acceptable by the children. The test also included examples of conjoining (both correct and incorrect forms) and the use of *which, whose,* and the free relative, *what.*

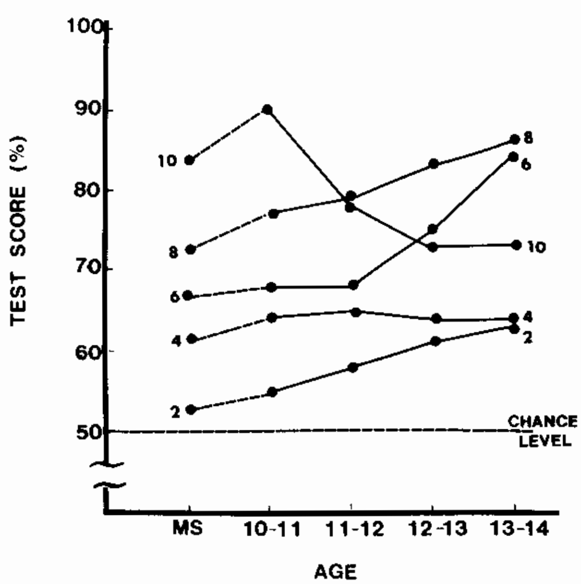

FIGURE 5.15. Mainstreamed and longitudinal data by decile: Relativization—Processing, Rps.

The test was made up of nine subdivisions, each of which covered a different form of embedding. There were two replications of each form. Each replication consisted of a pair of simple sentences followed by several relativized, single-sentence versions of the original two sentences. The child was required to indicate whether or not each relativized version "means the same" as the exemplar sentences. The relativized versions took the following forms:

a. a correct embedding of one sentence with the other by means of a relative clause
b. embedding via relativization but with deletion of the relative pronoun; this deletion would be syntactically correct in some instances (correct and incorrect deletions were tested on separate items)
c. a conjoined version of the two sentences or, in some cases, alternative forms of embedding. Both correct and incorrect versions were tested on separate test items

The nine forms of embedding and relative pronoun deletion covered by the test are listed in Table 5.17. After each exemplar sentence, the follow-up forms were given: the correctly embedding form using a relative clause, an embedded form with the relative pronoun deleted, and a conjoined form or, alternatively, variations of the embedding form (as in subdivisions, iv, vi, viii, and ix). Roughly half of the forms appearing in the test were syntactically

TABLE 5.16. Relative pronoun referents.*

Type number	Description	Mainstreamed	Age of child 10–11	11–12	12–13	13–14
i	*Who* from subject position E.g., I saw the boy _____ went home.	59.2	59.1	56.0	59.0	68.1
ii	*Who* from object position E.g., John hurt the girl _____ he hit.	17.3	31.3	22.8	26.1	25.4
iii	*Which* from subject position E.g., The man threw the ball _____ rolled under the house.	14.7	16.0	12.0	17.5	18.0
iv	*Which* from object position E.g., Mary loved the toy _____ she lost.	20.0	8.7	10.3	9.2	13.2
v	*Where* in final position E.g., John found the ball _____ Anne threw it.	25.3	15.0	17.2	16.1	24.8
vi	*When* in initial position E.g., _____ the man saw the policemen, he ran away.	46.7	20.7	24.2	27.8	36.3
vii	*When* in final position E.g., The man ran away _____ he saw a policeman.	39.5	18.6	21.5	26.1	29.4
viii	*Whose* E.g., I saw the boy _____ mother was sick.	2.6	12.7	12.4	20.1	22.9
ix	Free relatives E.g., Mary liked _____ her mother cooked.	17.8	31.9	19.2	25.1	31.7

*All entries are average score in percentage correct.

correct. The chance level of performance for this test was 50%.

This test was found to be difficult, and only about one-third of the children were able to complete it in all 4 years of the longitudinal study. Those children who could complete it typically occupied the three highest deciles (8, 9, and 10) with a few in Decile 7. A slightly higher proportion of the mainstreamed children (Deciles 6 and above) scored above the chance level. The data summarized in Figure 5.17 show that even the best children at schools for the deaf did relatively poorly, with only slight improvements shown towards the end of the 4-year period. The apparent regression after the first year for Decile 10 is a statistical artifact resulting from the ranking of near-random test scores in the first year.

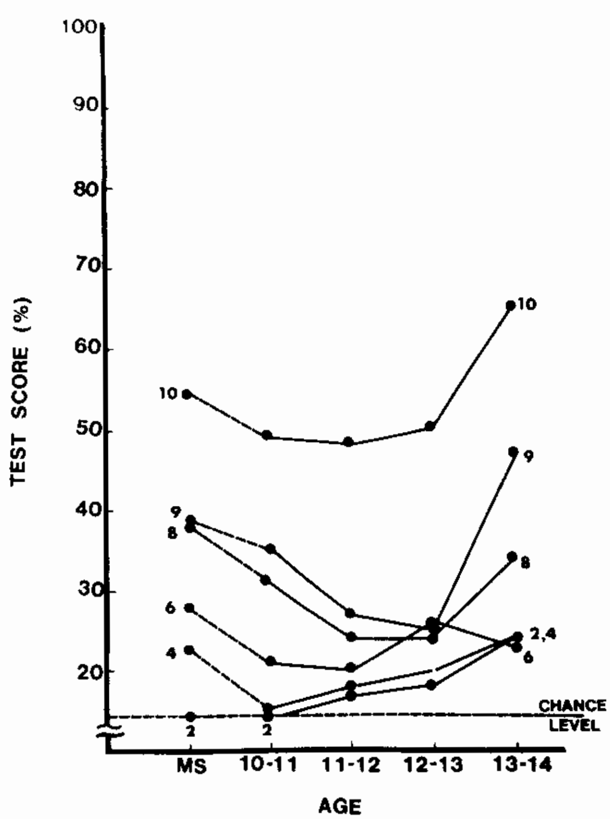

FIGURE 5.16. Mainstreamed and longitudinal data by decile: Relativization—Relative pronoun referents, Rrpr.

Table 5.17 shows the analysis by syntactic form. The data shown are for the top third of all the children (i.e., for the children who were able to complete the test in the longitudinal study and for the mainstreamed children above the 67th percentile). Although the data relate to children who are better than average, the test scores are nevertheless relatively poor. There was some evidence of learning, but only on a few forms (e.g., *who* with predicate adjective, *whose*, and free relatives).

The mainstreamed children showed higher scores, on the average. Relative performance by syntactic form was also slightly different from that for children at schools for the deaf. The highest scores were obtained for embedding that involved the pronoun form in the object position or following a preposition (e.g., *who* from object position, *which* from object position, *who* with predicate adjective, and *who* preposition-fronted). Scores were also relatively good for the free relative, *what*, and for *whose*. The lowest scores, on the average, were obtained for embedding that involved the pronoun form in the subject position (i.e., both *who* and *which* from subject position).

The children also showed a response bias for shorter syntactic forms. As a consequence, higher than average scores were obtained for syntactically correct forms with the pronoun deleted (e.g., *the boy ate the bananas he bought*) and lower than average scores, in some cases even lower than the chance level of performance, were

TABLE 5.17. Embedding and relative pronoun deletion.*

Type number	Descriptive	Main-streamed	Age of child 10–11	11–12	12–13	13–14
i	*Who* from subject position E.g., The dog chased the girl. The girl had on a red dress. The dog chased the girl who had on a red dress. The dog chased the girl had on a red dress. The dog chased the girl and had on a red dress.	52.5	40.3	39.7	53.1	53.9
ii	*Who* from object position E.g., John chased the girl. He scared the girl. John chased the girl who he scared. John chased the girl he scared. John chased the girl and he scared.	66.6	45.1	45.2	45.6	40.8
iii	*Who* in medial position E.g., The boy ran away. The boy kicked the dog. The boy who kicked the dog ran away. The boy kicked the dog ran away. The boy kicked the dog and ran away.	60.2	51.1	53.2	53.8	53.8
iv	*Who* with predicate adjective E.g., John has a sister. His sister is pretty. John has a sister who is pretty. John has a sister is pretty. John has a sister pretty. John has a pretty sister.	65.4	47.7	50.0	56.6	60.8
v	*Who—Preposition-fronted (with pied piping)* E.g., John met the boy. John gave a book to the boy. John met the boy who he gave a book to. John met the boy he gave a book to. John met the boy he gave a book.	75.7	60.1	51.5	52.4	41.6
vi	*Which* from subject position E.g., The baby like the car. The car had red wheels. The baby liked the car which had red wheels. The baby liked the car had red wheels. The baby liked the car and had red wheels.	51.3	44.3	43.3	51.5	50.8
vii	*Which* from object position E.g., The boy ate the bananas. He bought the bananas The boy ate the bananas he bought. The boy ate the bananas and he bought. The boy ate the bananas which he bought.	65.4	52.4	49.9	39.1	45.7
vii	*Whose* E.g., I helped the boy. The boy's mother was sick. I helped the boy whose mother was sick. I helped the boy's mother was sick. I helped the boy mother was sick.	66.7	41.2	35.0	42.6	55.6
ix	Free relatives E.g., John ate some food. His mother cooked some food. John ate what his mother cooked. John ate his mother cooked. John ate who his mother cooked. John ate which his mother cooked.	66.3	49.5	52.3	50.0	61.3

*All entries are average scores in percentage correct.

obtained for syntactically incorrect forms with pronoun deletion (e.g., *the dog chased the girl had on a red dress*).

It could be argued that lower than chance scores reflect the development of nonstandard forms, which hearing-impaired children may regard as correct, but which deviate from standard English usage. Nonstandard forms that were observed according to this criterion (i.e., forms showing poorer than chance performance) appeared to fall into these categories:

i. Forms showing correct surface word order over significant portions of the sentence, for example:
The dog chased the girl had on a red dress
The baby like the car had red wheels
The boy throw the ball rolled under the house
The fire burned the baby cried
John has a sister is pretty
The man played with the children were happy

(Note that in each of the above examples, both the first and last sections of the sentence have correct word order.)

ii. Conjoined forms using *and*, but with a noun phrase omitted, such as:
The dog chased the girl and had on a red dress
Mary lost a flower and she picked
The fire burned the baby and cried
The children met the woman and they loved
The baby liked the car and had red wheels

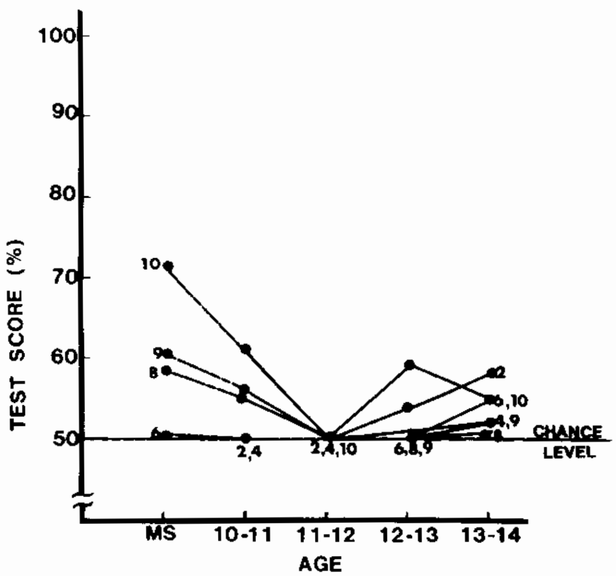

FIGURE 5.17. Mainstreamed and longitudinal data by decile: Relativization—Embedding and pronoun deletion, Repd.

The boy threw the ball and rolled under the house

iii. Telegraphic forms, such as:
The girl was in bed read a book
The boy kicked the dog ran away
John met a girl arm was broken

Even if these forms are treated as nonstandard and are scored as correct rather than incorrect in the data analysis, the resulting increase in test scores is not very large (roughly 6 percentage points, on the average). Whether or not this correction is made, only a small proportion of the children scored significantly above the chance level, and there was relatively little improvement in test score over the 4-year period of the study.

In short, embedding is particularly difficult for hearing-impaired children. Only about a third of the children at schools for the deaf and just under half of the mainstreamed children scored above the chance level on this subtest. Even those children who scored above the chance level in the first year of the study showed relatively slow progress in subsequent years. There was also evidence that several nonstandard or deviant forms were grammatically acceptable by many of the children.

COMPARISONS WITH OTHER DATA

By far the largest body of data against which comparisons can be made is that of Quigley and his associates (Jones & Quigley, 1976; Power & Quigley, 1973; Quigley, Montanelli, & Wilbur, 1976 (a&b); Quigley & Power, 1972; Quigley, Smith, & Wilbur, 1975; Quigley, Wilbur, & Montanelli, 1974; Quigley, Wilbur, Power et at., 1976; Russell, Quigley, & Power, 1976; Wilbur, Montanelli, & Quigley, 1975; Wilbur, Quigley, & Montanelli, 1976). Both this study and those reported by Quigley and his associates used the same tests (an experimental version of the Test of Syntactic Abilities), but there were important differences among the populations studied. Those differences resulted from differences in the overall objectives of the two sets of investigations and, in particular, from differences in the method of sampling. Quigley and his colleagues used a cross-sectional sample; that is, a different group of children was tested at each age level. Nine groups of 50 childern were tested, and they ranged in age from 10 through 18 years old. The children were selected from schools throughout the country to form a representative sample. To maintain the homogeneity of the test groups, a strict set of selection criteria was used.

The different selection criteria used by Quigley and by our longitudinal study led to major differences between the two populations studied. The Quigley studies did not include children with IQ scores of less than 80 (on the WISC, WAIS, or other comparable tests), nor did they include children who, in the judgment of the school personnel, had disabilities other than hearing impairment (excluding visual defects suitably corrected by lenses). The longitudinal study was more comprehensive and included children with low IQ scores (roughly 10% of the children tested scored below 80); children with other disabilities, including children labeled as "minimally brain damaged" (9% of the sample); children with emotional or behavioral problems (7% of the sample); and children with a home language other than English (usually Spanish, 13% of the sample). The proportion of deaf children of deaf parents was about the same in both studies (6 to 8%). About 10% of the children in the longitudinal study acquired their hearing loss postlingually; all of the children in the Quigley studies were prelingually hearing impaired. Another difference was that the children in the Quigley studies all had hearing levels (pure-tone average at 500, 1000, and 2000 Hz) of not less than 90 dB HL in the better ear. With very few exceptions, the hearing levels of the children in the longitudinal study exceeded 80 dB in the better ear.

The two populations were thus similar but not identical. Roughly two-thirds of the children in the longitudinal study met the set of criteria used by Quigley and his associates. The remaining third of the children can be subdivided into two groups, those who may be expected to do rather well on the test battery (the postlingually deafened children) and those who may be expected to do rather poorly (the children with additional disabilities). In comparing the two sets of data, interest will center not only on differences in average performance, but also on the relative performance of children at either extreme; that is, the children in the highest and lowest deciles.

Although the tests administered in the two sets of studies were essentially the same, they were not identical. The Test of Syntactic Abilities was still in the process of development at the time of testing, and there were small differences between the two experimental editions of the test that were used. The major difference was that not all of the subtests of the Test of Syntactic Abilities were administered in the current study. The tests omitted were those for which test scores were close to the chance level of performance in the first year of testing. This was done so as not to lose the child's interest and motivation in subsequent years of testing. (Note that the annual rate of improvement in test scores was very small and that if the majority of children performed at the random-guessing level in one year then, at best, only a few more children were expected to show better than chance performance the following year). The omission of the more difficult subtests did not present any difficulties because the two bodies of data were compared on a subtest by subtest basis.

Essentially the same order of difficulty for the various subtests was obtained by Quigley, Wilbur, Power et al. (1976) as in the current study. The highest scores were obtained for the subtests on negation, followed closely by the average score for the subtest on conjunction deletion. The subtests on question formation come next, followed by the subtests on pronominalization and on the verb system, which were roughly equally difficult, on the average. There were, however, wide variations in the relative difficulty of subtests within these general areas. The most difficult tests, by far, were those that involved the combining of sentences either by relativization or complementation. Subtests involving the latter were not administered beyond the first year of the longitudinal study because of their relative difficulty. Quigley, Wilbur, Power et al. (1976) found that it was not until they were 16 years of age that children showed better than chance performance on the complementation subtest.

Similar patterns of development were also observed within the areas covered by the above-mentioned subtests. The data on negation reported by Quigley, Montanelli, and Wilbur (1976b) showed an ordering of negative forms (as indicated by relative scores) that was similar to the ordering shown in Tables 5.2 and 5.3. Using relative score as an indicator of relative difficulty, both sets of data show that the relative difficulties exhibited by the hearing-impaired children on the various forms tested (and associated error forms) are consistent with the stages of development observed in hearing children. As noted in the next section, order of difficulty and order of acquisition do not necessarily follow the same sequence, but the former can be a reasonable estimate of the latter and is often used as such in lieu of direct observation of order of acquisition.

Although the patterns exhibited by the two sets of data are essentially the same, consistent differences in average score were observed. For example, the data reported by Quigley, Wilbur, Power et al. (1976) for the *be, do, have,* and modal forms were lower by about 8 percentage points at age 10 and by about 4 percentage points at age 13. These differences were among the largest observed for any of the subtests. At first glance it appears that the children in the longitudinal study were progressing at a slower rate, on the average, thereby showing a smaller advantage in average score with increasing age. The apparent difference in average rate of progress, however, appears to be a result of a saturation effect for children in the higher deciles. This being an easier test, average scores were relatively high, and an increasing proportion of children in the higher deciles approached the maximum score with increasing age. For those children, the test scores showed little improvement with increasing age, although children in the lower deciles showed much the same rate of improvement as reported by Quigley, Wilbur, Power et al. (1976). The difference in average score appeared to be part of a pattern, the children in the longitudinal study scoring slightly higher, on the average, for the easier tests and slightly lower, on the average, for the more difficult tests.

The data on question formation are comparable to those obtained by Quigley, Wilbur, and Montanelli (1974). On the average, *yes/no* questions were found to be easier to comprehend than *wh-* questions, which in turn were less difficult than tag questions. There were, however, several revealing differences in the ordering of these question forms by children in different decile groups. As shown in Figures 5.4A, C, and D, the children in the lowest deciles had relatively more difficulty with *yes/no* questions than with *What* and *What*-V questions. Thus, although, on the average, essentially the same patterns of development were observed as in other studies of this type, specific differences have emerged for subgroups of the population. The importance of these differences is discussed in the next section.

The data on the verbal system compare well with the findings of Quigley, Wilbur, Power et al (1976). Essentially the same pattern of relative difficulty was observed for the four problem areas identified by Quigley and his associates (auxiliary verbs, tense sequencing, *be/have* confusions, verb deletion). Both sets of data showed the use of auxiliary verbs and of tense markers to be particularly difficult for hearing-impaired children. The ordering of relative difficulty in the data for verbal auxiliaries and tense markers was not as clear cut in the longitudinal study largely because of the relative difficulty of the test and the high rate of random guessing. If the data for only the higher scoring children are considered, then the same ordering of relative difficulty is obtained as that reported by Quigley, Wilbur, Power et al. (1976); that is, scores for the progressive tense were higher than those for the perfective tense, which in turn were higher than those for the passive voice.

The scores for the *be/have* confusion showed a slightly higher level of comprehension than those for verb tense. It was also observed, as found by Quigley, Wilbur, Power et al. (1976), that the children were considerably better at identifying the correct use of *be* and *have* than in identifying an error. This may have been the result of a response bias in that in both studies the children appeared more likely to give a *Right* response when in doubt. This view is strengthened by the observation that, in both studies, improvements in score with increasing age resulted from an increase in the percentage of correct answers involving a *Wrong* response. The percentage of correct answers involving a *Right* response remained essentially the same (80 to 85%) for the age range considered in this study. Although the average scores for identifying *be/have* errors were low, both sets of data showed that the substitution of *have* for *be* was more readily identified as an error than *be* for *have*.

The data for verb deletion showed the same general pattern in both studies. The children showed greater difficulty in identifying verb deletion in intransitive sentences of the form subject-verb-prepositional phrase (e.g., *the baby (played) on the floor*) as opposed to transitive sentences of the form subject-verb-object-prepositional phrase (e.g., *Mother (put) the cake in the box*). Similarly, both studies showed that the children had greater difficulty in identifying verb deletion for sentences involving the verb *have* as compared to the verb *to be*. Both studies showed large improvements in average score with increasing age. The subtest on verb deletion was one of the easiest tests, and, as noted for the tests on negation, the average scores on the longitudinal study were relatively high initially (roughly 10 percentage points above those reported by Quigley, Wilbur, Power et al. (1976) for children age 10) but they increased at a slightly slower rate with increasing age, presumably because of saturation effects.

The data on pronominalization were consistent for the most part with the findings of Wilbur, Montanelli, and Quigley (1976), but with several revealing differences. For both sets of data, singular forms were found to be much easier than plural forms, first-person pronouns were easier than third-person pronouns, and both possessive and reflexive pronouns were found to be relatively difficult in comparison with personal pronouns and possessive adjectives. The major difference between the two sets of data related to the average scores for the personal pronoun and possessive pronoun subtests. Average scores for the longitudinal study were roughly 6 percentage points lower on the personal pronouns subtest and 3 percentage points lower on the possessive pronouns. Scores for the remaining subtests involving pronominalization were essentially the same.

An analysis of the longitudinal data by syntactic form showed that test scores for the children in the lowest two deciles did not improve above the chance level over the 4-year period for the most difficult forms. Specifically, by age 13 the children in the lowest two deciles were still not performing above the chance level for plural forms other than first person plural. Subtests with substantial numbers of test items involving plural forms were also the ones having low average scores. The subtests on personal pronouns and possessive pronouns belong to this category, and, as a result, the lowest scoring children in the longitudinal study, because of their exceptionally poor performance on plural forms, brought the average score down for these two subtests. It should be remembered that the lowest scoring children in the longitudinal study were primarily those children who, due to differing selection criteria, were not comparable to the sample of children studied by Quigley.

The largest differences between the data reported here and those obtained by Quigley and his associates pertain to the subtests dealing with the combining of sentences (Quigley, Smith, & Wilbur, 1974; Quigley, Wilbur, Power et al. 1976; Wilbur, Quigley, & Montanelli, 1975). Of the three methods of combining sentences in English, conjunction was found to be the easiest, relativization somewhat more difficult, and complementation the most difficult. The same order of relative difficulty was observed in the longitudinal study as in the Quigley studies. The subtest on complementation in fact was found to be so difficult that it was not administered in the longitudinal study beyond the first year.

The data on conjunction deletion were in fairly good agreement with the results reported by Wilbur et al. (1975). The one major difference that was observed involved the relative difficulty of conjoined subject and conjoined object forms. Test items involving conjoined objects were found to yield the highest scores in the longitudinal study, whereas conjoined subjects showed the lowest error rate in the data reported by Wilbur et al. (1975). Both studies showed the lowest scores for conjoined verb phrases and intermediate scores for conjoined sentences without reduction.

The data on relativization showed the largest differences of all. Of the three subtests administered in the longitudinal study, the average scores were higher for the sentence-processing subtest, about the same for the embedding subtest, and consistently lower for the relative-pronoun-referents subtest in comparison with the data of Quigley, Smith, and Wilbur (1974) and Quigley, Wilbur, Power et al. (1976). No explanation for these differences could be found except that these subtests were especially difficult, and, as a consequence, there was a considerable amount of guessing by children in the lower deciles. A second factor is that because the syntactic forms covered by these subtests are much more advanced, there is more room for different patterns of development and, hence, for between-group differences to emerge.

COMPARISONS WITH NORMAL LANGUAGE DEVELOPMENT

An important and pervasive issue is whether language development in the hearing-impaired child follows the same sequence as in normal-hearing children but on a much expanded time scale, or whether the developmental sequence differs in systematic ways that are characteristic of the hearing-impaired child. To address this question, it is first necessary to recognize certain inherent limitations in the study of language development in hearing-impaired children.

The early stages of language development in normal-hearing children are typically measured by noting the first occurrence of specific forms in the child's spoken language (Brown, 1973; Menyuk, 1971). This type of measurement is both time-consuming and difficult. As a result, much of our knowledge on normal language development is based on data obtained from a small sample of children. Further, many of the children studied have been the offspring of researchers in the area of language development. In drawing comparisons with normal language development it is important to bear in mind that the observed differences may be confounded with differences between this small, select group of experimental subjects and the larger population of normal-hearing children.

Another, more serious, problem is that language development in the hearing-impaired child is not measured in the same way as for normal-hearing children. The early stages of normal language acquisition are observed through the child's spoken utterances. The use of speech by the hearing-impaired child is severely limited, thereby forcing a fundamental change in the way in which early language development is measured. Whether or not the process of language development is itself altered is the issue being addressed, but it is important to recognize that the process of addressing the issue involves differences in methods of measurement that may be confounded with the very differences that we are attempting to measure.

A common practice is to test hearing-impaired children on specific aspects of language and to infer from the child's level of performance whether or not the child has acquired the specific language forms being tested. This approach is simplified and made considerably more efficient by the additional assumption (often implied, if not stated explicitly) that test scores will be high on those forms that emerge early and lower on forms that emerge later. The validity of this assumption depends on the child's relative rate of development on the forms being tested. If the rate of development is roughly the same for all the forms being tested, then relative scores will be a good indicator of the order of development in that higher scores will be obtained on forms that emerge earlier.

The longitudinal study, because of its great precision in tracking developmental changes, allows for a direct check on the validity of this assumption while at the same time shedding new light on the nature of language development in hearing-impaired children. The subtest on question formation in an answer environment is a particularly rich source of information, and the data obtained on this subtest will be used for the following illustrative example. Figures 5.4(A-H) show relative performance as a function of age for specific question forms. Separate curves are shown for children in different deciles. From these data it is possible to measure, for specific children or subgroups of children, the emergence of new forms by observing the first evidence of better than chance performance. It is also possible to compare order of development obtained in this way with the estimated order of development based on relative test score.

Table 5.18 shows the ranking of question forms obtained in these two ways. Note that this example is restricted to children in Decile 1 because this was the only group of children that showed little evidence of understanding any of the question forms at the start of the study, but in subsequent years they improved well beyond the chance level of performance on most of the question forms being tested. The first column of Table 5.18 shows the order of development by indicating the first evidence of better than chance performance. The ranking obtained in this way is fairly gross in that four forms emerged together after the first year (i.e., test scores

TABLE 5.18. Ranking of question forms (lowest decile only).

First evidence of better than chance performance	*Ranking by test score and age of child* 11–12	12–13	13–14
[What	What	What	What
What-V	What-V	How	Wh-
How	Wh-	Wh-	What-V
Wh-]	How	Tag	How
[Tag	Tag	What-V	Tag
Yes/No]	Yes/No	Yes/No	Yes/No
Intensive	Intensive	Intensive	Intensive
Rank correlation:	0.90	0.78	0.91

for children in Decile 1 on *what*, *what*-V, *how*, and *wh*-question forms were no better than the chance level at age 10–11, but above this level at age 11–12); another two forms emerged the following year. The square brackets indicate a tie in the estimated order of emergence. The remaining three columns in the table show the ranking of the relative scores on question forms for the children at 11–12, 12–13, and 13–14 years of age. No entries are shown for age 10–11, because, at this age, the children did not score above the chance level for any of the forms. Causal questions are not considered in this example because of the lack of homogeneity noted earlier between the test items used for this particular form.

The rankings obtained by the two methods are very similar. A measure of the degree of correspondence between the rankings is provided by the Spearman rank correlation coefficient shown in the bottom row of the table. These coefficients show the degree of correlation between the rankings obtained by relative score and those obtained from the first evidence of better than chance performance for three different ages. The correlations obtained were statistically significant ($p < .01$, $< .05$, and $< .01$, respectively) and did not show any systematic decrease with increasing age. The degree of correspondence between the rankings is relatively good considering that the ranking obtained by the first evidence of better than chance performance is very gross and that the precision of ranking by relative score is limited by the not inconsequential test-retest variability of the various subcomponents of the test.

The data of Table 5.18 typify the kinds of comparisons that can be made between estimated developmental sequences as derived from relative test scores and a reference developmental sequence obtained by direct observation. Note that the gradations in the reference sequence are relatively coarse because several new forms appear to be emerging concurrently. The resolution with which developmental sequences can be mapped according to the first evidence of a new form being used is also limited because of idiosyncracies in language usage.

Although Table 5.18 shows a reasonably good correlation between developmental sequences observed directly and those inferred from relative test scores, the sequences shown differ substantially from those obtained by other researchers (Quigley, Wilbur, Power et al.,

TABLE 5.19. Ranking of question forms.

		10–11 years of age			13–14 years of age		
Predicted	*Main-streamed*	*Low deciles (1–3)*	*Mid deciles (4–7)*	*High deciles (8–10)*	*Low deciles (1–3)*	*Mid deciles (4–7)*	*High deciles (8–10)*
Yes/No	Yes/No	What	What	Yes/No	What	What	Yes/No
What	What-V	Wh-	What-V	What-V	What-V	What-V	What
What-V	What	What-V	How	What	Wh-	How	How
Tag	Tag	How	Wh-	How	How	Yes/No	Wh-
Wh-	How	Tag	Tag	Wh-	Tag	Wh-	What-V
How	Wh-	Yes/No	Yes/No	Tag	Yes/No	Tag	Tag
Intensive	Intensive	Intensive	Intensive	Intensive	Intensive	Intensive	Intensive
Rank correlation:	0.85	0.40	0.46	0.96	0.46	0.76	0.85

1976), the most noticeable difference being the relative late development shown for *yes/no* question forms in Table 5.18. It should be remembered that the data shown in this table relate solely to children in Decile 1, this being the only group of children for whom direct and inferred observations of developmental sequence could be obtained. There is reason to believe that developmental sequences for this and other low-performance groups differ from those for the rest of the children.

Table 5.19 shows developmental sequences obtained for children grouped according to their relative overall performance. The poorest group consists of children in the lowest three deciles (1 through 3), the average group consists of children in the middle range of deciles (4 through 7), and the best group consists of children in the highest three deciles (8 through 10). Also shown are rankings for the mainstreamed children. Two sets of rankings are shown for children in the longitudinal study, the first obtained at the start of the study, at age 10–11, and the second at the end of the study, at age 13–14. The table also shows the estimated order of acquisition of the question forms in normal-hearing children, as derived from data reported, Quigley, Wilbur, Power et al. (1976), and Cairns and Hsu (1978). The exact order of acquisition in normal-hearing children is not critical for the discussion that follows, but it is useful to have a rough set of predictions to serve as framework. Other than these predictions, all of the rankings shown in the table are based on relative scores for the subtest on question formation in an answer environment.

The rankings shown in Table 5.19 clearly indicate that relative performance on different question forms depends on which group of children is being considered. The *yes/no* question form shows the largest change in relative performance. For children in the lowest deciles it is ranked second to last, whereas for the children in the highest deciles and the mainstreamed children it received the highest rank. For the children in the middle deciles, the *yes/no* question form showed a marked transition, from a low rank at age 10–11 to a middle rank at age 13–14. The predictions for normal-hearing children place the *yes/no* form in the highest rank. Aside from the marked change in rank for the *yes/no* question form and, to a lesser extent, the change in the rank of the tag question form between longitudinal and mainstreamed children, the other question forms show similar rankings across children.

The correlation between the observed ranking and that predicted for normal-hearing children is relatively poor for children in the lowest deciles and relatively good for children in the higher deciles; the correlation also appears to improve with age. The highest correlations were obtained with the mainstreamed children and with children in the higher deciles. The data suggest that children with relatively good language skills have developmental patterns similar to those of normal-hearing children, whereas those with very poor language skills are not only delayed but also have deviant patterns of development. It should, of course, be remembered that the children in the lowest deciles were those who are typically excluded from studies of the type considered here because of low IQ scores or additional disabilities.

The poor performance of the low-scoring children on the *yes/no* question forms raises another issue: that of a possible interaction between relative performance and method of testing. As noted earlier, language development in hearing-impaired children is typically observed by techniques other than those used with young normal-hearing children. A major concern is that the method of measurement should not affect the relative order in which developmental changes are observed, although there may be large differences in absolute levels of performance. Although the data obtained in this and related studies (Gaffney, 1977; Geffner, Chapter 3, this volume) show that, on the average, relative performance on different question forms is much the same for very different formats; for example, essentially the same order of relative performance was obtained, on the average, using a question/answer format for spoken or signed questions (Chapter 3), responding to written questions (subtest Qae used here), or judging the grammaticality of written questions (subtest Qma). Similarities in average relative performance, however, can obscure deviant patterns of performance by a small subgroup of children.

A possible alternative explanation of the data in Table 5.19 is that children in the lower deciles have particular difficulty in comprehending the written form of *yes/no* questions. Two word orders are acceptable for this particular form (e.g., *Will you come? You will come?*), one of which is used more frequently in interpersonal communication than in the written form. The children in the higher deciles may have little difficulty in acquiring both of these forms, whereas children in the lower deciles may acquire the more commonly used form fairly early, but be confused by the alternative form—possibly even showing regression on *yes/no* forms in general when exposed to alternative word orders.

Whichever interpretation is correct, the important aspect of the data is that subgroups of children, notably the children in the lowest deciles, differ from the more advanced children (and from normal-hearing children) not only in average performance but also in patterns of relative performance. The latter implies differences in patterns of development and should be a matter of some concern to educators. The available data, at present, are insufficient to resolve the question of whether these deviant patterns reflect differences in order of acquisition at the earliest stages of language development or are a manifestation of unusual difficulties (or possibly evidence of a regression) with written language forms.

Three major caveats have thus been identified that need to be kept in mind when comparing data on language development in hearing-impaired children with corresponding data on normal-hearing children. The first is that normative data on language acquisition have typically been derived from small, nonrepresentative samples of normal-hearing children. The reliability of and, in particular, the extent of individual differences in the measured developmental sequences are not known. It is to be expected that individual differences will increase as language becomes more complex. Second, the use of relative test scores to indicate relative order of development is based on the assumption that rates of development are essentially the same for the emerging forms being tested. This assumption appears to be fairly safe in measuring newly emerging forms because very large differences in rates of development are needed to alter the inferred developmental sequence. The assumption, however, is likely to break down when there is evidence of regression on one or more forms, or when fairly advanced developmental sequences are to be measured because, in these cases, there is ample room for an interaction between test score and order of development. Third, it is also assumed that there is no interaction between the test format and relative performance on the syntactic forms being tested. A review of the results obtained with similar sets of syntactic forms using subtests with different formats supports the validity of this assumption, on the average. The possibility nevertheless exists that some of the less advanced children may have particular difficulty with the more difficult test formats, resulting in unusually low scores on specific syntactic forms with these subtests.

With these caveats in mind, the data obtained in this study, in parallel with the findings of Russell, Quigley, and Power (1976), show a fairly high degree of consistency with language development in normal-hearing children. The degree of consistency is particularly good with those forms that emerge early in life. For example, the subtests on negation showed relative ordering in test scores that corresponded well with that obtained by Quigley, Wilbur, Power et al. (1976) on normal-hearing children. The subtests on question formation, for the most part, showed essentially the same ordering of question forms as has been observed in normal-hearing children (Brown, 1973; Menyuk, 1971; Quigley, Wilbur, Power et al., 1976). The major exception to this trend was the relatively poor performance on the *yes/no* question form by children in the lowest deciles.

The degree of correspondence on more advanced syntactic forms, such as occur in pronominalization, was also good, but there was also stronger evidence of different patterns emerging among subgroups of the population. Common characteristics that were observed included the relative difficulty of plural versus singular forms, first person being significantly easier than third person, and the neuter form being much more difficult than either masculine or feminine forms. The data for the second person were difficult to interpret because of an apparent regression in the acquisition of this form that varied among decile groups. The hearing-impaired children in this study did relatively poorly on possessive pronouns, although the normal-hearing children in the study by Quigley, Wilbur, Power et al., (1976) did best of all on this form of pronominalization. Other than these differences, relative performance on possessive adjectives, backwards pronominalization, personal pronouns, and reflexization was much the same for the hearing-impaired children in this study as for normal-hearing children on the same set of subtests (Quigley, Wilbur, Power et al., 1976).

The rules governing the use of verbs range from simple to complex, and the pattern of performance by the hearing-impaired children ranged from consistent for the simpler forms tested to disparate for the more complex forms. The verb-deletion subtest, for example, was relatively easy, and all of the children showed essentially the same pattern of performance; that is, verb deletion was detected more frequently in sentences of the form subject-verb-object-locative phrase as compared to the form subject-verb-locative phrase, and in sentences of the form subject-*be*-predicate adjective as compared to subject-*have*-object sentences. This pattern was observed for children in all of the decile groups and also by younger normal-hearing children (8 through 10 years of age) who were tested on the same material (Quigley, Wilbur, Power et al., 1976).

The subtest on verbal auxiliaries, however, covered more advanced forms, and the pattern of performance differed not only between normal-hearing and hearing-impaired children, on the average, but also among hearing-impaired children in different decile groups. Data obtained on normal-hearing children on the same subtest (Quigley, Wilbur, Power et al., 1976) showed distinct differences in relative performance on the verb forms tested. The highest scores (78 to 91% over the range 8 to 10 years of age) were obtained for the progressive tense (73 to 91%); relatively low scores were for the passive voice (66 to 78%). The order of these scores is consistent with the order of development of the associated forms in normal-hearing children. In contrast, the hearing-impaired children did not show consistent differences in their scores for these forms. Children in the highest deciles, at age 13, approached the pattern of performance shown by the younger normal-hearing children. Those in the middle deciles did slightly better on the passive voice than on either of the other two forms, and children in the lowest decile, at the start of the longitudinal study, scored above the chance level for the perfect tense only.

Another difference among decile groups was that children in the lower deciles had considerable difficulty with the *be/have* confusion, scoring relatively poorly on this section of the subtest. The children in the higher deciles, by comparison, scored best of all on the section dealing with *be/have* confusions. The normal-hearing children did relatively well on this section of the subtest.

Relatively large differences in patterns of performance were observed between the hearing-impaired children and normal-hearing children on the most advanced of the syntactic forms tested, specifically on those subtests involving the combining of sentences. The hearing-impaired children had considerable difficulty in handling embedding and relative pronoun deletion, although they did fairly well on the processing subtest. In contrast, the normal-hearing children did relatively well on the embedding subtest and not quite as well on processing. Of greater importance, there is evidence of deviant patterns emerging in the combining of sentences by the less advanced hearing-impaired children. Whole noun phrases that should be replaced by a referent pronoun are simply omitted, surface word order that is correct over a significant portion, but not all, of a sentence is often treated as acceptable, and errors involving the incorrect association of noun phrases that happen to be close to each other (when sentences are concatenated) are quite common. Further there is evidence of characteristic patterns (as opposed to errors) in the combining of sentences. Hearing-impaired children make disproportionate use of trivial forms of conjoining sentences without regard to their constituent structure. For example, sentences are often simply concatenated by using the conjunction *and*. Another common problem is the excessive use of archetypal sentence forms, as discussed by Parkhurst and MacEachron (Chapter 6).

By far the largest difference in language development between hearing-impaired and normal-hearing children is the extremely slow rate of development shown by hearing-impaired children, particularly those in the lower deciles. In the early stages of language development, differences in rate of development need not affect the order in which new forms are acquired. If differences in rates of development are very large, however, a stage can be reached when differences in rate will necessarily alter the order in which new forms are acquired. For example, the acquisition of elementary syntactic forms is extremely rapid in normal-hearing children. It is thus possible to identify a reasonably discrete sequence of stages in the development of new forms. The boundaries between these stages, however, will become blurred if the rates of development are extremely slow and new forms begin to emerge long before simpler forms are well established.

For the hearing-impaired child who shows substantial delays in language development, errors or incomplete forms that typically occur in the early stages of normal language development will be interwoven with more advanced forms, forming patterns that do not occur in normal language development. As a consequence, extremely slow rates of progress not only produce a blurring of the normal developmental sequence but are also likely to introduce increasingly deviant patterns of development with time.

There is ample evidence that this process is at work with hearing-impaired children. Thus, for example, many of the hearing-impaired children in the longitudinal study were still having difficulty with simple forms of negation by age 13. Despite their limited comprehension of this form, those children had also begun to develop new forms that typically emerge at a later stage in normal language development, such as simple forms of conjoining sentences. As a consequence, children with a relatively poor grasp of one of the earliest forms to emerge were also developing concurrently an even poorer grasp of much more advanced forms. Divergent patterns of development are thus inevitable in that certain of the later forms require an understanding of earlier, simpler forms, while others do not. Contrast, for example, the difference in relative performance between simple forms of conjoining sentences and more complex forms requiring processing of the constituent components. The hearing-impaired children (compared to normal-hearing children) show vast differences in their relative performance on these tasks. Further, archetypal error patterns appear to be emerging that are characteristic of the hearing-impaired child.

In short, two distinct trends have been observed. The first is that children in the lower deciles do not always show the same pattern of development that is demonstrated by the majority of hearing-impaired children. The second is that, for most of the children, patterns of development are much the same on the simpler forms, with divergent patterns of development emerging on the more advanced forms. There also appears to be a close interaction between delayed and deviant development. The two effects are not independent; delayed development on elementary syntactic forms will, in turn, create deviant patterns of development on more advanced forms.

DISCUSSION

The data presented in this chapter are valuable in several respects. First, they provide benchmark data on the development of the more common syntactic forms by hearing-impaired children. Second, the data confirm previous findings regarding the development of syntax in the hearing-impaired child. Third, by virtue of coming from a longitudinal study, the data provide a map of developmental changes that is far more precise than that achievable by traditional cross-sectional studies. Fourth, because of the greater precision, the data provide new insights on the nature of language development in hearing-impaired children, insights not obvious from earlier data. Each of these points is discussed in greater detail below.

Benchmark data are particularly useful in curriculum planning and in mapping the progress of individual children. It is well known that hearing-impaired children typically have a much poorer command of written and spoken language than their hearing peers—but by how much? It is important for teachers to know the answer in order to teach effectively. There is little point in attempting to teach embedding, relativization, and other more advanced syntactic forms to children who have yet to master single main clauses. At the same time, hearing-impaired children who have a good command of language can be easily "turned off" by lessons involving material well below their level of development. The need to match curriculum content to level of development is well known, and it is difficult enough when dealing with normal-hearing children having no handicapping conditions.

Two striking features of the data are the slow rates of progress shown, on the average, and the wide range of performance levels across children. The data for almost all of the subtests showed a spread of scores ranging from the chance level of performance to the maximum possible score. On the positive side, all of the children showed some improvement in syntactic comprehension over the 4-year period of the longitudinal study. Even those children with the poorest language skills, many of whom were labeled "learning disabled" or "retarded" by their teachers, showed small but consistent improvements over the years on the less difficult subtests. The rate of progress was extremely slow, however, and at the end of the study those children had not yet reached the average level of performance shown by their peers 4 years earlier. At this rate of progress, it would take at least twice as many years for the children in the lowest deciles to reach the same level of performance as that shown by their peers in the highest deciles at the start of the study.

The rate of progress shown by children close to the average level of performance (i.e., children in the 5th and 6th deciles) was also fairly slow. In the majority of cases, the improvement in test score (final score − initial score) was less than 20 percentage points. Assuming a continued rate of improvement of roughly this amount, the children in the midrange are estimated to be about 4 to 8 years behind their most linguistically advanced peers.

This diversity of language skills is exhibited not only by children at schools for the deaf, but also by mainstreamed hearing-impaired children. The range of skills may even be greater for the latter group in that the best of the mainstreamed children obtained significantly higher test scores than the highest scoring children at schools for the deaf, whereas the below-average mainstreamed children scored only marginally higher than the below-average children at schools for the deaf.

As noted in Chapter 1, the effects of mainstreaming cannot be separated from the effects of the selection process for mainstreaming. Given the nature of this selection process, it is to be expected that the mainstreamed children would perform at a higher level than do children at schools for the deaf. The observation that the below-average mainstreamed children are not doing significantly better than children of comparable age at schools for the deaf should thus be viewed with great concern, particularly because the sample of mainstreamed children did not include children with additional handicaps, as was the case for the sample of children at schools for the deaf. The small differences observed between the two groups of below-average children may be due in part to the difficulty of distinguishing differences in relative performance for children with very low test scores. In other words, the below-average mainstreamed children may be linguistically more advanced than the below-average children of comparable age at schools for the deaf, but because all of the children in the lower deciles were performing at or close to the chance level of performance, the tests do not discriminate well among the poorer children of either group.

Whatever the cause of this difficulty, it is clearly evident that the range of linguistic skills for children covered by this study is overwhelmingly large, and that differences between mainstreamed children and those at schools for the deaf are relatively small in comparison. It is crucial that these huge individual differences in linguistic skills be taken into account in educational planning. No single curriculum can deal effectively with such diversity. The data presented in this chapter provide useful benchmarks for children at all levels of performance (for children in the lower, midrange, or higher deciles), and, by using such benchmarks, realistic curricula can be tailored to the needs of individual children. Although these observations pertain specifically to measures of syntactic comprehension, there is evidence of similar patterns in both the written and spoken language of the hearing-impaired (see Chapters 6, 7, and 8).

Comparisons with other published data confirm, in general, previous findings on syntactic development in hearing-impaired children. The largest body of data against which detailed, quantitative comparisons can be made is that of Quigley and his associates (Quigley, Wilbur, Power et al., 1976; Russell, Quigley, & Power, 1976, and references cited therein). The findings of the current study compare well to the findings of these earlier studies.

The differences that were observed involved either differences in average score or differences in relative scores for specific syntactic forms. The differences in average score were not large and appeared to follow a simple pattern. The children in the longitudinal study scored slightly higher (in comparison with the data of Quigley and associates) on most of the easier subtests and slightly lower on the more difficult subtests. This trend could be attributed to the differences between the two populations. For example, the children in the highest deciles (of the longitudinal study) did extremely well on syntactic forms that were already well developed, whereas children in the lowest deciles did very poorly on difficult syntactic forms. The children in the highest and lowest deciles of the longitudinal study were also children who typically would not have met the selection criteria for inclusion in the studies of Quigley and associates (many of the children in the highest deciles were postlingually impaired, and most of the children in the lowest deciles had additional handicaps).

A more important observation relates to differences in relative scores for specific syntactic forms because the differences imply different rates of development for the syntactic forms in question. Differences of this type were not observed for the simpler syntactic forms, but they were observed for the more advanced syntactic forms (e.g., conjunction, relativization). As language develops, there is more room for varied development, and the differences observed here may be a reflection of this greater scope for variation. It is significant that in the comparisons with normal development (to be discussed shortly), the degree of divergence also increases with increasing syntactic complexity.

A related and extremely important question is the extent to which the diversity in relative performance (and slow progress) can be ascribed to factors in the educational process (e.g., age at onset of special education) and factors beyond our control (e.g., age at onset of hearing impairment). These issues are examined in some detail in Chapter 9.

The longitudinal study differs from other studies of language development in hearing-impaired children in two important respects. One is the broadness of the sample (i.e., all children at a certain age level attending schools for the deaf in the State of New York were included). The second is that the study was longitudinal rather than cross-sectional.

The broadness of the sample has led to greater spread of the data, as noted above, but it also places in perspective the effects of certain factors that are well known to teachers of the deaf, but which have eluded quantification in earlier studies. Specifically, a sizeable proportion of children at schools for the deaf have additional problems. Almost one-quarter of the children in this study would have been excluded from other studies of this type on the grounds that the children were retarded, had minimal brain damage, or had severe behavioral or emotional problems. It is of particular interest to know in quantitative terms how such children performed in comparison with their peers. The data show that they typically fell into the two lowest deciles and that, for many of the more advanced syntactic forms, they did not score above the chance level. On the other hand, for those syntactic forms that are well established in hearing-impaired children of comparable age, slow but steady progress was observed over the years. It is encouraging to know that deaf children with minimal language skills (including many who are often regarded as "unteachable") can and do make progress on syntactic forms appropriate to their level of development.

At the other end of the scale, roughly 10% of the children were postlingually impaired. Although it is well known that postlingually hearing-impaired children have better speech and language skills, there is relatively little information on expected levels of performance for them. Many, but not all, of the postlingually hearing-impaired children fell into the highest decile. A more detailed analysis of their relative performance with both speech and language skills is provided in Chapter 9.

An important advantage of longitudinal over cross-sectional studies is that developmental changes can be tracked with great precision. In a typical cross-sectional study, age-dependent changes are confounded with between-group differences because a different group of children is tested at each age level. Because of the large individual differences that have been observed in developmental studies, as is eminently evident from Figures 5.2 through 5.17, it is particularly important that the subject groups used in cross-sectional studies should be as homogenous as possible. Consequently, major constraints are typically imposed on the selection of subjects for such studies. Those constraints can be relaxed considerably in longitudinal studies because the same group of subjects is tested at each age level. As a result, it has been possible to track developmental changes in children with special problems, who are typically excluded from cross-sectional studies (e.g., the multihandicapped children). It is also possible to observe differences in language development that are not evident from an analysis of group averages.

A fundamental question in the study of language development in hearing-impaired children is whether such development is delayed or deviant. The findings reported here indicate that the question presupposes an independence that may not exist. Delay and deviance are not independent, as the either/or format of the question implies, but appear to be closely related, and, in some instances, delay appears to be a direct cause of deviance.

Of the two effects, delay is far more evident than deviance, which accounts for the widely held view that hearing-impaired children, for the most part, follow the same sequence of development as normal-hearing children but at a much slower rate. The evidence of deviance is much more subtle, particularly at the early stages of language development where there is relatively little scope for observing grossly deviant developmental patterns.

The longitudinal study showed two distinct trends in the occurrence of deviant patterns of development. Manifestations of deviance increased with increasing language complexity, and children with the poorer language skills were more likely to show deviant patterns of development. In both cases, deviance was accompanied by substantial delays in language development. In the case of the more advanced syntactic forms, the cumulative effect of substantial delays over many years appears to be the cause of specific deviant forms (e.g., the combining of incomplete early forms with errors in newly emerging later forms).

It is crucial to distinguish clearly between deviance and difference. The distinction between the two, however, can be quite subtle. The thrust in identifying deviant developmental forms should be to identify those patterns of development that, if left unchecked, will impede the development of more advanced language at a later stage. As noted earlier, there is greater scope for individual variation as language develops. The variations are a healthy manifestation of normal development, but they also serve to blur the boundary between normal and deviant patterns of development. Research on normal language development has concentrated primarily on identifying typical or representative patterns of development, with good results. An issue that now needs to be addressed is that of determining the normal range of variation about these developmental means.

ACKNOWLEDGMENT

This study was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Please see the general acknowledgment in Chapter 1 for more detailed information on the many individuals and organizations who assisted in this project and whose help is much appreciated.

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Chapter 6

A Computer-Based Syntactic Analysis of the Written Language of Hearing-Impaired Children

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Children with serious hearing impairments do not have normal access to the auditory channel for learning linguistic forms, and consequently they exhibit severe deficits in the production of both oral and written language. Both developmental delays and deviant forms, as well as large individual differences among children, are reported (cf. Bamford & Mentz, 1979; Kretchmer & Kretchmer, 1978; Levitt & Newcomb, 1978; Myklebust, 1964; Presnell, 1973; Quigley, Power, & Steinkamp, 1977; Taylor, 1969.) There have been many approaches to teaching language to the severely hearing impaired (see Kretchmer & Kretchmer, 1978, for a review), and recently there appears to be an emphasis on mainstreaming the hearing-impaired child into the regular classroom whenever possible. Further understanding of the linguistic development of the hearing-impaired child, as well as comparisons among hearing-impaired children functioning in different educational settings, would appear important for the appropriate educational management of such children.

This chapter reports data obtained from a computer-based syntactic analysis of written language samples produced by hearing-impaired children at schools for the deaf as well as hearing-impaired children mainstreamed into regular classrooms. The written language samples were produced by the same two groups of children considered in the preceding chapter: specifically, longitudinal data on 48 children attending schools for the deaf and one year of data on 21 mainstreamed hearing-impaired children of the same age as those in the first year of the longitudinal study. The number of children in this study is less than that used in the longitudinal analysis of syntactic comprehension because many of the children did not produce the required written language samples for each of the four project years.

Several computer programs for the analysis of natural language processing have been developed (Marcus, 1980; Newcomb, 1963, 1974; Thorne, 1968; Turner & Mohan, 1970; Winograd, 1972; Woods, 1973). The program used for the present study is closely based on that developed by Newcomb. Its application to the study of the written language of the hearing impaired was described by Levitt and Newcomb (1978). That early version of the program permitted: parsing sentences according to their phrase structure (i.e., dividing into constituents); identifying word classes; identifying error types; and measuring gross output and complexity with such indices as number of words, clauses, and sentences; type/token ratio; words per sentence; and subordination ratio. However, the program required user interaction for error correction. In this study, a revised version was used in which the program corrected syntactic errors independently. Thus a complete analysis of ungrammatical sentences without user interaction was possible. The program in its current form is called PERC (Parsing with Error Recognition and Correction) and is described in detail elsewhere (Parkhurst & MacEachron, 1980).

Briefly, PERC analyzes a sentence by testing an input string of word classes (assigned to words by its lexical component) against a programmed graph structure that describes grammatical (acceptable) sentences. An error is recognized when the input string fails to match any programmed structure. Pilot research with PERC has demonstrated good agreement between computer and human phrase structure parsing and overall correctness rating of sentences produced by children with severe hearing impairments (Parkhurst & MacEachron, 1980). Agreement on phrase structure parsing was about 90% when the samples contained sentences with and without errors and about 97% for sentences without errors. Differences in correctness scores were not found to be significant. However, such a detailed computer analysis of error-laden language samples as is attempted in the present study is an unusual undertaking, and the methodology itself must be considered experimental.

METHOD

Subjects

The data for the longitudinal study consisted of written language samples obtained annually over a 4-year period from 48 children attending schools for the deaf in New York State. As described earlier, the children were between 10 and 11 years of age when the first samples were collected and between 13 and 14 when the last were collected. There were 26 girls and 22 boys in the group. Five children were from homes where a spoken language other than English was predominant, and one was from a home where the parents used sign language as their predominant language. The children's pure-tone average calculated at 500, 1000, and 2000 Hz (PTA) in the better ear was 99.7 dB.

A total of 21 written language samples was analyzed for the mainstreamed children. Those children were all prelingually deafened with no additional handicaps, and they attended regular schools in New York City. They were tested only once, when they were between 10 and 11 years of age. There were 12 girls and 9 boys in the group. Two children were from homes where the predominant spoken language was not English. Their average PTA in the better ear was 75 dB.

Written Language Samples

Written samples were elicited from a picture sequence depicting a family picnic. This picture sequence was developed by Stuckless and Marks (1966) and was found effective in eliciting written language samples from hearing-impaired children. For the longitudinal study, one sample was obtained from each child for each year of the project. A single sample was obtained for each of the mainstreamed children. The children attending schools for the deaf produced additional samples elicited by other pictures, and some of those were also analyzed. A discussion of the effect of picture stimulus based on that additional analysis is included in this report.

The children's handwritten samples were prepared for computer analysis by PERC as follows:

1. Punctuation marks were added when necessary, because entries had to be in sentence form. This required judgments about sentence boundaries.
2. Spelling was corrected when possible so that the words matched entries in PERC's dictionary, but incorrect word endings were not altered. If a word was misspelled so badly as to be unrecognizable, it was entered as it appeared and labeled, by PERC, as an unrecognizable word.
3. Vocabulary items were changed occasionally to conform with those in PERC's dictionary.
4. Sentences with more than two clauses were sometimes broken into two sentences because there are program limitations on maximum sentence length. Sentences containing dialogue were also sometimes broken into two sentences. This was done when the material in quotation marks involved more than a simple complement to the verb. Such material is not now analyzed by PERC. These procedures had a small effect on the words per sentence and clause per sentence data.

A total of 192 samples was analyzed for the children in the longitudinal study (48 children × 4 project years) and 21 samples for the mainstreamed children (21 children × 1 project year).

Data Analysis

The PERC analysis obtained the following syntactic measures.

Gross output measures. These included total number of words (tokens), number of different words (types), number of phrases, number of clauses, number of subordinate clauses, and number of sentences.

Gross measures of diversity and complexity. These were derived from the gross output measures above and included type/token ratio, the number of words per sentence, words per phrase, clauses per sentence, phrases per sentence, phrases per clause, and the subordination ratio (percentage of clauses that were subordinate clauses).

Word-class distribution. For PERC, a word class is defined as a group of words that are unique in terms of the other word classes that can precede and follow them, that is unique in privilege of occurrence. For example, singular count nouns, plural count nouns, and collective nouns are separate word classes according to PERC. In some cases, a single word composes a word class, particularly certain auxiliary verb forms. PERC recognizes a total of 42 word classes (cf. Appendix B). For this study, some closely related classes (e.g., different pronoun forms) were combined, and those found to contribute less than 0.1% to the total output for any year or subject group were not reported.

TABLE 6.1. Condensed list of word classes.

Class
Nouns
Singular nouns
Plural nouns
Collective nouns
Pronouns
Verbs
Present tense, plural
Present tense, singular
Present participle
Present tense auxiliary or copula
Past tense
Past participle
Past tense auxiliary or copula
Modal
Form of *do*
Modifiers
Determiners
Adjectives
Adverbs
Connectors
Conjunctions
Includers
Prepositions
Infinitives
Interrogators

The percentage of words that a word class contributed to the total output for a given year or subject group was obtained for the 21 classes (or groups of classes) listed in Table 6.1. From these data, the number of children producing each word class and the number of word classes produced by each child were also obtained.

Phrase-structure analysis. A full list of the phrase types identified by PERC appears in Appendix B. A few infrequently used categories were combined for the purpose of this report. The proportional distribution of the phrase types is analyzed and reported.

Among other sentence constituents listed in Appendix B, PERC identifies structures serving as complements to the verb. Data on these are reported with the phrase-structure data.

Error analysis. PERC counted the number of times each error type occurred. The error rate was then normalized to allow for comparisons among years and between subject groups despite changes in gross output. It must be noted that the normalized error rate cannot be used directly to compare the frequency of the different error types because the process of normalization was dependent upon the error type.

TABLE 6.2. Error types.

*Phrase type**	*Error type*	*Error score*
Noun phrase	Determiner needed	8
	Determiner not needed	8
	Lack of agreement between modifier and noun	8
	Noun needed	5
Verb phrase	Verb needed	4
	Lack of agreement between subject and verb	8
	Wrong form of the verb	6
Prepositional phrase	Preposition needed	6
Infinitive phrase	Infinitive needed	6
	Infinitive verb needed	6
Total phrases (all types)	Incomplete thought	4
	Run-on sentence	6
	Unrecognizable sentence type	4
	Modifier needed	5

*The normalized error rate for each phrase type is the percentage of that type containing the error.

Table 6.2 presents the error types identified for this study and the method of normalization. Also shown is an error score, which will be discussed further.

Overall-correctness score. PERC assigned each sample an overall-correctness score that reflected the amount and severity of syntactic errors. The scoring system is based on one developed by Crandall (1977). However, many of her error categories were not used, and the system reported here is only an approximation of the one she described.

For this study, each error type was assigned an error score (see Table 6.2) based on the severity of the error, and each sentence was given the score of the worst error in the sentence. An errorless sentence was scored 10 and the more severe the error, the lower the sentence score. The overall-correctness score was the mean of the individual sentence scores in a given sample.

Advantages and Disadvantages of Computer-Based Syntax Analysis

A computer-based syntax analysis was considered advantageous for such a study because of the large amount of data involved and the desire for a consistent objective analysis. Once the language samples are entered into a computer, a detailed syntactic analysis is obtained within seconds. The problem of interrater reliability is eliminated. Once the data resulting from the syntactic analysis are obtained, the program can process it for further organization and analysis. Thus, exceedingly time-consuming activities are eliminated.

The advantages of such a computer program are great, but it is not without disadvantage. Some editing of language samples is necessary, and they must be entered into the computer, a time-consuming job. Furthermore, it must be emphasized that PERC is still in its developmental stage. For example, PERC, as it is used here, is semantically "blind"; that is, it accepts a string of words as correct if the word classes occur in allowable order. In this analysis, our interest was syntactic analyses, and therefore semantic errors per se were not considered. However, because PERC does not use semantic information, certain sequences such as strings of nouns, some of which may be functioning as adjectives or verbs, may be analyzed incorrectly. Such errors are similar to, but probably more frequent than, the errors made by human evaluators analyzing ambiguous material without benefit of context.

PERC had more trouble than anticipated recognizing a few of the more complex structures produced by some of the children. This problem will be discussed later. With these limitations, the computer provided a valuable instrument for detailed assessment of the language of severely hearing-impaired children.

RESULTS AND DISCUSSION

Results are reported as group means for a given age or subject group unless otherwise indicated. For purposes of clarity, results will be discussed and interpreted as they are reported. A summary section will integrate the findings.

Gross Output Measures

Table 6.3 shows that the mean number of words, word types, phrases, clauses, subordinate clauses, and sentences increased over the 4-year period. Scores for the mainstreamed children are higher than those for children of comparable age (10–11) in schools for the deaf. The performance of the mainstreamed children is most like that of children at schools for the deaf between ages 11 and 12. There was considerable variation in output among subjects. Figure 6.1 displays the distribution of the total number of words. The most noticeable change over the years is that fewer children wrote very short samples. However, samples for some 13- to 14-year-old

TABLE 6.3. Mean number of words, phrases, sentences, and clauses.

Measure	Mainstreamed children	Children attending schools for the deaf Age 10	Age 11	Age 12	Age 13
Total words (tokens)	52.7	38.5	44.7	64.1	65.1
Total different words (types)	28.1	18.3	23.6	31.7	36.1
Phrases	26.9	23.3	22.8	33.4	33.0
Clauses	8.6	7.1	7.5	10.5	10.3
Subordinate clauses	0.34	0.04	0.23	0.29	0.38
Sentences	7.1	6.9	6.8	10.0	9.2

children were as short as many of the samples from the least prolific 10-year-olds, and, conversely, the total output of a few 10-year-olds matched that of the oldest children. The distribution for the mainstreamed children most resembles that of the 11- to 12-year-old children attending schools for the deaf.

Gross Measures of Diversity and Complexity

Table 6.4 presents data related to diversity and complexity of output. Although some change over time for children attending schools for the deaf can be noted, change is not evident on all measures.

Despite the lack of change in the type/token ratio as seen on Table 6.4, there was evidently vocabulary diversification over the 4-year period for the children attending schools for the deaf, because the number of different words (types) increased as noted (see Table 6.3). Thus, the stability of the type/token ratio seen here does not indicate a lack of diversification. Unless there really were vocabulary diversification, as gross output increased, one would find a decrease in type/token ratio because high-frequency closed-class words like auxiliaries and determiners cannot diversify, and they contribute more to the total as the sample size increases. Bench, Mentz, and Wilson (1979) also reported no significant change in type/token ratio with age for their hearing-impaired subjects, who likewise exhibited a growth in number of tokens and number of types.

The children at schools for the deaf showed an overall increase in words per sentence. The words-per-sentence figures reported here are similar to those reported elsewhere in the literature for children of equivalent age and hearing level (Bamford & Mentz, 1979; Brannon, 1966; Goda, 1959; Marshall & Quigley, 1970; Myklebust, 1965) and are much lower than those usually reported for children of the same age with normal hearing (Bamford & Mentz, 1979; Myklebust, 1964, 1965).

Table 6.4 provides little evidence concerning the type of clause and phrase development that produced the increase in words per sentence. Overall, there are small increases in words per phrase and very small inconsistent gains in phrases per sentence and clauses per sentence. The subordination ratio is always very small and is much lower than that reported by Marshall and Quigley (1970). Marshall and Quigley, however, only used subjects who produced at least 50 words in response to a picture sequence. Many of the subjects in the present study produced fewer words than that. Some of the unexpected high values in the first column may have resulted from PERC's having imposed a structure on word strings. In addition, PERC did not accurately identify all subordinate clauses, particularly in sentences containing errors. It is estimated that even with an adjustment for computer error, the subordination ratio would not exceed .05 for these samples. Anticipated programming changes should improve PERC's performance on this aspect of the analysis.

The mainstreamed children produced sentences that surpassed the school-for-the-deaf children of the same age (10–11) on some measures, particularly words per sentence. They produced more phrases per sentence than the oldest children in the study (13–14 years of age).

The number of phrases per clause reported here is higher than that reported by Bamford and Mentz (1979),

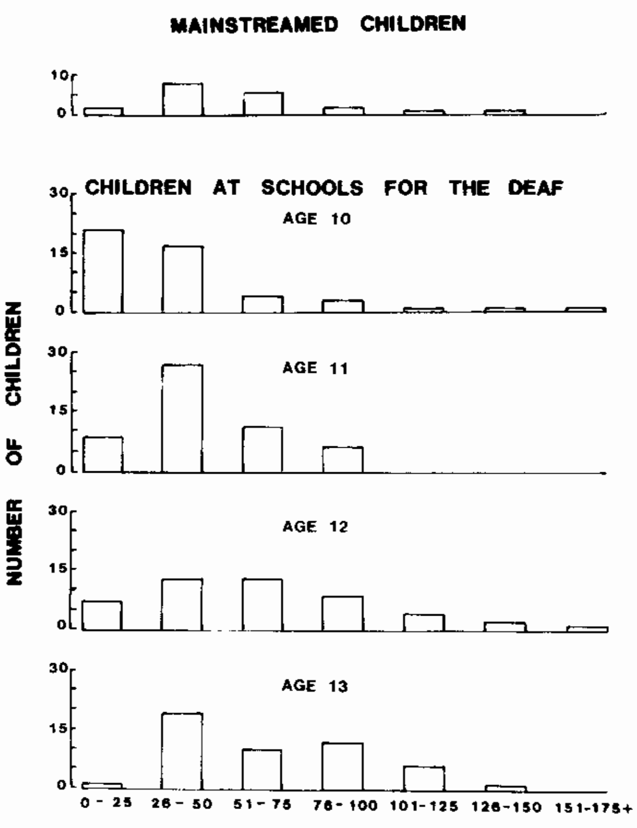

FIGURE 6.1 Histograms showing word distributions.

TABLE 6.4. Diversity and complexity measures: Group means.

Measure	Mainstreamed children	Children attending schools for the deaf Age 10	Age 11	Age 12	Age 13
Type/token ratio	.56	.58	.55	.54	.54
Words per sentence	7.45	5.61	6.62	6.41	7.10
Words per phrase	1.96	1.65	1.96	1.91	1.97
Phrases per clause	3.11	3.30	3.05	3.17	3.22
Phrases per sentence	3.80	3.39	3.38	3.35	3.60
Clauses per sentence	1.21	1.03	1.10	1.05	1.11
Subordination ratio	.04	.01	.03	.03	.04

but because clauses were counted differently in the two studies and because Bamford and Mentz used words from fewer word classes for their word data, comparisons are difficult.

Although the ratio of clauses to sentences remains low, and the subordination ratio is extremely low during the 4-year period, there was a noticeable increase in the number of children who could use more than one clause and/or subordinate clauses. Table 6.5 shows the growth in clause structure with the number of children using the structure as the index. Children who were identified as producing even one multiple clause are counted, and there is, of course, an overlap among rows in that all children appearing in the second row (subordinate clauses) must also appear in the first row (multiple clauses). Table 6.5 also shows that proportionally more mainstreamed children used such structures than children attending schools for the deaf.

Word-Class Distribution

Table 6.6 lists the word-class distributions obtained in this study. As noted above (see methods section), PERC separately identifies a larger number of word classes. Some were combined for this analysis, and a few were not reported because of their low frequency of occurrence. The left side of the table presents the mean percentage that each class contributed to the total output for a given year or subject group. Examination of this part of the table reveals relatively little change in the proportional use of word classes for the group attending schools for the deaf, with few classes showing steady growth over the 4-year period.

There is an increase in prepositions and determiners accompanied by an expected decrease in noun percentages. The proportion of present-tense plural verbs decreases, and the proportion of several types of past-tense verbs increases. Lack of change in the language of hearing-impaired children is reported elsewhere in the literature (Bench, Mentz, & Wilson, 1979; Goda, 1959). Marshall and Quigley (1970) report less change in their 10- to 14-year-old group than in their older group, although they saw evidence of pronoun growth that the present subjects did not demonstrate. Many of their categories were not comparable to the ones reported here.

The last column on the left side of Table 6.6 shows that the mainstreamed children produced fewer singular count nouns than did the children in schools for the deaf, even in the project's fourth year. They produced more pronouns, adverbs, and conjunctions than did the children at schools for the deaf at any age tested. Their verb usage was characterized by fewer present-tense plural verbs than that of children at schools for the deaf for the first 3 years of the study, but there was a corresponding greater use of present participles and auxiliaries. The mainstreamed children produced prepositions at a rate corresponding to that of children at schools for the deaf who were about 2 years older. Modals were not used in these samples by the mainstreamed children. They were used sometimes by children at schools for the deaf in stereotypic ways. Overall, the word-class distribution of the mainstreamed children was more mature than that of the other subject group.

As noted above, examination of the distribution of the word-class mean percentages reveals only a few changes over time for the children attending schools for the deaf. However, little change in word-class distribution for a group over a period of time does not mean a lack of growth in word-class usage. An alternative way to look at change in the children at schools for the deaf is to count the number of children who use a particular word class each year. The right side of Table 6.6 presents the data in this form. Examination of these data reveals that there were many forms that a greater number of children were able to use as they grew older. They include determiners, plural nouns, adjectives, adverbs, pronouns, prepositions, includers, and several verb forms. When we compare the mainstreamed children with the longitudinal group, we see that proportionally more mainstreamed children used pronouns, infinitives, present participle verbs, and auxiliaries. More mainstreamed children used adjectives, ad-

TABLE 6.5. Number of children using multiple clauses.

Structure	Mainstreamed children (N = 21)	Children attending school for the deaf (N = 48) Age 10	Age 11	Age 12	Age 13
Sentences with more than one clause	15	8	20	25	26
Subordinate clauses	5	2	9	12	13

TABLE 6.6. Word class distribution.

Class	Mean percentages: Mainstreamed children	Children attending schools for the deaf: Age 10	Age 11	Age 12	Age 13	Number of children using a given word class: Mainstreamed children (N = 21)	Children attending schools for the Deaf (N = 48): Age 10	Age 11	Age 12	Age 13
Nouns										
Singular nouns	20.4	31.1	27.5	26.0	25.9	21	47	48	48	48
Plural nouns	1.4	1.6	1.3	0.7	1.2	9	12	17	15	17
Collective nouns	11.2	11.1	10.8	9.4	9.6	20	44	46	45	46
Pronouns	6.0	2.7	3.0	3.7	2.9	17	20	27	32	26
Verbs										
Present tense, plural	8.2	9.6	9.2	10.0	7.4	20	42	45	48	44
Present tense, singular	0.1	0.0	0.3	0.2	0.2	1	1	4	6	7
Present participle	4.9	2.4	1.7	2.1	2.6	15	11	17	21	22
Present tense auxiliary or copula	5.4	4.1	3.5	3.8	2.9	17	18	23	30	25
Past tense	3.6	3.7	5.2	5.2	6.4	14	21	33	38	40
Past participle	0.4	0.6	0.8	1.1	1.0	4	7	14	18	21
Past tense auxiliary or copula	1.4	0.6	0.6	0.4	1.1	7	8	12	9	15
Modal	0.0	0.6	0.8	0.4	0.2	0	7	8	7	6
Form of *do*	0.0	0.2	0.0	0.1	0.0	1	2	0	3	0
Modifiers										
Determiners	17.4	16.9	19.7	19.9	22.0	20	42	45	46	48
Adjectives	1.5	1.8	1.3	2.0	1.9	10	15	17	27	27
Adverbs	3.6	2.4	1.8	2.0	1.5	14	14	20	29	22
Connectors										
Conjunctions	6.0	4.4	5.4	4.2	4.9	15	23	35	38	39
Includers	0.5	0.1	0.4	0.3	0.4	5	2	7	10	12
Prepositions	5.8	4.6	5.8	7.1	6.5	16	31	40	43	42
Infinitives	1.8	1.6	0.6	1.3	1.2	12	16	17	21	23
Interrogators	0.2	0.0	0.1	0.0	0.2	2	0	3	1	4

verbs, and plural nouns than did their peers (age 10–11) at schools for the deaf.

Thus, although the mean percentage of certain forms does not change, the number of children producing the form does. Additional differences between children in schools for the deaf and mainstreamed children can also be seen by viewing the data this way.

These trends can also be seen to some extent when the number of word classes used by each child is counted. Figure 6.2 displays the mean number of word classes used by the children each year. Overall, the children attending schools for the deaf exhibit greater word-class diversity with increased age except for the last year

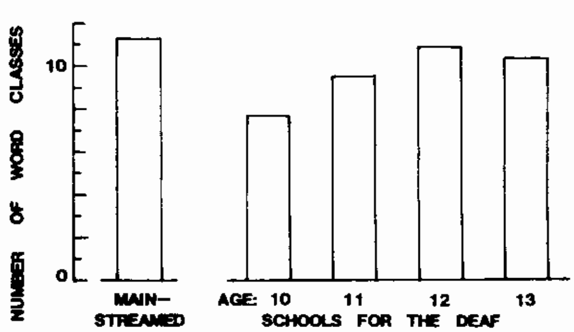

FIGURE 6.2 Histograms showing average number of word classes used by the mainstreamed children and those at schools for the deaf for each year of the study. The condensed list of word classes shown in Table 6.1 was used.

analyzed, and mainstreamed children exhibit greater diversity than children of any age in the longitudinal study.

The original language samples were closely examined for clues to why the word-class means remained relatively stable although diversity, as measured by the number of children using a word class and the number of word classes used by each child, increased. This may have resulted from specific children using specific forms in stereotypic ways and with great frequency in the early years of the study. For example, during the first year that the children were studied, there were several children who used the present participle accompanied by an auxiliary with great frequency and even exclusively as the sentence verb. By the third year, those children were varying their forms, but more children were using participles and auxiliaries. As another example, a single child ending every sentence with an adverbial phrase caused the first year adverbial group mean to be higher than that of any other year despite an increase in the number of children using adverbs.

The word-class data were further condensed to form eight traditional categories (noun, verb, adjective, adverb, preposition, conjunction, determiner, and pronoun) to allow comparison with data of other investigators (i.e., Bench, Mentz, & Wilson, 1979; Brannon, 1968; Marshall & Quigley, 1970; Myklebust, 1964). The figures generated by PERC were found to be similar to those reported in the literature except for the lower proportion of adjectives for all groups and the lower proportion of pronouns for the longitudinal group. The deficit pattern reported for hearing-impaired children with a higher than normal proportion of nouns, verbs, and

TABLE 6.7. Phrase type distribution—Mean percentages.

Phrase type	*Mainstreamed children*	*Children attending schools for the deaf* Age 10	Age 11	Age 12	Age 13
Noun phrases	49.6	54.4	54.9	51.8	53.3
Verb phrases	30.4	30.1	31.3	29.6	29.6
Prepositional phrases	9.3	8.4	10.2	11.7	11.0
Adjectivial phrases	0.8	1.3	0.8	1.1	1.5
Adverbial phrases	6.2	2.6	0.9	2.5	1.9
Infinitive phrases	3.4	2.6	0.9	2.5	1.9
Other phrases	0.3	0.5	0.8	0.9	1.2
Complements	17.8	15.9	18.8	18.8	19.3

determiners and a lower than normal proportion of other word classes is substantiated.

When the eight word-class categories were used for group comparisons, mainstreamed children were noted to use fewer nouns and more verbs, adverbs, and pronouns than did children attending schools for the deaf of any age studied here. They also used more conjunctions and prepositions than did their age peers attending schools for the deaf.

Phrase-Structure Analysis

Table 6.7 summarizes the children's use of the various phrase types. No significant change over the 4-year period was observed for noun and verb phrases. As would be expected, noun phrases and verb phrases are used with much greater frequency than any other phrase types because they form the basis of most simple sentences. Because noun phrases that occurred within other phrase types are counted separately, this adds to their proportional contribution. There was an increase in the proportion of prepositional phrases and complements over the 4-year period for the children attending schools for the deaf. This reflects the increases in prepositions and in phrases per sentence that were noted earlier. This kind of gain is consistent with the observation that hearing-impaired children learn most easily those structures that are easily and consistently observable from surface structure organization of sentences (Kretchmer & Kretchmer, 1978). The proportion of adjectivial, adverbial, and infinitive phrases remains low and does not increase over the period studied.

Mainstreamed children were found to use more adverbial and infinitive phrases than did children attending schools for the deaf. The appropriate use of these forms

TABLE 6.8. Error analysis.

Error types	*Normalized error rate* *Mainstreamed children*	*Children attending schools for the deaf* Age 10	Age 11	Age 12	Age 13	*Number of children producing a given error type* *Mainstreamed children* (N = 21)	*Children attending schools for the deaf* (N = 48) Age 10	Age 11	Age 12	Age 13
Noun phrase										
Determiner not needed	0.8	1.2	0.8	0.5	1.2	2	4	5	5	6
Lack of agreement between modifier and noun	2.0	0.9	2.7	0.6	0.9	3	1	2	1	3
Determiner needed	22.6	33.2	25.3	22.3	17.5	18	38	39	41	39
Noun needed	8.3	3.2	8.1	4.8	4.9	10	13	19	27	20
Verb phrase										
Verb needed	7.2	14.1	7.0	8.4	9.9	8	18	14	19	21
Lack of agreement between subject and verb	28.6	29.9	35.8	32.5	25.4	17	34	40	42	40
Wrong form of the verb	14.6	3.1	6.6	8.7	7.2	12	7	14	22	19
Prepositional phrase										
Preposition needed	4.1	12.1	7.3	4.8	8.0	3	10	10	11	11
Infinitive phrase										
Infinitive needed	0.0	6.3	2.1	13.5	2.1	0	3	1	7	1
Infinitive verb needed	0.0	10.4	3.5	5.2	11.1	0	5	2	4	6
Sentence form										
Incomplete thought	1.7	6.1	1.9	1.1	1.1	7	15	9	9	13
Run-on sentence	3.5	5.9	4.6	4.1	3.3	11	26	28	29	27
Modifier needed	0.6	0.0	0.0	0.1	0.0	3	1	0	2	1
Unrecognizable sentence type	0.0	0.3	0.0	0.0	0.0	0	1	0	1	0

may not be determined as easily from surface structure cues.

Although the proportional use of the less frequent phrase types was not found to increase for the children attending schools for the deaf as a group, the number of children producing those forms increased as the children got older. This finding is similar to that reported in the section on word-class usage.

Error Analysis

Table 6.8 lists the error types identified by PERC. The error rates reported on the left side of the table are normalized to adjust for differences in amount of output among subjects and years, and to acknowledge that it is not possible for all error types to occur in the same places in a sentence (cf. methods section). As mentioned earlier, the method of normalization was dependent upon error type. There should, therefore, be no attempt to make direct comparisons among error types based on the percentages because they were derived to show changes within an error type over time or between groups.

The right side of Table 6.8 reports the number of children in a given year or group whose samples were identified as containing a particular error.

The error data must be interpreted with caution. For PERC to continue the analysis of a sentence when a word in the sentence string did not belong to any allowable word class for that point in the string, it had to identify an error and make an internal correction. Sentences that were fairly well formed but contained such errors as lack of agreement between subject and verb or lack of the required article presented rather straightforward tasks to PERC because the words surrounding the error clearly define the appropriate syntactic form. PERC, however, also attempts to correct sentences or sentence parts that are characterized by poor and ambiguous syntax. In such cases, PERC inserts or deletes the word class that, according to its programmed structures, is most likely to correct the sentence at that point. Sometimes such a correction can create another error, one that did not originally exist but must be identified and corrected.

Noun-phrase and verb-phrase errors. Most of the determiner errors are fairly straightforward. As expected from the word-class data, the children made fewer *determiner needed* errors with successive years. However, about 75% of the children made some of these errors even at age 13–14. Examination of the data reveals that the proportional decrease in this type of error represents a change in ability to use articles and not simply an increase in the percentage of nouns that do not require them. The other determiner errors do not occur with great frequency. An occasional child inserted many unnecessary *thes* or *as* when the form emerged (*determiner not needed* error). The errors involving lack of agreement between modifier and noun were usually either *a/an* confusions or expressions such as "two of the boy" or "two boy."

Noun needed and *verb needed* errors are particularly difficult to interpret. They do not simply reflect sentences without a noun or without a verb. Rather, they reflect points in sentences where PERC added a noun or verb in order to continue processing the sentence. For example, if, in a long string of words, two verbs occurred together in an environment where that was not allowable, PERC might identify a run-on error as well as demand a noun. Sentences identified as containing such errors were often quite poorly constructed.

The *lack of agreement between subject and verb* errors and the *wrong form of the verb* errors seem to reflect definite trends in the language development of the children. The children produce a lower percentage of the former and a higher percentage of the latter with age. Examination of the word-class data shows that this parallels the children's proportional decrease in simple present-tense verbs and the increase in other verb forms. When they do use the simple present tense, most children continue to exhibit lack of agreement between subject and verb. The children did not learn to use the third person singular form of regular verbs during the period studied and used few plural nouns (even though most children could use them occasionally). The *wrong form of the verb* errors usually involved the use of a present participle without an auxiliary or the use of an auxiliary with a simple present-tense verb. As the participles and auxiliaries increased over the years studied, so did this type of error.

Infinitive-phrase and prepositional-phrase errors. The identification of the need for an infinitive reflects the number of times a verb such as *want* is followed by a verb such as *go* (e.g., "He want go home"), and identification of the need for an infinitive verb reflects instances of the word *to* appearing with no appropriate form following it. Such constructions are ambiguous for computer and human evaluators alike, and labeling them as incomplete infinitive phrases may not always be correct.

A *preposition needed* error is identified when a sentence contains a noun phrase immediately following an intransitive verb. The proportional decrease of this error type over the 4-year period reflects the increase in prepositions noted earlier. However, the number of children making the error does not decrease.

Sentence-form errors. In the first year of the study, *incomplete thought* errors were usually assigned to children producing strings of words with no real structure. Such errors decrease in frequency after that year, and later they are accounted for by the occasional sentence fragment that is produced even by children with good complex structures.

Run-on sentences are usually sentences with missing conjunctions or, sometimes, missing prepositions. Sentences may be labeled as such when one verb follows another, when a noun phrase follows a prepositional phrase (not when it is included within one), or when a verb that does not accept an indirect object is followed by a complement and noun phrase, as well as when two clauses appear without a conjunction between them.

The *unrecognizable sentence type* error was only labeled three times over the whole period studied. The *modifier needed* errors usually appear when PERC is incorrectly analyzing subordinate clauses and do not reflect the children's abilities.

A striking aspect of the data in the left side of Table 6.8 is that for most error types, the number of children that produce the error does not decrease over the 4-year period even when the error percentage decreases. It appears that the children do not use forms consistently and correctly even after they have learned them.

There are many similarities, but some differences, in error patterns between mainstreamed children and those at schools for the deaf. The *lack of agreement between subject and verb* is one of the most common errors, and both groups make this error with great frequency. However, lack of agreement between subject and verb (e.g., "He go") may be considered an error that is not very serious even though it occurs frequently. Its occurrence does not usually interfere with the conveyance of meaning because subject/verb agreement is a convention that adds redundancy to the message.

Mainstreamed children also make many *determiner needed* errors. This error also is common among the hearing impaired and usually does not seriously interfere with sentence meaning.

The mainstreamed children are identified by PERC as producing about as many *noun needed* and *verb needed* errors as did the 11-year-old children in schools for the deaf. The identification of those errors by PERC usually indicated a poorly constructed sentence; the number of such errors reflected more the overall lack of structure than the actual number of nouns and verbs needed.

Thus, the two groups were similar in that each contained some children with very poor language skills. Furthermore, both groups were alike in that the less serious errors that are considered so typical of the language of the hearing impaired occurred with relative frequency.

The mainstreamed group differed from the group attending schools for the deaf by producing a greater proportion of verb phrases that were identified as containing the *wrong form of the verb*. This probably reflects the mainstreamed group's greater usage of present participle and auxiliary verb forms. With increased attempts to use these forms, there are more opportunities to make errors such as omitting an auxiliary or omitting the *ing* at the end of a verb following an auxiliary. As with the lack of agreement between subject and verb, these errors involve omission of redundant grammatical forms and do not usually interfere with meaning.

Mainstreamed children are identified as producing *incomplete thoughts* at a rate equivalent to that of children in schools for the deaf who are a year or two older. They produced sentences identified as *run-on* with the frequency of children at schools for the deaf who were three years older, and proportionally fewer of the mainstreamed children produced that error. They produced phrases where PERC demanded a preposition with less frequency than did children at schools for the deaf at any age studied, and proportionally fewer of them

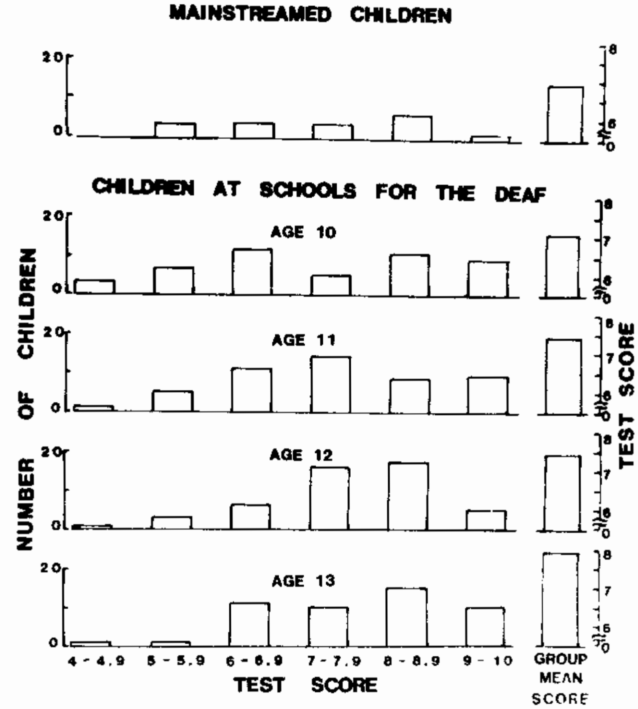

FIGURE 6.3 Histograms showing distribution of overall-correctness score and group means for overall-correctness score (scale on far right).

made this error. They did not, as did children at schools for the deaf, produce phrases where PERC demanded either an infinitive *(to)* or an infinitive verb.

This probably means that the mainstreamed children did not produce as many sentences with incomplete or ambiguous structures as did children at schools for the deaf. *Run-on sentences*, for example, were usually identified by PERC when two verbs or two clauses followed each other without any appropriate connective. *Infinitive needed* errors were usually identified when the verb *want* was followed by another verb, and when the word *to* was not followed by any appropriate form. *Preposition needed* errors usually reflected instances of a noun phrase following an intransitive verb. Such errors tended to create sentences that, while not entirely lacking in structure, were poorer, and probably more ambiguous for a listener, than those containing the common *lack of agreement between subject and verb, wrong form of the verb,* or *determiner needed* errors.

Overall-Correctness Score

Figure 6.3 displays the overall-correctness score (cf. methods section) distribution for a given score for a given year or subject group, and it presents both group and year means. The children attending schools for the deaf show improvement over the period studied. Their improvement is not evident in the mean of the third year (age 12) when few children achieved high scores, but it can be seen in the rest of the distribution. The overall mean score never exceeds 8, which is the score given to omission or misuse of such redundant forms as verb inflections and articles. As noted above, these errors occur frequently in the language of hearing-impaired children.

The mean overall-correctness score for the mainstreamed children is below that of the children at schools for the deaf at any age, and their distribution of scores is not as wide.

Although the change in overall-correctness score for the children at the schools for the deaf is in the direction of improvement, examination of the data shows that the pattern of change is variable. Almost a third of the children have a lower score (by ¼ of a point or more) in the fourth year than they had in the first year. This tends to mask the amount of improvement shown by other children who made large and consistent gains.

The question that must be raised is whether the overall-correctness scores represent the linguistic performance of the children, or whether they are, instead, artifacts of the nature of the scale compounded by some computer errors in error recognition. A difficulty with any correctness scale is that correct stereotypic sentence patterns get higher scores than complex patterns with errors. In addition, as noted earlier, PERC had difficulty analyzing some of the poorest sentences (word strings to which PERC assigned a structure) and some of the best (multiple clauses with some errors). The former problem tends to inflate scores in the first year; the latter tends to deflate them in the last year and in the mainstreamed group. Thus, group trends toward improvement and the best performances of the mainstreamed children probably are not adequately represented in the scores. On the other hand, close examination of the data reveals that score variations may indicate some developmental trends. For some children, a drop in the score was accompanied by a more varied sentence structure. Those children produced repetitive stereotypic sentence patterns with few errors in an early year of the study, which gave them high scores. When they stopped using such patterns, they made more errors, and their scores dropped. This was more evident when the additional language samples were evaluated. The stereotypic sentence patterns may, in part, reflect specific educational techniques that have been used traditionally to teach linguistic skills to hearing-impaired children at schools for the deaf (see Kretchmer & Kretchmer, 1978, for a review of those techniques). Close examination of the language samples also reveals that the mainstreamed children did not typically use stereotypic patterns. This might partially explain their low scores.

The overall-correctness score, as it is now derived, is, therefore, probably not accurate enough for studying group trends, but it may be helpful in identifying the children with particular developmental patterns, some of which may be related to educational techniques. This observation is based on informal examination of data and needs more thorough exploration.

Effect of Stimulus Picture

Originally, written descriptions of two pictures or picture sequences per year were analyzed for the children at schools for the deaf. To allow for comparisons with the mainstreamed children, only the analysis of one picture sequence was used for the present study. Examination of the results generated by the analysis of two written samples per year for the children at schools for the deaf revealed, in general, a pattern of small but inconsistent gains over the 4-year period; the areas in which those gains took place remained the same. However, the nature of the stimulus material and the number of written samples used for analysis must have some effect on identified linguistic output. Differences that were noted as being due to stimulus selection are reported in this section.

The total output for the picture sequence used for the present study (to be referred to as the picnic sequence) was greater in any given year than that for the other picture or picture sequence examined for that year. There were small differences in type-token ratio, with the picnic sequence surpassing the other sequence in the first year but producing a slightly lower type-token ratio than the other picture materials for the other years. Differences in picture content may have been responsible. The picnic sequence generated more phrases per clause and per sentence than the other pictures did.

Overall, the picnic sequence appears to have generated a greater proportion of nouns and conjunctions than did the other picture stimuli and a smaller proportion of verbs, determiners, and adjectives. Most of the differences were small, and some were probably related to the content of the picture.

The picnic sequence generated more past-tense verbs in the third and fourth years of the project than the other picture stimuli did. In those years, the second picture stimulus was a single picture rather than a sequence, and this may have affected tense choice.

There was little difference in the type of errors made in response to various picture stimuli. The picnic sequence did generate fewer *preposition-needed* errors and more *determiner-needed* errors than were generated by most of the other pictures.

Samples generated by two pictures or picture sequences instead of one produced a larger variety of errors from individual children and more examples of stereotypic responses. They also elicited the occasional use of a greater variety of word classes. This is to be expected with increased sample size and is not necessarily related to picture content or type.

As noted above (cf. the discussion of overall-correctness score in the results section), there was a relation between decreases in stereotypic sentence patterns, or increases in structural diversity, and decreased overall-correctness score that was observed through examination of the larger number of written samples. This observation should be studied further before any conclusions can be drawn.

Effects of Hearing Level and Home Language

The average hearing level of the mainstreamed children was better than that of the children attending schools for the deaf. Among the mainstreamed children, there was a tendency for those with better hearing to perform better on the measures studied, but this trend was not consistent. Some children with comparatively good hearing performed quite poorly, and some with very poor hearing did well.

Examination of the data also reveals that the children from homes where a spoken language other than English was predominant performed somewhat below the other children on many measures. Again, this trend was inconsistent. There were seven such children. Two performed in a way that was quite low for his or her group. Three performed at a level slightly below the group, one was about average for the group, and one usually performed better than average. The child from a home where sign language was the predominant language tended to perform slightly better than the group. There did not appear to be anything unique about the written language of those children from homes where the predominant language was not spoken English. These observations should be interpreted with caution, however, because the number of children involved was small, and the data were too inconsistent for any strong conclusions to be drawn regarding the relationships among home language, school language, and syntactic performance.

SUMMARY AND CONCLUSIONS

The use of a computer program for syntactic analysis yielded a large amount of data in a relatively efficient manner. The many group means examined in this study revealed some limited syntactic gains over time for the 10- to 14-year-old children attending schools for the deaf who were studied. They also revealed differences between those children and hearing-impaired children who have been mainstreamed into regular classrooms. The data also afforded ways of looking at linguistic diversification that was not reflected in group means and provided insights into the effect of diversification on accuracy of performance.

The largest gains made by the children attending schools for the deaf were overall increases in output and vocabulary. That the other gains were not as great indicates that amount of output and vocabulary may not be strongly related to some syntactic measures.

The children in schools for the deaf also showed some gain in words per sentence and phrases per sentence. The word-class means revealed that the greatest increases were in use of prepositions and articles. Some changes in verb form over time were also revealed. Structures easily observable from surface word order seemed to be the easiest learned. Overall, group changes were quite small, and 13- to 14-year-old children continued to make many errors. Relatively small gains in language skills over time for hearing-impaired children in this age group have been noted by other investigators (Bench, Mentz, & Wilson, 1979; Goda, 1959) and are reported elsewhere in this monograph (Chapter 5).

The mainstreamed hearing-impaired children generated output, vocabulary, and sentence complexity measures that were similar to those generated by children attending schools for the deaf who were one to three years older. Their word-class distribution may be considered more mature than that of children at schools for the deaf because they produced fewer nouns, but more adverbs, conjunctions, auxiliary verbs, and participles. Their phrase structure distribution was also more varied and appeared less dependent upon observable surface structure regularities. Although the mainstreamed children made many of the less severe errors and did produce some poor sentences, there were certain error types that were seldom or never identified in their output. Those errors may be ones that create sentences that are difficult to parse and that therefore are difficult to interpret. The overall score of the mainstreamed children as a group was lower than that of the children attending schools for the deaf during any project year. This may, in part, be related to the observation that the mainstreamed children did not tend to produce stereotypic (but syntactically correct) sentence patterns.

Not all growth was reflected well in the group means. There were large individual differences among the children, and there were children whose performance appeared, at times, to get worse instead of better. These differences tended to mask the large and consistent gains made by some children who were able to develop such complex structures as subordinate clauses by age 13–14. The use of a computer analysis, with the large number of measures it quickly yields, allows for the observation of such detailed individual growth trends.

Diversification of structure is an important aspect of language development. As noted, the proportional distribution of word classes and phrase types changed in only limited ways over the 4 project years. However, it was observed that even when a word class or phrase type remained stable or varied inconsistently over time, there might be an increase in the number of children who used the form. This indicates that, as more children were using a form, some of those who used it frequently in the early years of the study were using it less frequently later; this may be interpreted as diversification.

Counting the number of children who used a form gave information about clause development as well. Although the use of multiple, and particularly subordinate, clauses was infrequent, the number of children producing them increased over the years.

A related measure of growth that was generated by PERC's analysis was the number of different word classes used by each child. This, too, increased over the period studied except for the last year, indicating increased diversification of structure. Mainstreamed children, as a group, used more word classes than did children attending schools for the deaf at any age studied.

The overall-correctness score was fraught with methodological problems but did give some information about developmental patterns. It increased over time for the children attending schools for the deaf, but many children showed an inconsistent pattern with a score that went down from one year to the next. Examination of the original language samples, along with additional samples that were analyzed but not reported in detail, gave the impression that as some children used fewer stereotypic sentence patterns and attempted more complex forms, their overall-correctness score decreased, at least temporarily. The nature of hearing impairment, along with specific techniques used to teach hearing-impaired children, results in these children learning, through the visual channel, the grammatical forms that the normal-hearing child learns and integrates through the auditory channel. This may present particular problems for learning grammar, and it reaffirms the necessity for providing extensive and appropriate remediation for these children (see Kretchmer & Kretchmer, 1978, for a discussion of linguistically based approaches to teaching language to the severely hearing impaired).

The computer program that was used here to study the language of these children needs further modification to allow for more accurate identification of structures and errors, particularly in the more complex sentences. It did, however, seem able to describe the language of children with severe hearing impairments in ways that identified deficits that are in agreement with findings of other investigators, and it provided insights into certain growth trends, such as word-class diversification and the problems that could accompany such diversification. It appears that it would be useful to continue developing this instrument for the purpose of describing the language of the hearing impaired.

ACKNOWLEDGMENT

The research reported in this chapter was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions.

The computer programs used in this study were based upon programs first developed by William Newcomb of the Center for Communications Research. We are especially grateful to Dr. Newcomb and Robert A. Houde, Director of the Center, for allowing us access to the programs and for their help and encouragement. We are also grateful to the Computer Center, Queens College, City University of New York, for allowing us to use their facilities. We similarly wish to make known our deep appreciation to the many others who helped us in this research. (See the general acknowledgment in Chapter 1.)

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Chapter 7

Communication Skills of Hearing-Impaired Children in Schools for the Deaf

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In this chapter, longitudinal data are reported on speech reception and speech production skills of hearing-impaired children. Approximately 120 children were tested as part of the study, with about 80–90 children followed over the 4 years. The background data on the children are described in Chapters 1 and 5 and will not be repeated here. It should, however, be noted that the subjects attended 10 different schools for the deaf throughout New York. The schools differed significantly from each other in educational philosophy as well as in approaches to auditory and speech training. The data reported are unusual with respect to previous investigations of speech reception or speech production in hearing-impaired children. For most of the studies reported in the literature, data were gathered at one or two institutions where philosophy of education and training presumably were fairly similar. Examples of such studies would be those of Hudgins and Numbers (1942), conducted at the Clarke School and Mt. Airy School for the Deaf, or Smith (1975), conducted at the Lexington School for the Deaf. Thus, one might argue that patterns of errors, in speech production, for example, might be due to a particular teaching strategy (Ling, 1976). Alternatively, one might adopt the point of view that a generic "deaf speech" pattern exists that is not dependent on the fine-grained details of training procedures. However, a survey of the literature provides neither cross-sectional studies nor longitudinal data to address these issues.

Our goals for this part of the study were therefore threefold. First, we wished to obtain longitudinal data on the patterns of development of speech reception and speech production skills to parallel the data obtained on language (cf. Chapters 1 and 5). Second, we wished to ascertain if patterns of reception and production similar to those reported in the literature would be found for a fairly comprehensive sample of hearing-impaired children receiving training in a wide variety of settings. A third goal, to obtain data on the interrelationships between language and communication skills, will be discussed separately in Chapter 9.

Data were collected for the reception and production of both segmental and suprasegmental features as well as speechreading. However, there is a particular difficulty in studying various communication skills in the hearing-impaired; namely, selecting appropriate instruments to measure those skills. In some cases, existing tests were adapted and used; in other cases, it was necessary to develop our own measures. Descriptions of each test will be included under the respective sections: Segmental Features (reception and production); Suprasegmental Features (reception and production), Speech Intelligibility, and Speechreading.

SEGMENTAL CHARACTERISTICS

Phonemic Reception

A question of major concern to those who work with severely to profoundly hearing-impaired children is to what extent this population can make use of residual hearing for the reception of speech. Several tests of speech discrimination for hearing-impaired children exist (Haskins, 1949; Myatt & Landes, 1963; Ross & Lerman, 1971; Siegenthaler & Haspiel, 1966). However, most of those tests were not suitable for our test population for one or more of the following reasons:

1. The language of the test stimuli resulted in reduced discrimination scores because of the child's difficulty with vocabulary, syntax, etc., and, thus, scores reflected language performance and not auditory discrimination ability.
2. The written or verbal response mode for the test was not appropriate for severely to profoundly hearing-impaired children.
3. The test provided word discrimination scores rather than information on the reception of phonetic contrasts.
4. The children had either too little residual hearing or insufficient auditory training to score above chance level.

The phoneme reception test developed by Smith (1975) was used as the measure of segmental reception ($Rseg_1$) for the first 2 years of the longitudinal study. (Data from mainstreamed hearing-impaired children on the Smith test are reported in Chapter 8.) Because most of the children in the project had limited residual hearing, the scores obtained using Smith's test were quite low. Useful information was possible for only a small number of children, generally those with better hearing. Consequently, a second phoneme reception test, the Children's Nonsense Syllable Test ($Rseg_2$), using only the gross acoustic contrasts, was developed and administered in the last 2 years. We will describe both receptive measures because they illustrate unique problems in assessing phonemic reception in the severely to profoundly hearing-impaired population as well as providing important baseline data on the reception skills of hearing-impaired children.

Smith test ($Rseg_1$). The phoneme reception test developed by Smith (1975) was designed for hearing-impaired children 8 years of age and older. The test consists of a

TABLE 7.1. Contrasts on Smith's (1975) phoneme reception test ($Rseg_1$).

Type of contrast	*Test word**	*Contrasting words*	
Place	sat	fat	hat
	pea	tea	key
	bum	dumb	gum
	she	he	see
	let	wet	yet
	read	weed	lead
	sit	sip	sick
	big	bid	bib
Manner	new	zoo	do
	bill	mill	will
	lot	dot	not
	zip	dip	lip
	wet	bet	met
	me	be	we
	pan	pad	pal
	buzz	bud	bun
Place-manner	fair	chair	pair
	mumps	dumps	jumps
	gee	we	D
	then	den	men
	do	you	moo
	hen	ten	when
	bug	bum	buzz
	mass	map	match
Voicing	mat	bat	pat
	bark	mark	park
	pill	mill	bill
	two	do	new
	D	tea	knee
	nip	tip	dip
	sup	sub	some
	rib	rip	rim
	come	cup	cub
	pat	pad	pan
	seed	seat	seen
	bun	but	bud
Vowel	beet	bit	boot
	Pete	pit	pot
	hot	hut	hoot
	not	nut	neat
	luck	lock	look
	suck	sock	sick
	hit	heat	hut
	fit	feet	foot
	fool	full	feel
	pull	pool	pill
	pal	pool	peel
	lid	lead	led
	full	fool	fall
	pot	pet	put

*The word in this column is the correct response.

series of monosyllabic words spoken by a male speaker (educated New York City dialect). The child identified the test word from three alternatives (see Table 7.1) consisting of the test word and two similar words that differed from the test word in a specific phonetic feature. For example, a typical set of contrasts was "sat, fat, and hat." The test word was *sat*, and the other two words differed from *sat* only in place of articulation of the initial consonant. Five types of contrasts were included: place of articulation, manner of articulation, place and manner of articulation, voicing, and vowel contrasts.

TABLE 7.2. Percentage correct averages for project children on Smith's phoneme reception test ($Rseg_1$).

Feature contrast	*Project children* Age 10–11	*Project children* Age 11–12	*Smith study**
Place contrast	41.7	38.8	42.5
Manner contrast	43.0	42.8	50.4
Place-manner contrast	32.5	31.9	34.1
Voicing contrast	39.8	37.5	48.4
Vowel contrast	33.6	35.1	42.9

*Data from Smith, 1975.

The stimuli were prerecorded on magnetic tape and presented to the children via a tape-playback system, high gain amplifier, precision attenuator, and standard TDH-49 headphones. The intensity of the stimulus was adjusted to the Most Comfortable Loudness Level, but never exceeded a maximum peak level of 125 dB SPL. Many of the profoundly deaf children wanted higher signal levels, but for precautionary reasons, the 125 dB SPL level was not exceeded.

The averaged data summarized according to feature contrast are shown in Table 7.2. Scores from Smith (1975) are also included for comparison. A 3-way analysis of variance (question type × year × decile) showed no statistically significant change in overall performance for the project children during the 2-year period in which the test was given. Scores for all feature contrasts were relatively low, and for contrasts involving place of articulation or voicing, the average scores for the children showed a small, but not statistically significant, decline between the two years. The data most resemble Smith's for items involving the place of articulation and place-manner contrasts. Scores obtained for project children were within 2 percentage points of those reported by Smith. Scores for other contrasts—manner, voicing, and vowels—were 7 to 10 percentage points poorer than those reported by Smith. These differences may be accounted for, in part, by differences in subject populations. All subjects in Smith's study were children who had been enrolled in an oral school for the deaf where they received considerable auditory training. All of them had residual hearing through 750 Hz, and none had any other handicapping conditions. As previously noted, children in this project differed from Smith's group, and from each other, in type of schooling, degree of residual hearing, and handicapping condition.

Figure 7.1 shows the decile diagram for the two years. While there was a statistically significant difference between deciles, the overall range of scores for children in the highest decile (10) to lowest (1) was limited. Children in the highest deciles showed a slight decline in performance although the difference between years was not statistically significant. Children in the lowest deciles (1–3) had average scores at chance performance for ages 10–11, and, although these decile groups showed some change in scores, the change was not statistically significant. No pattern (either improvement or decline) in average scores was noted for any decile as a function of any

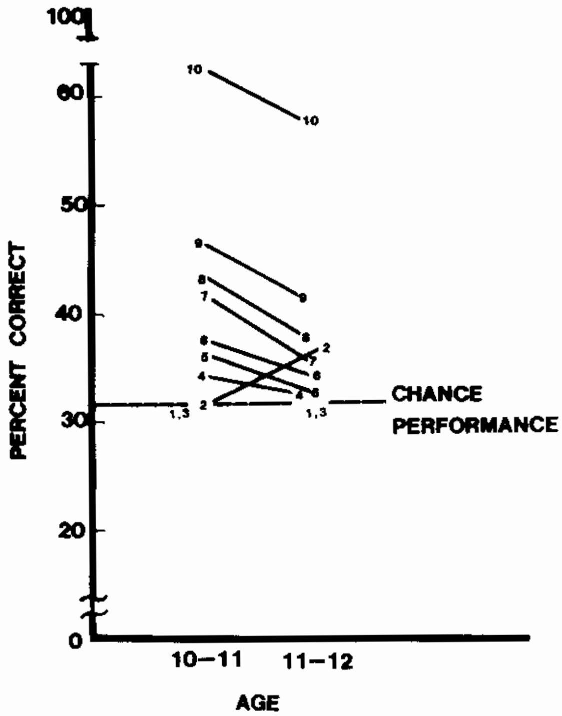

FIGURE 7.1. Decile diagram for percentage of correct scores obtained by children 10–11 and 11–12 years old on Smith's (1975) test of phonemic reception ($Rseg_1$). See Levitt, Chapter 5, for a more detailed description of decile analysis.

question type (see Table 7.2), and thus the interaction between main effects was not statistically significant. When data were examined with respect to decile group and question type, it was noted that children in Deciles 1–5 scored no better than chance level performance (33%) for items involving place-manner, voicing, or vowel contrasts. Scores for place or manner contrasts were only slightly better than chance performance for some decile groups. The poor performance on this test, even for children in the highest deciles, is rather surprising because some of the children in the project had sufficient residual hearing to expect some improvement in scores, especially if their curriculum included some auditory training. In particular, manner of articulation has many important cues in the low-frequency region, and even children with very little low-frequency residual hearing may learn to identify those cues. This is also true of voicing and some vowel contrasts. Cues with respect to place of articulation are more heavily concentrated in the high-frequency region; thus improvement on this feature might be more difficult to obtain.

Children's Nonsense Syllable Test ($Rseg_2$). Because the data from the Smith test provided useful information on only a limited group of children, and because many children scored only at chance level for a number of question types, a different test was developed to measure reception of gross phonemic contrasts by severely to profoundly deaf children (Levitt & Resnick, 1978; McGarr, Stromberg, & Hochberg, 1977). The test was a

TABLE 7.3. Phonemic contrasts for the children's nonsense syllable test ($Rseg_1$).*

Type	*Contrasts*		
Vowel	i	ɑ	u
CV	mi	si	gi
	mɑ	sɑ	gɑ
	mu	su	gu
VC	im	is	ig
	ɑm	ɑs	ɑg
	um	us	ug

*Each stimulus type becomes the test item for a total of 21 tokens.

closed response nonsense syllable format consisting of vowels (V), consonant-vowel (CV), and vowel-consonant (VC) syllables. Test items are shown in Table 7.3. The vowels /i, ɑ, and u/ were chosen to represent the extremes of the vowel triangle; the consonants /m, s, and g/ were chosen to represent gross acoustic contrasts in frequency as well as different places and manner of articulation. In the CV or VC stimuli, the vowels were always held constant while the consonants varied. During the test, each consonant was combined in turn with each vowel. Each token was repeated three times during the test for a total of 63 items (21 tokens × 3 repetitions). The child was required to identify the test word from a set of three alternatives. The stimuli were recorded and presented to each child in the same manner as described above. The test appears in Appendix C.

Table 7.4 summarizes changes in the average scores during the 2 years. A 3-way analysis of variance (question type × year × decile) showed no statistically significant main effects or interactions. Scores for vowels alone were slightly higher than scores for CV or VC syllables, and they also showed the greatest average gain over the 2 years. Data were collapsed across all vowels, and again across all consonants, and analyzed. No effect of consonant or vowel environment was noted across the various possible combinations—again, the scores were in the range of 40%. Although there were average improvements greater than 10% for the vowels /i/ and /ɑ/, and also for the consonant /m/+V combination, the differences were not statistically significant.

Data were analyzed and confusion matrices generated for each year. Since scores were essentially the same for both years, averaged data are shown in Table 7.5. For vowel contrasts, scores for /i/ and /ɑ/ were nearly the same with scores for /u/ being only slightly lower. No significant differences were noted for manner contrasts in either the VC or CV conditions. Scores across each of the contrasts averaged about 44%. Confusion matrices revealed no particular pattern of difficulty.

The decile diagram (Figure 7.2) showed a pattern that was similar to that obtained for Smith's test, although the average scores were higher overall. In general, there was a slight decline in scores for nearly each decile, although the differences in scores between the 2 years were not statistically significant with the exceptions of Decile 1, which

TABLE 7.4. Percentage correct scores for the children's nonsense syllable test (Rseg$_2$).

Feature	Project children's scores (%) Age 12–13	Age 13–14
Vowels alone		
i	40	52
ɑ	53	65
u	55	55
Vowel effects[a]		
C V		
m + V	33	46
s + V	46	49
g + V	34	36
V C		
V + m	43	51
V + s	43	45
V + g	28	30
Consonant effects[b]		
C V		
C + i	40	45
C + ɑ	40	46
C + u	38	39
V C		
i + C	40	43
ɑ + C	35	41
u + C	38	42

[a]Items collapsed across all vowels.
[b]Items collapsed across all consonants.

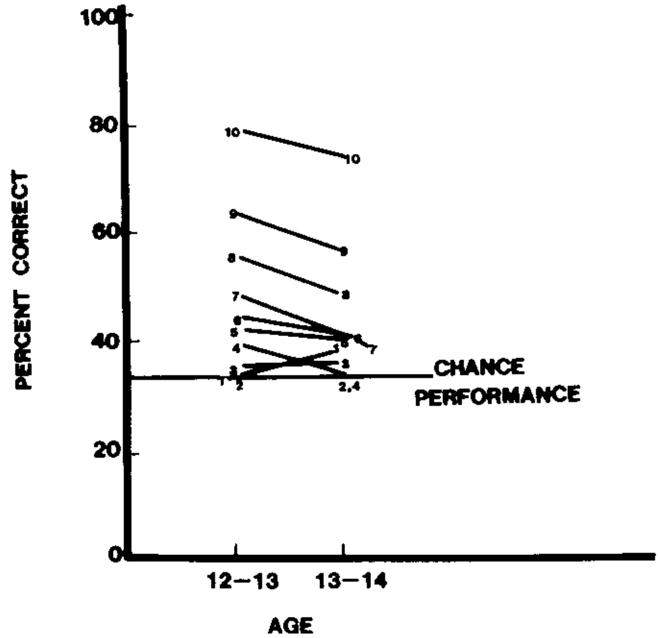

FIGURE 7.2. Decile diagram for percentage of correct scores obtained by children 12–13 and 13–14 years old on the Children's Nonsense Syllable test (Rseg$_2$).

improved with performance, and Decile 7, which showed a decrement ($p < .01$). Although the data suggest that reception of phonemic contrasts was possible for many children, the low overall scores show the magnitude of difficulty that the severely to profoundly deaf have in perceiving even the most extreme contrasts, that is, nasal, stop, and fricative. These data also suggest the importance of gaining a better understanding of how specific auditory cues—voice onset time (VOT), formant transitions, bursts, etc.—are perceived by hearing-impaired children with different types and configuration of hearing losses (cf. Revoile & Pickett, 1982). Because many programs have the maximum use of residual hearing as their educational priority, the type of data obtained from this study highlights the need for better assessment measures and also curriculum to maximize the reception of segmental features.

Segmental Production

Perhaps of all the speech production characteristics of hearing-impaired children, the area that has received the greatest attention is that involving the articulation of phonemes (cf. Osberger & McGarr, 1982). Several studies (e.g. Hudgins & Numbers, 1942; Markides, 1970; Smith 1975) report that error types involving consonants include confusion of the voiced-voiceless distinction, substitution of one consonant for another, added nasality, misarticulation of consonant blends, misarticulation of abutting consonants, and omission of word-initial or word-final consonants. These patterns have been described in other studies (Brannon, 1964; Geffner, 1980; Gold, 1978; Levitt, Smith, & Stromberg, 1974; Markides, 1970; Nober, 1967). Errors for vowel production include substitutions, neutralizations, diphthongizations, and nasalization of vow-

TABLE 7.5. Confusion matrices for the children's nonsense syllable test (Rseg$_1$).

Vowel contrasts	i	ɑ	u	VC contrasts	mi	si	gi	CV contrasts	im	is	ig
i	59	24	17	mi	43	31	25	im	46	26	29
ɑ	18	58	24	si	26	45	29	is	26	44	29
u	27	21	53	gi	27	26	47	ig	32	30	38
					mɑ	sɑ	gɑ		ɑm	ɑs	ɑg
				mɑ	51	24	25	ɑm	38	35	26
				sɑ	27	43	30	ɑs	33	42	25
				gɑ	29	41	29	ɑg	32	27	41
					mu	su	gu		um	us	ug
				mu	40	33	27	um	42	34	25
				su	29	38	33	us	25	43	32
				gu	33	28	39	ug	25	26	40

TABLE 7.6. Rank order of the percentage of correct productions of consonants averaged across 3 years ($Pseg_2$).

Consonants	*Project children*	*Smith study**	*I*	*M*	*F*
w	85	79	82	88	–
b	84	85	90	89	72[b]
f	83	70	92	80	76
l	77	70	81	83	67
v	70	64	76	66	67
p	67	70	66	72	63
n	64	61	71	57	63
j	62	53	62[b]	–	–
ð	56	38	58	68	41
m	55	72	46	47	72
r	51	55	53	50	50
h	51	39	50	53	–
θ	47	38	57	35	49
d	42	40	56	47	24
t	41	37	41	39	42[b]
ʃ	40	22	36	33	51
k	31	40	43[a]	24[a]	26[b]
g	28	36	34	31	18[b]
ŋ	26	30	–	–	26[b]
s	23	24	22[a]	22[a]	24[a]
z	17	21	14	22[a]	15[a]
dʒ	15	18	23	11	11
tʃ	12	16	13	12	10
Means	49	47	53	49	43

[a]Scores increased 10% over 3 years.
[b]Scores decreased 10% over 3 years.
*Data from Smith, 1975.

els (Angelocci, Kopp, & Holbrook, 1964; Hudgins & Numbers, 1942; Smith, 1975).

An articulation test ($Pseg_1$) was administered as part of the test battery to assess production of phonemes in our population. In the first year of the project, the Photo Articulation Test (Pendergast, Dickey, Selmar, & Sodie, 1964) was administered. The test vocabulary proved difficult for many children, and it was not used after the first year. A phoneme production test ($Pseg_2$) similar to standard articulation tests but using vocabulary familiar to deaf children was developed. The test vocabulary was selected from Smith's (1975) corpus produced by a similar population of hearing-impaired children. This test of phonemic production differed from Smith's and also from Gold's (cf. Chapter 8) in that single vocabulary words were used to assess production of vowels as well as consonants in the initial, medial, and final position of test words, whereas the aforementioned studies assessed productions in sentence context. Each child was presented with a printed version of the test word, and the examiner scored the production either as correct or as an error of omission, substitution, distortion, or addition. It should be noted that different examiners administered this test, although the reliability among examiners was high. The test materials are shown in Appendix C. Data were analyzed for each of the 3 years when children spanned an age range of 11–14 years old. Because the percentage correct per item was nearly the same for each year of the study, the data were averaged and then ranked from highest to lowest score. The consonant scores are shown in Table 7.6. Scores for children in this project are remarkably similar to those obtained by Smith (1975), shown in the same table. Higher scores were generally noted for phonemes produced near the front of the mouth, followed by those in the mid and back regions, respectively. Table 7.6 also shows that scores were higher for phonemes in the initial position, followed by those in the medial and final positions. There were very few segmental productions that improved (> 10%) during the 3 years of testing, and scores for a number of phonemes decreased on average. These changes in performance are also noted in Table 7.6.

Figure 7.3 (top) shows data plotted according to place of articulation. Scores were highest for the most visible places of articulation, lowest for the least visible places of articulation. Figure 7.3 (bottom) shows data plotted according to manner of articulation. Scores were highest for glides, about the same for nasals, stops, and fricatives, and considerably poorer for affricates. These data are in agreement with previous research (Hudgins & Numbers, 1942; Smith, 1975).

Table 7.7 shows the average scores obtained for correct

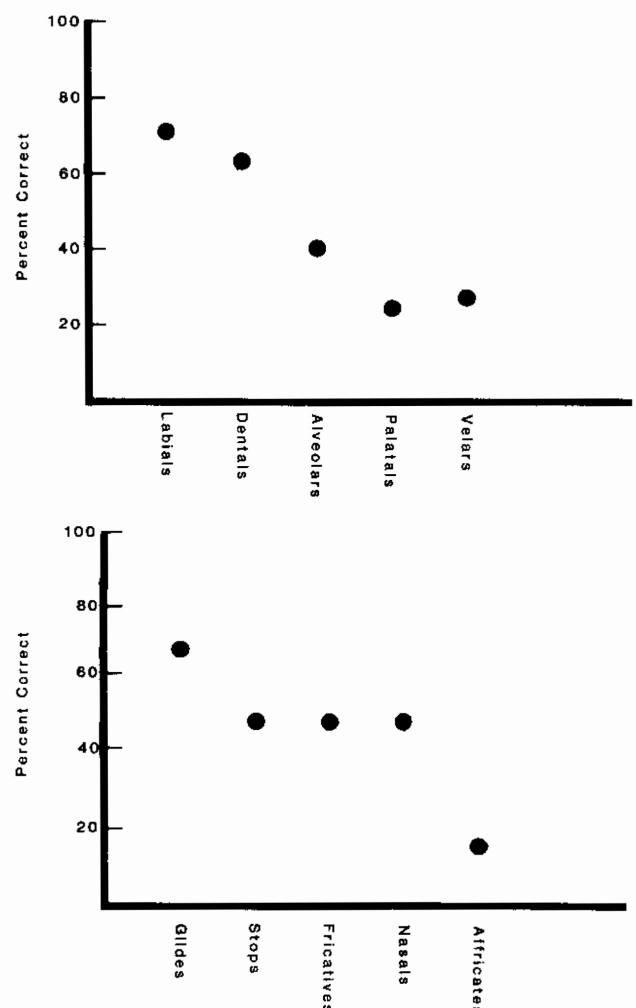

FIGURE 7.3. Percentage of correct productions plotted as a function of place of articulation (top) and manner of articulation (bottom).

TABLE 7.7. Percentages of correct productions of vowels and diphthongs averaged across 3 years of testing ($Pseg_2$).

Vowels	*Project children*	*Smith study**
i	93.4	60.6
ɪ	89.8	69.2
ɛ	78.0	79.0
æ	83.0	74.6
ɑ	88.3	84.2
ɔ	93.2	67.1
ʊ	89.6	73.7
u	91.0	74.7
ɚ	53.8	15.0
ʌ	96.4	92.5
eɪ	86.8	51.7
aɪ	95.0	58.5
oʊ	90.4	64.0
aʊ	95.1	–
ɔɪ	86.3	–
ju	44.2	20.0

*Data from Smith, 1975.

production of vowels and diphthongs. Scores for children in the project are somewhat higher than those obtained by Smith (1975). These scores do, however, differ from previously reported patterns in that scores for front and back vowels and for high and low vowels are similar.

Figure 7.4 shows the decile diagram for the percentage of correct segmental productions on the articulation test.

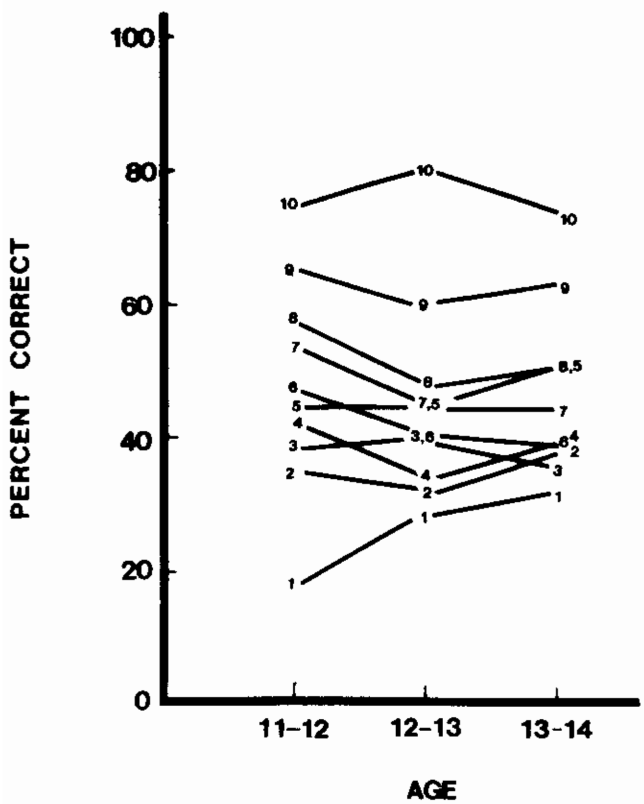

FIGURE 7.4. Decile diagram for percentage of correct scores obtained by children 11–12, 12–13, and 13–14 years old on the test of segmental production ($Pseg_2$).

The analysis of variance showed no significant main effects. Little change in performance was noted for any decile, and minor variations in score may be attributed to differences among examiners. Although there are changes in scores as the children get older, the differences are not statistically significant. Scores for children in the lowest decile increased slightly, although the number of phonemes correctly articulated remained rather low over all years for this group. Figure 7.5 shows the data plotted for errors of omission (left) and errors of substitution (right) for the different deciles. Here it should be noted that the decile groups are inverted in the plots, with the highest decile (10) plotted near the bottom of the figure because this decile shows the lowest error score. Decile 1 (the poorest group) had the greatest number of omission and substitution errors. This decile group is distinguished from all others, however, because both error categories showed a statistically significant decline ($p < .01$) in the percentage of errors. This undoubtedly contributed to the slight improvement in the percentage of correct productions noted in the previous figure. On the other hand, Deciles 9 and 10 (the better groups) showed a statistically significant increase ($p < .01$) in the number of substitution errors, although the relative contribution of this error category in and of itself was not sufficient to affect articulation scores adversely (see previous figure). On the whole, the percentage of errors produced remained about the same in each decile during the 3 years of testing.

SUPRASEGMENTAL FEATURES

Prosodic-Feature Reception

Although it is common to test speech reception by measuring the discrimination of single words, there is

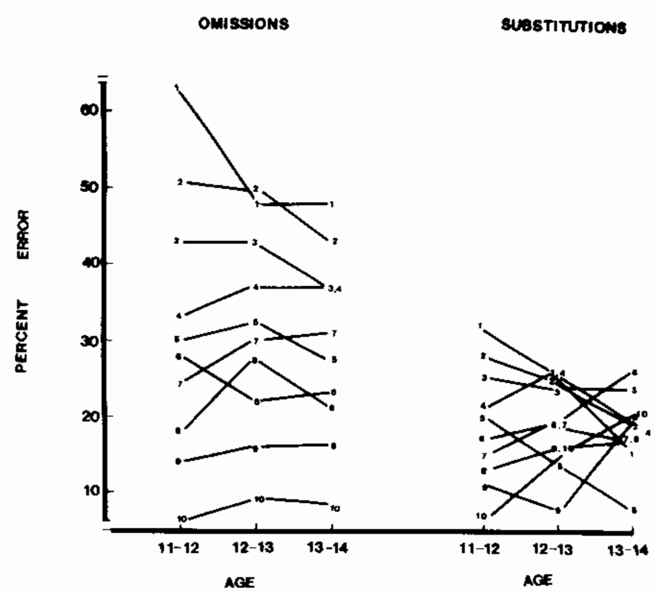

FIGURE 7.5. Decile diagram showing the percentage of omissions (left) and substitutions (right) on the test of segmental production, ($Pseg_2$). Note that since the percentage of errors (as opposed to percentage correct) is shown, and data for Decile 1 appear at the top of the figure, and data for Decile 10, the group evidencing the fewest errors, at the bottom.

TABLE 7.8. Preliminary prosodic-feature reception test ($Rpros_1$).

Number of syllables	Form	Sentence
3	statement	I can run.
	added stress	I can *run*. I *can* run. *I* can run.
	pause	I can . . . . run. I . . . . can run.
	question	I can run?
	added syllable(s)	I can not run. I do not want to run.
	statement	Joe buys meat.
	added stress	*Joe* buys meat. Joe buys *meat*.
	pause	Joe . . . . buys meat. Joe buys . . . . meat.
	question	Joe buys meat?
	added syllable(s)	Joe buys some meat.
		Joe buys a lot of meat.
5	statement	It was cold Friday.
	added stress	It was cold *Friday*. It was *cold* Friday.
	pause	It was cold . . . . Friday.
	question	It was cold Friday?
	added syllable(s)	It was not cold Friday.
		It was cold and windy Friday.
	statement	Nancy eats apples.
	added stress	*Nancy* eats apples. Nancy eats *apples*.
	pause	Nancy . . . . eats apples.
	question	Nancy eats apples?
	added syllable(s)	Nancy eats red apples.
		Nancy and Jane eat red apples.
7	statement	Harry and I saw two bears.
	added stress	Harry and I saw *two* bears.
		Harry and I saw two *bears*.
	pause	Harry and I . . . . saw two bears.
	question	Harry and I saw two bears?
	added syllable(s)	Harry and I did not see two bears.
		Harry and I saw a dog and two fat bears.
	statement	Tom went to fish and you slept.
	added stress	*Tom* went to fish and you slept.
		Tom went to fish and *you* slept.
	pause	Tom went to fish . . . . and you slept.
	question	Tom went to fish and you slept?
	added syllable(s)	Tom went to catch fish and you slept.
		Tom went to catch fresh fish and you slept.

also much information conveyed by suprasegmental or prosodic characteristics of speech. These features are not assessed by conventional speech discrimination testing, although knowledge of the reception of prosodic features by hearing-impaired children is important. For this reason, a test of prosodic-feature reception as well as a corresponding test for prosodic-feature production (to be described further below) was developed. The prosodic-feature reception test measured three suprasegmental features of English: stress, intonation, and pausal juncture (Bronstein, 1960). Because we were testing a severely hearing-impaired population, only gross contrasts were used in the construction of the test.

Preliminary test ($Rpros_1$). Two versions of the prosodic-feature reception test were used. A preliminary version was tried during the first year of the study (Stark & Levitt, 1974). The test was then refined and used for the remainder of the project (McGarr, 1976). In both versions of the test, the prosodic contrasts were conveyed by means of simple sentences. The sentences used in the preliminary test are listed in Table 7.8. Six basic sentences were used: two 3-syllable, two 5-syllable, and two 7-syllable. Each of the sentences appeared in several different contrasting prosodic forms including statement, question, change in stress pattern, addition of pausal juncture, and a variation of the sentence in which one or more syllables were added. The latter, strictly speaking, does not represent a change in prosodic form, but rather a change in syllable number, which, in itself, is believed to be an important factor in speech reception by deaf children.

A test tape was prepared using the same male speaker as for the phoneme reception tests. The tape consisted of 56 sentence pairs in a randomly selected order. Each member of the pair was formed from the same basic sentence. The sentence pair might have the same prosodic form (e.g. two statements, two sentences containing a pause, or two questions). Alternatively, the pair

TABLE 7.9. Prosodic-feature reception—Preliminary test ($Rpros_1$) year 1. Each entry is percentage correct averaged over all children.

Prosodic contrast	Number of syllables 3	5	7
3 additional syllables	64.5	57.7	57.2
Addition of pause	62.7	57.2	62.7
1 additional syllable	49.5	49.5	42.8
Change in stress pattern	47.3	46.9	51.8
Question vs. statement	33.3	39.7	34.7
Means	51.4	50.2	49.8

might consist of contrasting forms (e.g. a statement contrasted with a question, a statement contrasted with a sentence containing a pause, or a statement contrasted with a sentence with one or more additional syllables). When word stress was present, however, it was always present in both sentences (e.g, on the same word, "*I* can run" and "*I* can run") or on different words in the two sentences (e.g., "I can *run*" and "I *can* run"). During the test, a sentence pair was presented and the child was required to make a "same or different" judgment. Before testing began, it was established that the child understood the "same/different" concept and could use these words correctly in the discrimination of simple test materials. The child was given eight practice trials with nontest sentence pairs before the formal test began.

The data are summarized in Table 7.9. The prosodic forms are listed in descending order of average correct scores, with scores for random guessing equal to 50%. The children were best able to detect a relatively large change in syllable number, such as the addition of 3 syllables to one of the basic sentence lengths of 3, 5, or 7 syllables. The children were able to detect a change in pausal junction. The children did significantly worse in detecting the addition of only one syllable to the basic sentence and in detecting a change in stress pattern. The poorest performance of all was obtained in detecting the intonational change between a statement and a question. The mean scores at the bottom of the table show a small, but systematic, reduction in performance with increase in sentence length.

One problem with this test is that the children showed a marked bias toward responding "same" on those sentence pairs in which they were unsure of any perceptual difference, and scores were often close to random guessing. Further, because the test was not balanced across contrasts, it was difficult to estimate precisely the magnitude of the bias effect. A second problem with this test format was that no information could be derived from incorrect responses. For these reasons, it was decided to modify the test.

Revised prosodic-feature reception test ($Rpros_2$). This test was based on the same philosophy as the preliminary test except that the "same/different" response format was replaced with one in which the child identified the prosodic form directly. Specifically, the child was required to listen, and to circle one out of four possible choices corresponding to the sentence heard. The test items are shown in the Appendix C. This test format eliminated the response bias problem but, in turn, required that the child should know and understand the prosodic forms being tested. At first, practice items were reviewed verbally by the examiner to familiarize the child with the task. When the child appeared to understand the concepts and test procedure, the items were presented to the child using the listening procedures described in the section on segmental reception.

There were some changes in the prosodic forms assessed in the revised test. Change in syllable number, which is not a true prosodic feature, was omitted from the revised form. The question items were limited to short 2-syllable sentences. The number of stress and pause examples was expanded to include differences in the location of the pause or the emphatic stress (early or late in the sentence). The prosodic forms used in the test are listed in Table 7.10. Nine basic sentences were used, each of which appeared in four different forms. The test thus consisted of 36 test items plus several practice items that were not scored. The nine basic sentences were evenly divided into sentences of 2 syllables, 3 syllables, and 5 syllables in length. The prosodic forms for the 2-syllable sentences were: primary stress early in the sentence, primary stress late in the sentence, pause, and question. The prosodic forms for the 3- and 5-syllable sentences were: primary stress early in the sentence, primary stress late in the sentence, pause early in the sentence, and pause late in the sentence. It is obvious that there is only one possible location for pause in a 2-syllable sentence.

The data are summarized in Table 7.11 for the 3 years (children spanning the age range from 11–14 years) in which the test was given. Pause was generally found to be the form most easily identified by the children. There was a significant interaction between location of pause and number of syllables. For the 3-syllable sentences, the early pause was identified with the highest accuracy, but in the 5-syllable sentences, the highest average score was obtained on the late pause. Generally, the children were able to identify early stress more accurately than late stress, the margin of difference decreasing systematically with increasing sentence length. These results may be accounted for in part by the narrow dynamic range of hearing in the children tested. Those syllables that fell below auditory threshold, particularly those produced near the end of the sentence, would not be perceived. Therefore, one might argue that early sentence stress would be perceived more accurately than late sentence stress. Average scores for the question form were relatively low, although the lowest scores of all were obtained on late stress in 2-syllable sentences. The children frequently identified those as questions, which is not surprising because the rise in intonation and elongation of the final syllable of the question form is similar to the rise in pitch and elongation of the final stressed syllable in the 2-syllable utterance.

The children showed substantial improvements in average score as evidenced from the decile plots of Figure 7.6. Analyses of variance revealed that most of the chil-

TABLE 7.10. Revised prosodic-reception test ($Rpros_2$).

Sequence	Number	Set number		Number of syllables	Feature
5	1	1	*Oh* boy.	2	Early stress
16	2	1	Oh *boy*.	2	Late stress
32	3	1	Oh .... boy.	2	Pause
35	4	1	Oh boy?	2	Question
33	5	2	*Thank* you.	2	Early stress
36	6	2	Thank *you*.	2	Late stress
24	7	2	Thank .... you	2	Pause
18	8	2	Thank you?	2	Question
1	9	3	*Come* here.	2	Early stress
11	10	3	Come *here*.	2	Late stress
30	11	3	Come .... here.	2	Pause
4	12	3	Come here?	2	Question
22	13	4	*I* can run.	3	Early stress
6	14	4	I can *run*.	3	Late stress
14	15	4	I .... can run.	3	Early pause
9	16	4	I can .... run.	3	Late pause
15	17	5	*John* drinks milk.	3	Early stress
28	18	5	John drinks *milk*.	3	Late stress
31	19	5	John .... drinks milk.	3	Early pause
29	20	5	John drinks .... milk.	3	Late pause
20	21	6	*Bob* eats cake.	3	Early stress
17	22	6	Bob eats *cake*.	3	Late stress
10	23	6	Bob .... eats cake.	3	Early pause
7	24	6	Bob eats .... cake.	3	Late pause
25	25	7	My *new* hat is blue.	5	Early stress
27	26	7	My new hat is *blue*.	5	Late stress
19	27	7	My .... new hat is blue.	5	Early pause
13	28	7	My new hat .... is blue.	5	Late pause
3	29	8	I *want* to see it.	5	Early stress
26	30	8	I want to *see* it.	5	Late stress
23	31	8	I .... want to see it.	5	Early pause
2	32	8	I want .... to see it.	5	Late pause
12	33	9	He *has* one big dog.	5	Early stress
8	34	9	He has one *big* dog.	5	Late stress
21	35	9	He has .... one big dog.	5	Early pause
34	36	9	He has one .... big dog.	5	Late pause

Summary

2-syllable sentences		*3-syllable sentences*		*5-syllable sentences*	
3 questions		6 stress	(3 early) (3 late)	6 stress	(3 early) (3 late)
6 stress	(3 early) (3 late)	6 pause	(3 early) (3 late)	6 pause	(3 early) (3 late)
3 pause					

dren (with the exception of Decile 3) showed statistically significant improvements ($p < .01$) in scores. Unlike in the other tests, children aged 11–12 years whose scores were at the chance level of performance (25% correct in this test) also showed significant improvement.

Prosodic-Feature Production (Ppros)

The test on prosodic-feature production was analogous to that on prosodic-feature reception, but it was only administered beginning in the second year of the project. In this case, the children were required to produce the prosodic features of stress, pausal juncture, and intonation. The test items are also listed in Table 7.10. Because of time constraints, the children were limited to six basic sentences, rather than the full set of nine sentences used in the prosodic-feature reception test. Specifically, sentence numbers 1, 2, 4, 5, 7, and 9 were used. These sentences were ones that could be read meaningfully with the characteristics of stress, pause, and rising intonation, thereby constituting 18 different utterances in all. Each of the utterances was printed on a separate card. The feature of pause was indicated by three dots. Stress was indicated by capital letters and underlining. Rising intonation was indicated by a question mark. Features were always tested together as a group of six basic sentences, but the order of the features tested, as well as

TABLE 7.11. Prosodic-feature reception—Revised test ($Rpros_2$).

Number of syllables	Prosodic form	Average score (%) Age 11–12	Age 12–13	Age 13–14
2	Early stress	59.8	70.2	68.9
2	Late stress	22.6	42.8	44.6
2	Pause	61.0	74.3	80.9
2	Question	41.5	46.6	43.7
	Means	46.2	58.5	59.5
3	Early stress	55.7	76.7	74.4
3	Late stress	42.6	46.6	47.9
3	Early pause	71.7	77.0	68.9
3	Late pause	51.8	61.7	77.9
	Means	55.4	65.5	67.3
5	Early stress	47.9	65.5	73.4
5	Late stress	46.1	63.1	61.1
5	Early pause	35.9	49.3	55.1
5	Late pause	48.7	65.5	81.0
	Means	43.6	59.5	67.7

the order of the sentences within each feature group, was rotated. Thus, there were six different randomizations of the test.

The six basic sentences were printed as statements on separate cards. Each child was asked to read the cards out loud before testing began in order to familiarize him or her with the test vocabulary. Then, according to the scrambling, practice items were selected. When the examiner believed that the child understood the concept, he or she was asked to read the test sentences, and the utterances were recorded. Those productions were then rated by two or more independent raters experienced

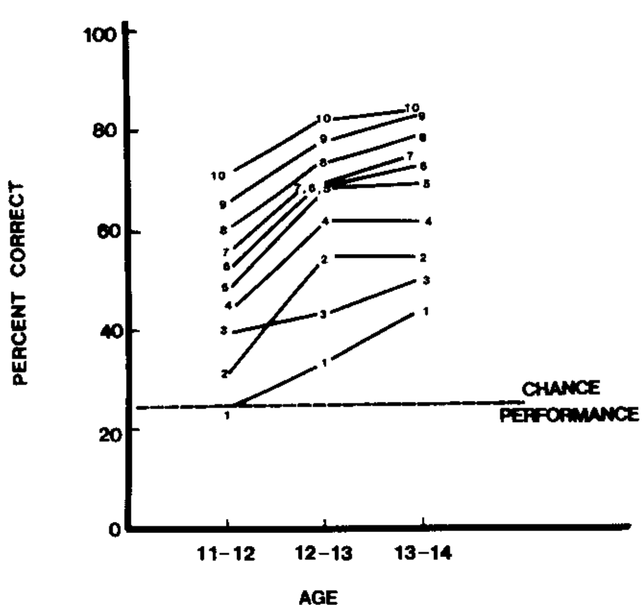

FIGURE 7.6. Decile diagram for percentage of correct scores obtained by children 11–12, 12–13, and 13–14 years old on the test of prosodic-feature reception ($Rpros_2$).

TABLE 7.12. Mean scores for project children on prosodic-feature production test (Ppros).

Prosodic feature	Average score (%) Age 11–12	Age 12–13	Age 13–14
Early stress	53.1	62.9	69.1
Late stress	60.8	67.3	74.6
Early pause	76.6	82.6	84.1
Late pause	85.5	72.4	92.2
Question	4.0	3.7	6.3
Other productions			
Statement	5.5	8.0	9.1
Staccato	27.3	19.3	15.2
Unintelligible	4.1	6.8	3.6

with deaf speech production. The raters were given a printed version of the test item the child had produced and asked to indicate whether the child had produced the intended prosodic feature or, if not, what feature was substituted. The choices of substitutions included: a pause that occurred early in the sentence, a pause that occurred later in the sentence, stress that occurred early in the sentence, stress that occurred later in the sentence, or a statement for a question. In addition, the rater could indicate if the speech was unintelligible, or if a staccato form—equal stress and equal pause on each syllable—was used. The data are summarized in Table 7.12. Because of technical difficulties, the recordings made in the first year of the project were not good enough to warrant detailed analysis.

The children were most successful at producing the pause feature, and average scores of over 70% were obtained for that feature. The children did less well on the production of stress, with average scores ranging from 53.1 to 67.3%. The children also appeared to be slightly better for late than early stress. The average scores for the question form were extremely poor, and only a small proportion of the children were able to control intonation sufficiently well for the question form to be recognized by the raters. The most common error on the question form was that of producing a statement instead. About 1 in 3 attempts at a question were identified as a statement. Stacato errors decreased over the 3 years of testing from 27% to 15%. They occurred with about equal frequency on all of the attempted prosodic forms, and thus the overall rate for staccato errors was higher than for any other type of error. The frequency of unintelligible productions was relatively low, but it should be remembered that the test materials were limited to six basic sentences and that the raters knew those sentences well.

The children showed fairly good overall improvement in scores with increased age. It was also observed that staccato errors decreased steadily on all prosodic forms except late stress, on which an increase was observed (roughly 17% of the errors on this test item). It may be that those children who are still learning to produce this prosodic form are more prone to staccato errors than others are.

The decile plots for this test are shown in Figure 7.7. In

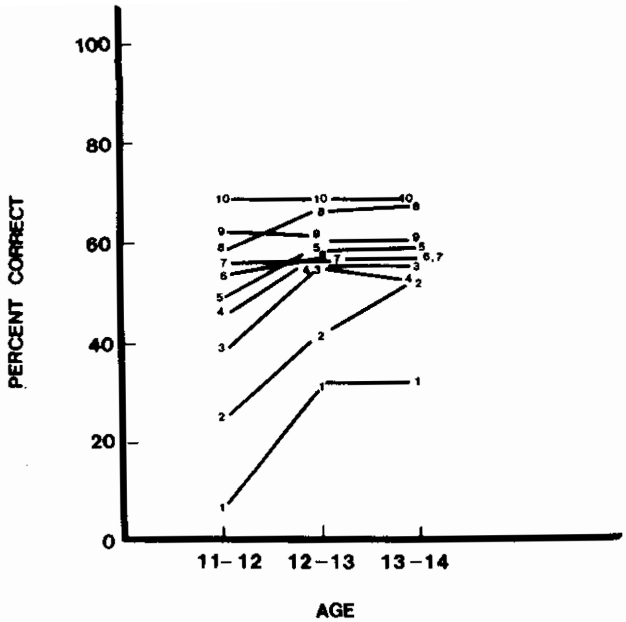

FIGURE 7.7. Decile diagram for percentage of correct scores obtained by children 11–12, 12–13, and 13–14 years old on the test of prosodic-feature production (Ppros).

general, there were large gains in scores from the first test (ages 11–12) to the second (ages 12–13) years. The figure also shows that children in the lowest deciles (1–3) showed statistically significant amounts of improvement ($p < .001$). Scores for children in Decile 10 remained about the same over all years, although these were relatively high at the start. The lack of improvement is attributed to the children's difficulty in producing changes in intonation (e.g., questions).

SPEECH INTELLIGIBILITY

Overall ratings of speech intelligibility (Isp) paralleled the procedure used for rating written language. Each child was required to describe two or more short picture sequences. Recordings made of the child's speech were subsequently evaluated by several raters. A 5-category rating scale was used (Johnson, 1975). The rating scale is shown in Table 7.13 together with the percentage of children falling within each category boundary for each year of the study. Several raters were used because the rating for overall speech intelligibility, unlike the ratings of written language, showed a fair degree of variability. The raters were usually within one scale category of each other, and interrater differences were fairly constant.

The data are also summarized in Table 7.13. The left side of the table shows the five categories used by the raters, and the right side shows the percentage of children whose average rating fell within the category range shown. For example, the second row shows the percentage of children having an average rating of betwen 1.00 and 1.99, the third row shows the percentage of children with an average rating between 2.00 and 2.99, and so on. The first and sixth rows are slightly different in that they represent the ends of the range and show the percentage of children with the lowest possible (1.0) and highest possible (5.0) average ratings respectively.

A striking feature of the data is the relatively large proportion of the children with low ratings. Nearly two thirds of children received a rating of unintelligible or barely intelligible speech. This pattern remained essentially the same across the 4 years of testing. The lack of improvement in speech intelligibility according to deciles is illustrated in Figure 7.8. In this analysis, the data are plotted for the one listener who rated each of the children in the 4 years of the project. It should be first noted that the data for each decile grouping remained nearly the same during the 4 years. Indeed, a large number of children (Deciles 1–8) received averaged ratings of 3.0 or poorer, indicating that the children's speech was difficult or nearly impossible to understand by a listener who was familiar with the deaf population. Only children in Deciles 2 and 3 showed a statistically significant change in scores over the 4 years. However their ratings remained below 2, indicating that only occasional isolated words or phrases were intelligible. Correlations between speech intelligibility and residual hearing have been remarked on by previous researchers (Boothroyd, 1969; Smith, 1975) and are further examined in Chapter 9.

SPEECHREADING

Myklebust and Neyhus Test (SR_1). During the first 2 years of the project, the Myklebust and Neyhus Diagnostic Test of Speechreading (1970) was administered. This test assesses lipreading of words, phrases, and sentences. The stimuli are presented in a film in which the speaker repeats each test item twice without auditory cues. The child is required to point to one of four pictures, which are not related to each other in any systematic way. Thus no information is gained from the particular type of error a child might make. The mean scores for the subjects were relatively high, and scores exceeded 80% for many subjects during the second year.

Figure 7.9 shows the decile plot for the 2 years the test was administered. No decile group scored at or below random guessing (25%), and, in the second year, significant progress was noted. Many of the scores were at or close to the ceiling, and because the children were beyond the age norms of the test, it was necessary to develop a more advanced test. Because no test was available for this specific age population, an experimental test was developed.

LCS Speechreading Test (SR_2). The test was designed to assess the child's comprehension of language and not just discrimination of facial movements corresponding to words or sentences. Further, we wished to develop a test that would yield a hierarchy of errors by varying the syntactic structures. The 4-picture format of the Myklebust and Neyhus test was kept; however, each picture (foil) in the new test was closely related to the test

TABLE 7.13. Ratings of overall intelligibility (Isp).

Rating	Category	Category range	Breakdown of average rating % in each range Age 10–11	Age 11–12	Age 12–11	Age 13–14
1	Speech cannot be understood	1	31.1	31.4	23.4	22.0
		1.00–1.99	27.4	23.8	31.8	24.0
2	Speech very difficult to understand (only isolated words or phrases intelligible)	2.00–2.99	17.9	17.1	21.5	19.0
3	Speech difficult to understand, but the gist can be understood	3.00–3.99	9.4	11.4	11.2	12.0
4	Speech intelligible except for a few words or phrases	4.00–4.99	8.5	10.5	9.3	17.0
5	Speech completely intelligible	5	5.7	10.5	2.8	6.0

item so that when a mistake was made information could be obtained on errors. Vocabulary for the test items was chosen to be within the norms established for deaf children (Silverman-Dresner & Guilfoyle, 1972). An attempt was also made to control the sentences for differences in production visibility, although this was not always possible because of constraints of vocabulary, syntactic structure, and stimuli that could be pictured. The test was named the LCS Speechreading Test, an acronym for the project title (Language and Communication Skills). The test is found in Appendix C.

The LCS test consists of four sections with two picture sets in each section. Symmetry is maintained in that each picture in each set becomes the test item. Thus, there are a total of 32 test items (4 sections × 2 picture sets × 4 pictures per set) with 6 practice items preceeding the test. The four sections of the test evaluate the following constructions (cf. Table 7.14):

1. Subject or object reversals when the verb remains the same
2. Subject or object changes when the verb changes
3. Changes in qualifying phrase
4. Subject or object and prepositional changes

A female speaker who said each sentence once was filmed. No auditory cues were available to the child. The interstimulus interval was long enough to allow the tester

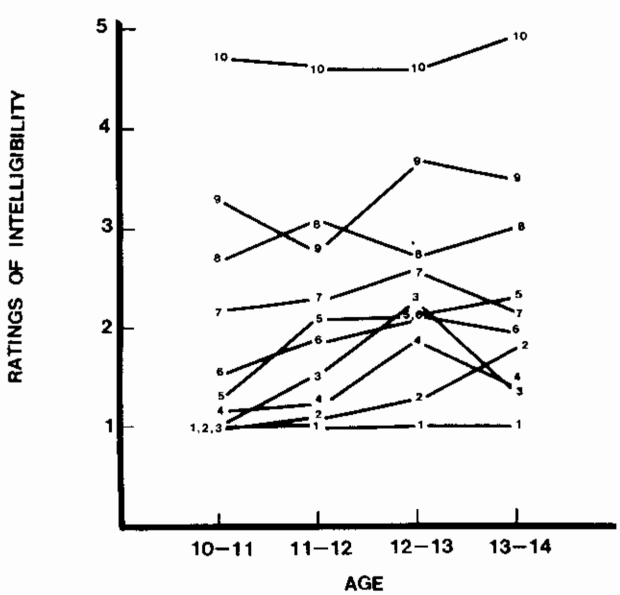

FIGURE 7.8. Decile diagram for ratings of speech intelligibility (Isp) for children 10–11, 11–12, 12–13, and 13–14 years old. A rating of 1 indicates "speech cannot be understood," a rating of 5 indicates "speech is completely intelligible" (Johnson, 1975).

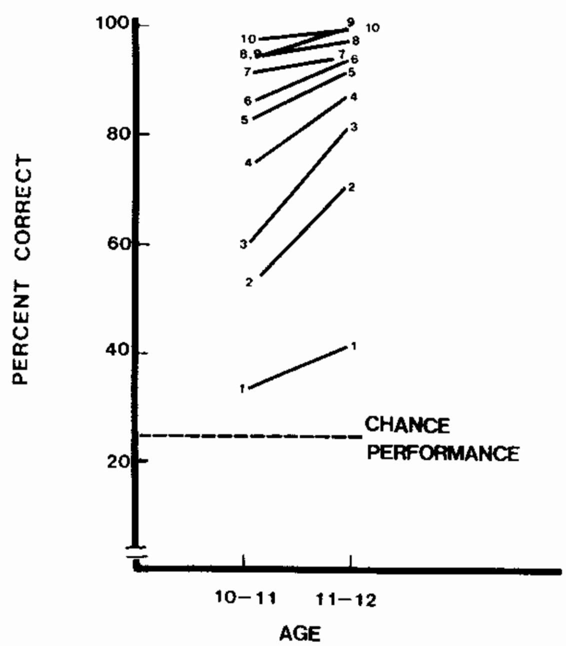

FIGURE 7.9. Decile diagram for percentage of correct scores obtained by children 10–11 and 11–12 years old on the Myklebust and Neyhus Diagnostic Test of Speechreading (SR_1).

TABLE 7.14. The four sections and test items for the LCS speechreading test (SR_2).

Type	*Set 1*	*Set 2*
1. Subject or object reversals—verb remains the same	The boy chases the dog. The dog chases the boy. The cat chases the boy. The boy chases the cat.	The mother feeds the baby. The baby feeds the mother. The father feeds the baby. The baby feeds the father.
2. Subject or object changes—verb changes	The baby drinks the milk. The baby spills the milk. The man drinks the milk. The man spills the milk.	The boy eats the cake. The boy eats the apple. The boy drops the cake. The boy drops the apple.
3. Changes in qualifying phrase	The cat with the ball runs after the mouse. The cat runs after the mouse. The man with the ball eats ice cream. The man eats ice cream.	The lady wearing a hat talks to the man. The lady talks to the man. The girl wearing a hat jumps rope. The girl jumps rope.
4. Subject, object, and preposition changes	The book is on the table. The book is under the table. The book is on the chair. The book is under the chair.	The hats are in the box. The hats are next to the box. The shoes are in the box. The shoes are next to the box.

to stop the projector while the child viewed the pictures, chose one, and had his or her response recorded.

Table 7.15 shows the mean scores obtained for each of the four sections. Scores generally increased over the 3 years of test administration. The highest scores were obtained for items testing subject-object reversals when the verb remained the same, followed by subject or object and verb changes, changes in qualifying phrases, and subject or object and prepositional phrase changes. Scores for the latter two sections did not improve.

As noted above, during the test, each of the sentences in turn becomes the test item. Each of the foils is also closely related to the test item so that patterns of errors can be determined when mistakes are made. For items in the section related to subject-object reversals, the most common error type was confusion between the two most closely related sentences. For example, if the target sentence was "the boy chases the dog," nearly one quarter of the errors were made to the sentence "the dog chases the boy." Introduction of a new concept, for example, "the cat chases the dog," resulted in some errors, although not as many as noted for subject-object confusions. Similar patterns of difficulty were noted for the section containing items where the subject or object and the verb changed (e.g., "The boy eats/drops the cake/apple"). The greatest number of errors was made between verbs, whereas errors involving changes in the subject or object were relatively less frequent. Errors for items involving qualifying phrases were most often confusions between the sentences with or without the phrase (e.g., "The lady wearing a hat talks to the man" versus "The lady talks to the man"). However, approximately 10% of the children chose the different sentence with the same qualifying phrase ("The girl wearing the hat jumps rope"), and approximately 10% chose the totally different sentence ("The girl jumps rope"). The fourth section, which involved prepositional phrase changes, was most difficult for all subjects. The highest proportion of confusions was to items that differed from the test sentence by only one factor (e.g. "The book is on the table" versus "The book is under the table"). Sentences with the prepositions "on" and "under" were judged correctly more often than sentences with the prepositions "in" or "next to."

Figure 7.10 shows the decile plot for the LCS Speechreading Test during the 3 years it was administered. Scores were greater than chance level for all deciles. An analysis of variance reveals that even children in the lowest deciles showed significant improvements ($p < .001$). As might be expected, the speechreading measures showed a high correlation with other language measures discussed in detail in Chapter 9.

TABLE 7.15. Scores for LCS speechreading test (SR_2).

Subtests	*Average score (%)* Age 11–12	Age 12–13	Age 13–14
Subject-object reversals	67	73	75
Subject or object plus verb changes	61	65	67
Changes in qualifying phrase	58	64	58
Subject, object, and preposition changes	47	49	49
Means	60	67	64

DISCUSSION

The primary purpose of this study was to obtain comprehensive data on the development of communication skills in a large and fairly heterogeneous group of deaf children attending many different schools for the deaf throughout New York State. We are interested in whether speech-production and speech-reception skills would improve over a 4-year period. The project did not attempt to provide any direct intervention programs in speech or auditory training, although profiles of each child's per-

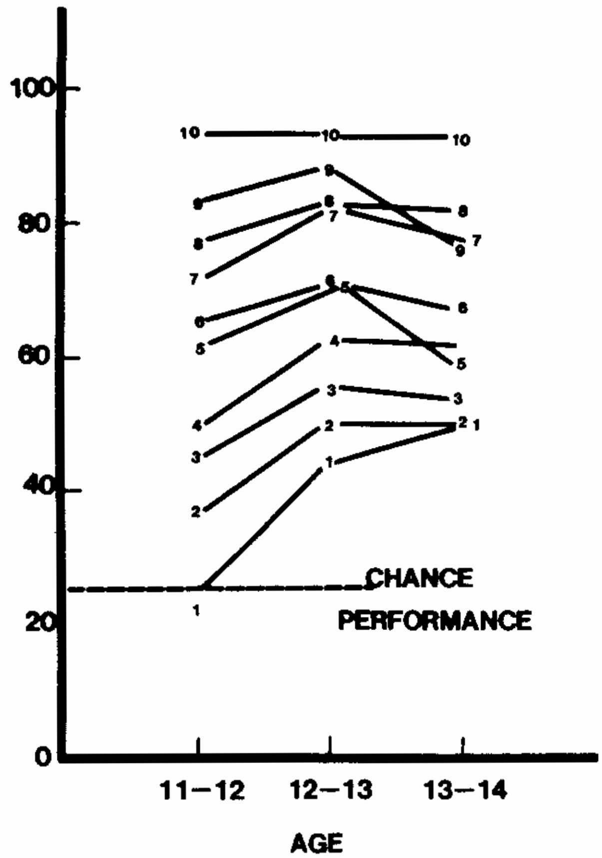

FIGURE 7.10. Decile diagram for percentage of correct scores obtained by children 11–12, 12–13, and 13–14 years old on the LCS Speechreading Test (SR_2).

formance were provided to each school at the end of each testing year. To summarize briefly, the results of our study showed little improvement in measures of segmental reception and production, some improvement in scores in both the reception and production tests of prosodic features, but essentially no improvement in intelligibility ratings over the 4 years. Most of the children (7 of 10 decile groups) had speech intelligibility that was classified by an experienced listener as very difficult to understand. In contrast to the data for speech-reception and speech-production tests, all subjects had scores better than chance level for measures of speechreading, and nearly all deciles showed significant improvements. These data concerning communication skills contrast particularly with the substantial progress that the children made in language areas (cf. Chapter 5 and 6).

The data also provide a unique benchmark, albeit a rather discouraging one, of the relative success that severely to profoundly hearing-impaired children have in acquiring basic communication skills. The results also imply the need for development of better assessment measures and better training programs. We address these issues in a more detailed discussion of our research findings. For convenience, we discuss speech production first, followed by speech reception.

Two measures of speech production were obtained, one on the articulation of speech sounds, the other on the production of prosodic features. In addition, ratings of the child's overall speech intelligibility were also obtained. As noted previously, suitable tests were not available to assess prosodic characteristics, and there were difficulties with tests to assess segmental production in the project age group. Therefore, special tests were developed. The two new speech-production tests showed a similar range of scores among the children. Some children were in the poor category, but few were in the excellent category. There was some evidence of an overall improvement in the production of prosodic features over the 3 years the test was administered, although the scores for the articulation test showed a decrease in performance for some decile groups. Examination of the error patterns for consonant production revealed that the percentage of omission of target phonemes remained stable over 3 years for nearly all but the worst group. Changes were noted in the percentages of substitution errors although these changes were not for the better for some of the children with higher articulatory scores. Several of the higher decile groups actually showed an increase in their percentage of substitution errors, but remained the same in the number of omission errors and decreased slightly in overall percentage of correct phonemes. Only a small percentage of children decreased in the number of omission or substitution errors. A matter of serious concern was the very small average improvement in overall intelligibility shown over the 4 project years. Few children obtained ratings of highly intelligible speech; the vast majority of the children had speech that was either totally unintelligible or included only a few words or phrases that could be understood by a listener highly experienced with the deaf. Correlations among the speech-production measures are discussed in Chapter 9. On the whole, the rate of improvement for the vast majority of children on speech-production measures was negligible at the time of the project's conclusion.

The pattern of errors made in the tests of segmental and suprasegmental production provides some direction as to the practical steps that might be taken to improve intelligibilty. Although the development of intelligible speech by a deaf child may require years of sustained effort, there is little doubt that improvements can be obtained by intensive speech training (Osberger, Johnstone, Swarts, & Levitt, 1978). For example, the articulatory test showed that errors occurred less often with consonant sounds produced near the front of the mouth and that omission of consonants was the most common error, with substitutions being the next most common. Vowels were produced correctly more often than consonants. The prosodic-feature production test indicated that the most difficult form (of the three forms tested) was that of intonation for simple questions. The prosodic feature produced with the lowest frequency of error was that of pausal juncture. An extremely common error was production of a staccato stress pattern in which all the syllables were stressed with intervening pauses. However, there was a reduction of the frequency of staccato production over the years.

From these data, several suggestions may be made regarding speech training. The staccato error, which has a markedly deleterious effect on intelligibility, was not only prevalent but also appeared susceptible to training especially because improvement in scores was observed over the 4 years of the project. Question intonation, because of its difficulty and also because monotonous speech can be intelligible, could be left until a later stage of training. Closely allied to the problem of staccato stress is that of timing. It is well known that deaf children prolong their vowels and other continuous sounds, and because this effect is particularly damaging to the quality and intelligibility of speech (Osberger & Levitt, 1979), remedial work on timing errors should be encouraged.

With respect to misarticulations, errors of omission reduce intelligibility significantly, and some errors of substitution have a more deleterious effect than others because of their frequency in the language. Given these observations, and the data previously summarized on the most common errors of articulation, the elements of strategy for articulatory training emerge. Unlike the consonants, vowels were not prone to as many errors, although the listeners may have been more tolerant in their evaluations of those productions. Because vowels convey a great deal of information about consonants by means of the formant transitions, as well as provide information on prosodic characteristics, articulatory training might begin with vowels. Vowel differentiation, that is, front-back and high-low contrasts, should be particularly stressed. The vowel features of high or low positions are augmented by the salient visual cues provided by jaw opening and closing, although these should not be used at the expense of tongue movement. Once the child is capable of producing some, but not necessarily all, of the vowels, work could begin on consonants, starting with those produced at the front of the mouth and paying particular attention to the distinction in manner of articulation (oral-nasal, stop-continuant, fricative-nonfricative). Other contrasts for different places of articulation (middle and back productions) should also be drilled. It is important not to work on individual sounds in isolation, but rather to work on phonemes in context to avoid creating a staccato effect. The strategy suggested is similar to that proposed by Ling (1976) and modified by Osberger et al. (1978). An important aspect of this procedure is to encourage the child acquiring articulatory skills to use those skills, no matter how rudimentary, to communicate with others.

Two measures of speech reception were included in the profile—a test of phoneme reception and a test of prosodic-feature reception. These tests were analogous to the articulation tests and the prosodic-feature production test. The phoneme reception test developed by Smith (1975) was found to be relatively difficult, and the majority of the children did poorly on it. Many of the children scored no better than chance level on many of the contrasts. There was no significant difference in scores during the successive years of the project. Because of the relative difficulty of the test, a second phoneme reception test was developed. However, even this test, which required discrimination of gross phonemic cues, proved very difficult for the children. The correlation between pure-tone average and phoneme reception scores is discussed more fully in Chapter 9. However, these data generally showed that as the pure-tone average increased, the phoneme reception scores decreased. Unfortunately, some children with relatively good hearing (PTA = 85 dB) scored at or below chance level. Those children had no other handicapping conditions, their parents were hearing, and English was the primary language in the home. They clearly were not making maximum use of their residual hearing. Vigorous hearing aid usage coupled with auditory training programs might assist such children in reaching their auditory potential. On the other hand, there were also children with relatively poor hearing (PTA-100 dB+) whose phoneme reception scores fell in a relatively high range. In general, these children showed some residual hearing (110–120 dB) in the frequency range of 2 kHz-4 kHz and seemed to be making particularly good use of their residual hearing. Interestingly enough, they were, in each case, successful hearing aid users. For either the Smith (1975) or the Children's Nonsense Syllable Test, the scores were very poor. Although children in this study had severe and profound losses, many of them should be capable of discriminating very gross contrasts in time and intensity. These data point out the importance of developing more effective auditory training curricula to help each child realize his or her maximum auditory potential. Furthermore, as described in the section on phonemic reception, additional parallel research is needed to assess the deaf child's capability of perceiving the fine auditory cues that are important for successful discrimination.

The prosodic-feature reception test was found to be much easier than the phoneme reception test for the children. There was also evidence of a consistent improvement in scores for almost all the children, the largest improvements being for children in the upper deciles. Nearly all of the children had scores significantly higher than chance level. Although the scores were higher on the prosodic-feature reception test than on the prosodic-feature production test, the pattern of errors was similar for the two tests. Intonation for simple questions was the most difficult. Scores for perception and production of pause and stress were similar and were substantially higher than scores for question intonation. Although the average scores for both tests were ranked in roughly the same order, individual children did not necessarily show the same ranking. In many cases, children with relatively high scores on the prosodic-feature reception test did poorly on the production test. These results again suggest that major improvements could be obtained by using appropriate speech training methods. It is also surprising that certain children have difficulty in detecting pause or locating stress because these features can be taught to even profoundly deaf children with suitable amplification or the use of visual or tactile sensory aids (McGarr, Head, Friedman, Behrman, & Youdelman, 1986).

Of all the communication skills, the measures that showed the greatest improvement were those of speechreading. For both tests, the Myklebust and Neyhus Test (1970) and the LCS Speechreading Test developed for this project, the scores for nearly all children were significantly above chance level. It is likely that the improvements in speechreading scores are more aligned to the improvements that occurred in language than to improvements in speech production and speech reception skills. These notions are discussed more fully in Chapter 9. However, in assessing the ability of a hearing-impaired child to communicate effectively, we take note of visual acuity, speechreading ability, and measures of receptive sign language and fingerspelling, which were not measured as part of this study. While the LCS Speechreading Test enabled us to assess the children's ability to comprehend language structures and not just facial movements, we would stress that the test is still experimental, and that a speechreading instrument is still much needed for this age population of hearing-impaired children.

A second goal of this study was to compare our data with previous studies of communication skills of deaf children. Direct comparisons are not made easily because this study was fairly comprehensive and tested in some areas (e.g., prosodic features) that have not been examined previously in the same ways. Our data on segmental production and reception compare rather well with the literature. Articulatory patterns found in the speech of hearing-impaired children in this study resemble results obtained by previous researchers (e.g., Hudgins & Numbers, 1942; Smith, 1975; among others) who conducted their assessments on a more homogenous population. These comparable results are encouraging because they suggest that there are typical error patterns associated with deafness of severe to profound magnitude that are not the result of specific teaching. This statement does not imply that some of the children in this project were not receiving speech training in their institutions, nor does it suggest that speech training is unimportant or futile. It does illustrate the need for a more effective teaching curriculum in order for the children to progress in their speech production skills. Where comparisons of phonemic reception were possible, we again note findings similar to those previously reported for this population (e.g., Smith, 1975). The tremendous difficulty that many of the children had in perceiving even the most gross auditory contrasts underscores the need for research in the area of speech reception. Although many children wear hearing aids, and many schools have maximum use of residual hearing as their goal, one wonders, in light of our results, how effectively they are pursuing these aims. Again, this is not to suggest that auditory training is futile, but rather impels us to develop more effective measurement tools and programs. It is, however, no easy task to find words or nonsense syllables that are in a deaf child's lexicon because children with hearing impairment are often limited in vocabulary, and scores in reception as well as in production may reflect this deficit.

Although there are many tests of segmental production and reception, there are few measures of suprasegmentals or prosodic features. These areas are particularly important to overall speech intelligibility, and although aspects of voice quality, for example, are often noted in evaluation, there is no systematic test to evaluate a child's production or reception of prosodic features. The measures we developed for this study were experimental and were further refined by Gold (described in Chapter 8). Data from this study and for Gold's mainstreamed children are similar, although the magnitude of the error patterns varies. This again is an area that needs considerable research in order to develop an assessment test for both reception and production of prosodic features.

Although measures of speechreading ability exist for young deaf children (Craig, 1962; Myklebust & Neyhus, 1970), the test we developed is considered experimental and is in need of refinement. More problematic is the need for an instrument that assesses a child's overall communication skills, or the child's ability to communicate with audition and speechreading; audition, speechreading, and sign; and so forth. This type of assessment is available for adults using the CHABA sentences (Johnson, 1975), but there is nothing comparable for younger deaf children. (See however, Gaffney, 1977, for an interesting approach to this problem for preschool deaf youngsters.)

In summary, the results of this study provide us with basic information concerning the communication skills of severely and profoundly hearing-impaired children who are fairly typical of those found in many schools for the deaf. The data are not encouraging in that the children make limited use of their residual hearing, particularly in perceiving segmental and suprasegmental features. Furthermore, successful production of segmentals and suprasegmentals is limited, and most of the children have speech that is unintelligible even to a listener highly experienced with the deaf. The data are disappointing, but they nonetheless leave us with a challenge—to provide our teachers with better assessment tools and more effective curricula. The results of this project clearly point a direction for future research.

ACKNOWLEDGMENT

Many persons are responsible for collecting the data in this chapter. They are acknowledged in the monograph. The author is personally indebted to each, although she takes sole responsibility for the chapter's prose. In addition, I thank Harvey Stromberg and Nancy Springer for assistance with the data analysis, Nancy also for the final figures, and Gail Reynolds for typing the manuscript. We thank Harry Van Meter for drawing the pictures for the LCS Speechreading Test. Preparation of the chapter has been graciously supported in part by NINCDS Grant NS-13617 and NS-13870 to Haskins Laboratories, NINCDS Grant NS-17764 to the Graduate School and University Center, City University of New York, in addition to the support received from the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions.

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Chapter 8

COMMUNICATION SKILLS OF MAINSTREAMED HEARING-IMPAIRED CHILDREN

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This chapter reports data on speech reception and speech production skills in mainstreamed hearing-impaired children.

SUBJECTS

Forty-three hearing-impaired children served as subjects. There were 24 girls and 19 boys who were born between 1962 and 1964. The range of ages was from 9 years, 5 months, to 12 years, 4 months, with a mean age of 10 years, 2 months. The children were pupils in the New York City Public School system, and they received additional assistance from resource room teachers in their schools. The resource room program, under the auspices of the Bureau for Hearing Handicapped of the Board of Education of the City of New York, is designed to maintain severely hearing-impaired children in a regular school setting by means of supportive instruction in all subject matter, including language and speech skills. The hearing-impaired children are seen daily on an individual or group basis.

A list of all 9- to 12-year-old hearing-impaired children known to attend resource room classes in the New York City Public Schools was provided by the bureau. Of the 13 schools included on the list, the 7 that were chosen represented a distribution of geographic areas and socioeconomic levels of the city. Three schools were in Brooklyn, three in Queens, and one in Staten Island. The schools covered a range of socioeconomic levels from low (some on welfare) to middle income. None of the children were from high income families because few such families in New York City send their children to public schools. The number of children sampled from each of the schools ranged from two to nine. Once the schools were chosen, permission was obtained from the parents before any testing began.

The severity of the hearing losses, as reflected by the pure-tone averages, ranged from 40 dB to 110 dB+HTL in the better ear. The pure-tone averages were calculated from thresholds at 500, 1000, and 2000 Hz. If there was no response at one or more of these frequencies, a value of 110 dB+ was assigned as the pure-tone average. A pure-tone average of 80 dB was adopted to distinguish between hard-of-hearing children (PTA < 80 dB) and deaf children (PTA ≥ 80 dB) because this level is used as a criterion for entry into a school for the deaf in New York. There were 23 children with pure-tone averages less than 80 dB HTL and 20 with average hearing losses equal to or worse than 80 dB HTL. Audiological data on the children were obtained from the Board of Education records and, whenever possible, from clinical files at individual hospital centers where the children were seen for hearing aid evaluations. The children were all fitted with monaural or binaural amplification. Descriptive audiologic data for each of the subjects appear in Appendix D.

The purpose of this part of the study was to determine whether there were significant differences in the performance of the hard-of-hearing and deaf children on specific tests of speech reception and speech production skills. Some of the test materials used were the same as those described in Chapter 7 and administered to the deaf children in the longitudinal study. Other tests were added as necessary.

SEGMENTAL FEATURES

Phonemic Reception

Smith's (1975) test of phonemic reception ($Rseg_1$, see Chapter 7 for more detail) was administered. That test has a closed response format consisting of 50 sets of three monosyllabic words. The phonetic contrasts are based on place of articulation, manner of articulation, place and manner of articulation, voicing, and vowel contrasts. Each child heard the same tape that was prepared for the longitudinal study and listened under the same experimental conditions as described in Chapter 7. The child was required to circle one of three choices on the answer sheet for each stimulus presented.

The data are summarized in Table 8.1. There was a significant difference between the mean scores for the deaf and the hard-of-hearing children ($t = 5.59$, $df = 41$, $p < .001$). The mean for the deaf children was 47%; for the heard-of-hearing children it was 70%. Averaging the data over both groups of children, the test feature that was most often perceived correctly was manner of articulation (71%). This was followed by voicing (65%). Place-manner

TABLE 8.1. Mean scores and range of proportion correct for the five test features on the Phoneme Reception Test for the hard-of-hearing and deaf groups of children.

	Hard-of-hearing		*Deaf*	
Feature	*Mean*	*Range*	*Mean*	*Range*
Manner	.833	(.50–1.00)	.575	(.25–1.00)
Voicing	.783	(.42–1.00)	.504	(.25–1.00)
Vowel	.643	(.29– .86)	.496	(.14– .86)
Place-manner	.557	(.25– .75)	.438	(.13– .75)
Place	.652	(.25–1.00)	.313	(.13– .63)

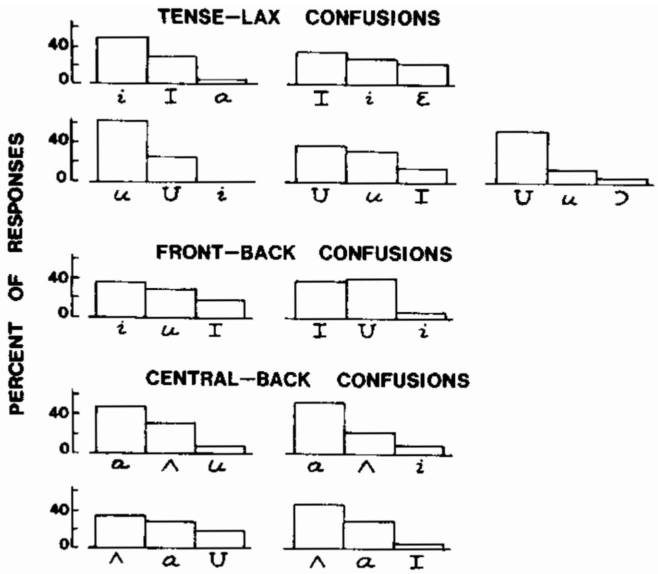

FIGURE 8.1. Vowel confusions on Smith's (1975) Phoneme Reception Test, $Rseg_1$. The target vowel is represented by the left-most bar in each set of histograms.

and place contrasts were correct 51% and 50% of the time respectively. The ranking of these features agrees with previous studies (Aston, 1972; Miller & Nicely, 1955; Smith, 1975). Acoustic cues for manner of articulation are generally in the low-frequency region, which is compatible with the children's residual hearing. Those features are thus likely to be perceived correctly. Perception of acoustic cues for place of articulation is generally dependent on high-frequency information, which hearing-impaired children are less likely to have available. When the performance for the hard-of-hearing children was compared to that of the deaf children, the relative rankings of difficulty remained the same for all features except the place and place-manner contrasts. However, as noted above, the average scores for the hard-of-hearing group were higher than those for the deaf group. The hard-of-hearing group had slightly more difficulty with place-manner contrasts than with contrasts of place alone, and this pattern differed from that of the deaf group.

Test items for nasals and glides were perceived as correct 65% and 64% respectively. Regardless of whether place, place-manner, or manner contrasts were intended, the items were perceived as correct more often if the target was a voiced phoneme. Voiced phonemes were perceived as correct 64% of the time, whereas the voiceless contrasts were perceived as correct only 52%. Although these differences were large, they were not statistically significant.

There was little difference in performance for target items with contrasts in either the initial or final position of words. Scores for test words with contrasts in the initial position were 59%, and those in the final position were 61%. Again, when the contrasting phonemes were voiced, they were perceived as correct more often than when they were voiceless.

Figure 8.1 shows the data for vowel contrasts. The intended vowel was perceived correctly 57.5% of the time. Several trends can be identified for items testing vowel recognition. Back vowels were correct more often (63%) than front vowels (59%), although, again, the difference between the back and front vowels was not statistically significant for either group of children. Frequently, vowels were confused with their tense-lax counterparts when there was the opportunity for this error type (e.g., /ɪ/ for /i/, and /ʊ/ for /u/. There were also perceptual confusions with other vowels having similar first formants when the second formant was beyond the audible frequency range of the subjects (e.g., /i/ for /u/, cf. Figure 8.1). The more central vowels of /ʌ/ and /ɔ/ were frequently confused with each other.

Phoneme Production

The test of phoneme production ($Pseg_3$) consisted of having the child read a set of 20 sentences designed by Smith (1975) for hearing-impaired children. The sentences contain key words that incorporate the most frequent phonemes of English with transitions to and from the vowels /i/, /æ/, and /u/ for all places of articulation. A recording of each child reading the 20 sentences was made. If the child was unfamiliar with one of the words in the sentences, or if he or she did not appear to read the sentences well, the child was helped with the word(s) and asked to read the sentence a second time. If severe reading problems seemed to exist, as demonstrated by 6 of the 43 subjects, testing was terminated, and the subjects were not included in this part of the study. Thus, the data base for this test was 37 subjects. Broad phonetic transcriptions were made of the children's productions. Based on those transcriptions, confusion matrices of intended productions versus transcribed productions were plotted. Separate matrices were obtained for the deaf and the hard-of-hearing groups.

Table 8.2 shows the data for the deaf children and the hard-of-hearing children. As anticipated, the deaf children had more errors than the hard-of-hearing children. Phonemic error scores were generated for each child based on the number of errors made compared with the number of phonemes in the corpus of 20 test sentences. Whereas 28.6% of the phonemes produced by the deaf group were in error, only 19.4% of those by the hard-of-hearing group were in error. A t test showed that the average proportion of phonemes produced correctly by the two groups was significantly different ($t = 1.998$, $df = 78$, $p < .05$). However, the relative frequency of error types, after adjusting for differences in the total number of errors, revealed that the pattern of errors was the same for both groups of children. Table 8.3 contains a breakdown of the major categories of phonemic errors made by the hard-of-hearing and deaf children. The frequency of occurrence of these errors with respect to the total number of phonemes intended is indicated in the first and third columns in the table. Entries in the second and fourth columns show the relative proportion of the total number of errors. For example, phonemes were omitted by the

TABLE 8.2. Proportion of phoneme error for each of the hard-of-hearing and deaf children. Values are derived from the number of phonemes in error relative to the total number of phonemes intended.

Hard-of-hearing		*Deaf*	
Subject	*Proportion phoneme error*	*Subject*	*Proportion phoneme error*
1	.254	19	.148
2	.325	20	.457
3	.325	21	.319
4	.196	22	.184
5	.104	23	.281
6	.092	24	.303
7	.137	25	.141
8	.207	26	.227
9	.147	27	.254
10	.101	28	.465
11	.247	29	.195
12	.104	30	.255
13	.214	31	.216
14	.229	32	.287
15	.129	33	.246
16	.308	34	.456
17	.179	35	.444
18	.194	36	.150
		37	.405
Mean	.194	Mean	.286

hard-of-hearing group 7.6% of the time that they were intended (row 1, column 1). This constituted 39.2% of all segmental errors made by these children (row 1, column 2) and was the most common error type. Entries in this table show that for both deaf and hard-of-hearing groups, omissions constituted approximately 40% of all errors,

TABLE 8.3. Relative frequency of articulatory errors for hard-of-hearing and deaf children for all phonemes in test sentences. Two entries are shown for each group of children. The first is the proportion of error to the total number of phonemes intended. The second is the relative frequency of the error type as a proportion of the total number of errors made.

	Hard-of-hearing		*Deaf*	
Error type	*Proportion of error*	*Relative proportion of error*	*Proportion of error*	*Relative proportion of error*
Omission	.076	.392	.116	.406
Vowel-vowel substitution	.050	.256	.065	.227
Consonant-consonant substitution	.035	.180	.060	.210
Recognizable distortion	.019	.098	.023	.080
Severe distortion	.007	.036	.013	.045
Diphthong	.004	.021	.004	.014
Non-English substitution	.002	.010	.004	.014
Other	.001	.005	.001	.003
Total	.194	1.000	.286	.999

vowel-vowel substitutions (production of an incorrect vowel for the intended one) made up 20% of the total errors for the hard-of-hearing group and 23% for the deaf group, and consonant substitutions made up about 20% of the errors. Other categories of errors occurred less frequently. These included: recognizable distortions (phonemes distorted but still identifiable as the intended phoneme), severe distortions (so severe that the intended phoneme was unrecognizable), diphthong errors (prolongation or omission of part of a diphthong), non-English substitutions, and other errors (words misread, substitution of consonants for vowels and vowels for consonants).

Table 8.4 compares consonantal errors for hard-of-hearing and deaf children. For both groups of children, omission of the intended phonemes constituted about 52% of all consonantal errors. The next most common error was the substitution of an incorrect consonant for the intended one. Place-manner errors due in large part to the substitution of /d/ for /ð/ accounted for a large proportion of the substitutions; manner errors ranked second, followed by voicing and place-manner-voicing errors. There were few major differences between the kinds of substitutions made by the hard-of-hearing and deaf children.

When manner of production errors were viewed, the rank order of correct production for both groups were glides and laterals, nasals, stops, fricatives, and affricates (Table 8.5).

The rank order of correct productions of consonants according to place of articulation was bilabial, glottal, labio-dental, lingua-velar, lingua-dental, lingua-alveolar, and lingua-palatal (Table 8.6). Voiced phonemes were correct slightly more often than voiceless phonemes, but the porportions were not significantly different.

The most common kind of phonemic substitution for the fricatives was place-manner. A large proportion of those errors was due to the substitution of /d/ for /ð/, a

TABLE 8.4. Relative frequency of consonant errors for hard-of-hearing and deaf children for all consonants in the test sentences. Two entries are shown for each group of children. The first is the proportion of error out of the total number of consonants intended. The second is the relative frequency of the error type as a proportion of the total number of consonantal errors made.

	Hard-of-hearing		*Deaf*	
Error type	*Proportion of error*	*Relative proportion of error*	*Proportion of error*	*Relative proportion of error*
Omission	.116	.520	.182	.529
Consonant-consonant substitution	.060	.269	.104	.302
Recognizable distortion	.030	.135	.031	.090
Severe distortion	.011	.049	.020	.058
Non-English substitution	.002	.009	.007	.020
Other	.004	.018	.000	.000
Total	.223	1.000	.344	.999

TABLE 8.5. Distribution of the proportion of correctly produced consonants according to the manner of articulation. Entries represent the mean proportion correct across phonemes for hard-of-hearing, deaf, and both groups of children.

Manner of articulation	*Hard-of-hearing*	*Deaf*	*Both*
Glides and lateral /w,r,j,l/	.867	.797	.830
Nasals /m,n,ŋ/	.879	.715	.795
Stops /p,b,t,d,k,g/	.816	.692	.752
Fricatives /f,v,θ,ð,s,z,ʃ,h/	.697	.553	.623
Affricates /tʃ,dʒ	.513	.362	.436

common occurrence in New York speech patterns. Stop substitutions usually consisted of voicing errors. Errors for nasals were most often place substitutions.

The confusion matrices for the hard-of-hearing and deaf children were compared in terms of a statistic, G^2, which compares data from discrete multivariate distributions (Bishop, Feinberg, & Holland, 1975). This statistic compares confusion matrices on a row by row basis and takes into account differences in overall error rate among matrices. When the G^2 was computed with the diagonal eliminated, that is, setting aside the fact that the hard-of-hearing children produced the sound correctly significantly more often than the deaf children, only two consonants, /z/ and /ŋ/, remain as sounds for which the two hearing-impaired groups had significantly different ($p <$ .05) patterns of errors. In both cases, the deaf children omitted the sound more often than did the hard-of-hearing group. The hard-of-hearing children tended to substitute a closely related sound, for example, /s/ for /z/ and /n/ for /ŋ/.

TABLE 8.6. Distribution of the proportion of correctly produced consonants according to place of articulation. Entries represent the mean proportion correct across phonemes for hard-of-hearing, deaf, and both groups of children.

Place of articulation	*Hard-of-hearing*	*Deaf*	*Both*
Bilabials /p,b,m,w/	.937	.894	.915
Glottal /h/	.924	.793	.859
Labio-dental /f,v/	.879	.834	.856
Lingua-velar /k,g,ŋ/	.811	.592	.701
Lingua-dental /θ,ð/	.728	.609	.669
Lingua-alveolar /t,d,s,z,n,l/	.660	.504	.582
Lingua-palatal /ʃ,tʃ,dʒ,r/	.597	.439	.178

TABLE 8.7. Relative frequency of errors for hard-of-hearing and deaf groups of children for all vowels in the test sentences. Two entries are shown for each group of children. The first is the proportion of error out of the total number of vowels intended. The second is the relative frequency of the error type as a proportion of the total number of errors made.

	Hard-of-hearing		*Deaf*	
Error type	*Proportion of error*	*Relative proportion of error*	*Proportion of error*	*Relative proportion of error*
Omission	.021	.135	.027	.130
Vowel-vowel substitution	.111	.712	.151	.729
Recognizable distortion	.005	.032	.013	.063
Severe distortion	.001	.006	.003	.014
Diphthong	.009	.058	.008	.039
Non-English substitution	.000	.000	.000	.000
Other	.009	.058	.005	.024
Total	.156	1.001	.207	.999

Vowels

Of all vowels intended, 18.2% were produced in error. The greatest proportion of errors for both the hard-of-hearing and deaf groups was due to the substitution of an unintended vowel for the target one (about 72%) (Table 8.7). Typically, the vowel substitutions involved production of a near neighbor of the intended vowel on the vowel quadrilateral. No other single vowel feature confusion occurred as often, on the average, as tenseness (e.g., /i/ for /ɪ/, /u/ for /ʊ/). Confusions based on errors of rounding and tenseness together, i.e., /ɔ/ for /ɑ/ and /ɑ/ for /ɔ/ were the most common kind of vowel substitution. Another common error was production of /ə/ or /ʌ/ for the intended vowel.

Use of the G^2 statistic to compare vowel confusions for the hard-of-hearing and deaf groups failed to show statistically significant differences of any importance. One of the differences was due to transcribers' labeling; some chose to describe the error on the intended diphthong /aɪ/ as elimination of the final component, whereas others identified it as substitution of the phoneme /a/. The other difference was in reading the modifier *a*, which some children were more inclined to read /ə/ while others read it /eɪ/.

Discussion

Phonemic reception. Mean overall scores and scores on subsections of the test of phonemic reception were significantly better for the hard-of-hearing than for the deaf group. Both groups did best on that subsection of the test involving manner contrasts, and scores on the section involving voicing contrasts were almost as high. A much greater proportion of errors was obtained on items testing place and place-manner contrasts. These results are consistent with the published literature, which reports relatively good discrimination of voicing and poor performance on recognition of place of articulation (Bilger & Wang, 1976; Owens & Schubert, 1968; Oyer & Doudna, 1959; Pickett et al., 1972; Schultz & Kraat, 1971; Siegenthaler, 1949; Smith, 1972).

Smith's subjects and the hard-of-hearing children in the present study had lower mean scores for items testing place-manner than for place contrasts. This seems unusual because one would expect the presence of manner cues that are perceived fairly well to make the perception of place-manner contrasts better than the perception of place contrasts. A possible explanation is that the low-frequency manner cues cause a spread of masking to the higher frequency place cues. This kind of behavior was demonstrated by Pickett et al. (1972) for synthetic speech samples. If this is the case, place cues occurring alone are more readily perceived by the hearing-impaired subjects than place cues occurring in conjunction with manner cues.

Smith created the test of phonemic reception for severely to profoundly deaf subjects attending schools for the deaf. A comparison of the present findings with those reported by Smith (1972) shows that scores on subsections of the test were similar for the two populations. For all but one subtest, the children in schools for the deaf had lower mean scores than those mainstreamed into regular schools. However, for items testing place contrasts, Smith's deaf children had a higher mean score than did the deaf children in the present study. The mean score for Smith's subjects was 42.5%, and for the mainstreamed deaf subjects it was 31.3%. However, the differences were not significant.

As in Smith's study, performance on target phonemes in word-final position was not significantly worse than performance on target items in initial position. This is contrary to many previous findings that report significantly better scores when the target phoneme is in initial position (Jones & Studebaker, 1974; McGarr, Stromberg, & Hochberg, 1977; Owens & Schubert, 1968; Oyer & Doudna, 1959; Pickett et al., 1972; Rosen, 1962; Sher & Owens, 1974). In 1976, Bilger and Wang noted better performance on consonants in final position of nonsense syllables than in initial position. They suggested that their results may differ from findings for CVCs because of the generally poorly articulated final consonant in CVCs, which contributes to the sound being identified correctly less often. When the talker is more careful with producing the targets, as in nonsense syllables, there is less difference between initial and final position, and final position may even be better if the initial vowel serves to alert the listener to the coming consonant.

Phonemic production. Although the frequency of articulatory errors for the deaf children in the present study (29%) was considerably less than for other hearing-impaired populations studied (Markides, 1970, 69%; Smith, 1975, 43%), the types of errors found in the present study are similar in form to those reported previously. Errors of omission, reported by Hudgins and Numbers (1942), Markides (1970), and Smith (1972) and voicing errors found by these authors and also Carr (1953), Heider, Heider, and Sykes (1941), Mangan (1961), and Nober (1967) occurred frequently for the mainstreamed population as well.

If the consonants are ranked according to their relative frequency of correct production, the same ranking is obtained as that reported by Markides (1970), Nober (1967), and Smith (1972); bilabials and labiodental fricatives, /f/ and /v/, were best, whereas palatal and alveolar fricatives and affricatives were worst. Whereas Nober claimed that correct phoneme production decreased as place of articulation moved posteriorly, the present findings show greatest accuracy for more visible phonemes, with the exception of the glottal sounds, which were produced fairly accurately. It has been suggested by Huntington, Harris, Shankweiler, and Sholes (1968) that visibility of the phoneme was not as important a factor as the degree of tongue involvement in determining how difficult a phoneme was to produce. They noted that if visibility alone were the key factor, then glottal sounds should be among the most, not the least, difficult to produce. They believed that accuracy of tongue involvement in lingua-palatal and lingua-alveolar fricatives contributes to the low proportion of correct production of these phonemes.

Vowel substitutions were characterized by production of a closely related vowel in the quadrilateral. There was also a tendency to neutralize the vowel, with frequent substitutions of /ə/ or /ʌ/ for the intended vowel. These findings are in good agreement with those reported by Mangan (1961) and Smith (1972) for related vowel errors and by Angelocci, Kopp, and Holbrook (1964), Heider et al. (1941), Markides (1970), Monsen (1976), and Smith (1972) for centralization of the intended vowel. Back vowels were produced correctly more often than front vowels, as reported by Boone (1966), Mangan (1961), and Nober (1967). However, in the present study, differences among vowels based on categories of tongue height were not large.

Although the pattern of articulatory errors for the present population seems similar to that of errors produced by other hearing-impaired children, close comparisons among most studies cannot be made because of the differences in test materials, methods of evaluation, and types of populations tested. The most valid comparison would be with Smith's because test materials and procedures were common in both studies. Statistical tests that compare the kinds of errors, on a phoneme by phoneme basis, made by the deaf subjects in the present study and those deaf subjects in Smith's study show some similarities and differences in their patterns of confusions. The same kind of phoneme classes (palatal and alveolar fricatives and affricates) caused both groups of children difficulty. Both groups manifested the tendency toward omission of phonemes and substitution of place-related vowels. The most striking statistically significant differences in error types between the groups were in the relative proportion of /ə/ and /ʌ/ substitutions for vowels and in the number of omissions for consonants. Also, Smith's subjects substituted the glottal stop for /t/ and /k/ far more often than did the deaf mainstreamed children. In addition, her subjects frequently substituted /b/ for other labial sounds.

Thus, while the nature of the confusions did not differ significantly between the hard-of-hearing and the deaf children in the same educational setting, there were significant qualitative and quantitative differences between the deaf children in schools for the deaf and those in regular public schools. However, the differences in performance for the two groups must be interpreted carefully. In many cases, the mainstreamed children may be compared with those in the top of their class in the schools for the deaf. These are children who were either "successful products" of schools for the deaf or who have bypassed the special educational system entirely. They are children judged by qualified individuals to be able to cope with the regular school environment. Although one must not eliminate the possibility that their speech skills improved as a result of being in a completely oral setting, one must not forget that they were probably placed in that environment because their speech skills were already good. To determine the effects of the setting itself, the progress in overall intelligibility made by those deaf children should be compared with that made by some of the better students in schools for the deaf over the same period of time.

Aside from these variables, the type of speech training, the frequency of speech training, the criteria of speech production, and the acceptance of speech intelligibility by the teachers are factors that may account for differences between the groups in different studies. Nevertheless, the patterns of production errors for the hard-of-hearing and deaf subjects within the same school setting tested for this study were very similar, except for differences in the frequency of occurrence of the errors.

The data from the present study show that mainstreamed hard-of-hearing and deaf children manifest strikingly similar patterns of articulatory errors. This is not to say that all hearing-impaired children follow the same phonological rules and sound exactly alike, but that they share basic patterns of errors. Understanding these similarities can give the teacher a basis for establishing norms for developmental work as well as a framework for creating remedial lessons. Furthermore, following the assumption that there is an underlying pattern of errors for all hearing-impaired children, better tests can be developed for evaluating the specific errors made by each child.

SUPRASEGMENTAL FEATURES

The deaf speaker's inadequacy at dealing with the reception and production of the prosodic features of speech has been described earlier. This part of the chapter focuses on the question of whether there were significant differences in the prosodic-feature reception and production skills of hard-of-hearing and deaf children. These were the same children who participated in the segmental reception and production testing. Because of schedule constraints, some children did not participate in both the segmental and suprasegmental testing. Hence, the number of children described in parts of this section is slightly smaller than in the previous section.

TABLE 8.8. Distribution of the mean proportion correct for hard-of-hearing and deaf children for each of the test features on the Prosodic-Feature Reception Test.

Feature	*Hard-of-hearing*	*Deaf*
Pause		
Late	.717	.600
Early	.690	.711
Question	.594	.467
Stress		
Late	.556	.395
Early	.440	.456

Prosodic-Feature Reception

The revised prosodic-feature reception test ($Rpros_2$) described in Chapter 7 also was used in the present study. Nine simple sentences divided equally into 2-, 3-, and 5-syllable utterances were used to test the child's ability to differentiate the features of stress, pause, and intonation of *yes/no* questions through a strictly auditory channel. A multiple-choice test format was used, and the child was asked to circle the answer after hearing the taped target item presented through earphones. All 43 children took this test.

Mean scores on the prosodic-feature reception test were not significantly different for the hard-of-hearing (59.0%) and deaf (52.8%) groups. Individual data for prosodic-feature reception and production appear in Appendix E. On the average, both groups performed best on the items testing pause, considerably poorer on question, and poorest on stress items. For eight of the prosodic forms tested (Table 8.8), the hard-of-hearing group scored essentially the same or considerably better than the deaf group.

Figure 8.2 shows the response patterns obtained on the revised prosodic-feature reception test ($Rpros_2$). The figure is made up of 12 sets of histograms arranged in a matrix of 3 columns by 4 rows. The columns subdivide the histograms according to the number of syllables in the test utterance. The rows subdivide the histograms according to the intended prosodic form. Each set of histograms consists of four pairs of bars. The open bars show the average percentage of responses by the hard-of-hearing children; the hatched bars show the average percentage of responses by the deaf children. The vertical arrow in each set of histograms identifies the intended prosodic form. The height of the bar under an arrow thus shows the percentage of correct responses for the intended prosodic form. The other bars show the percentages of confusions.

The first row of histograms shows data for early stress as the intended prosodic form. The second row shows data for late stress. The third row shows data for early pause as the intended prosodic form. It should be noted that pause

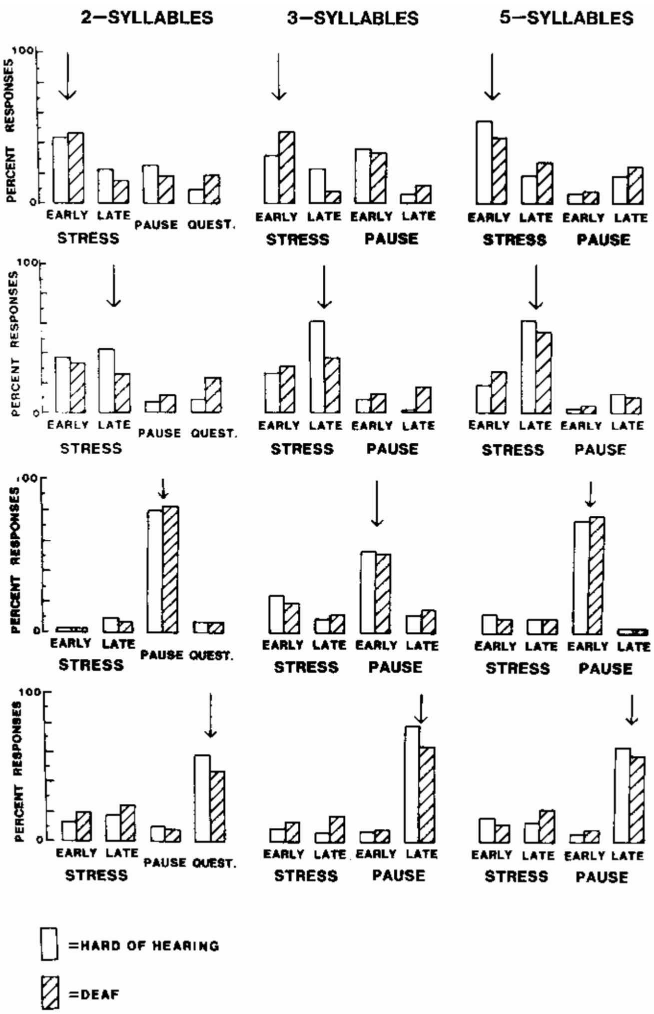

FIGURE 8.2. Percentage of responses on the Revised Prosodic-Feature Reception Test, $Rpros_2$. The left section of the diagram shows data for 2-syllable utterances, the middle section for 3-syllable utterances, and the right section for 5-syllable utterances. The arrow identifies the intended prosodic form.

in 2-syllable items was arbitrarily referred to as early pause; therefore, there is no entry for late pause in 2-syllable items. Also, question intonation was tested only in 2-syllable items. The last row of the figure shows histograms for either question (2-syllable items) or late pause (3- or 5-syllable items) as the intended prosodic form.

The deaf group had slightly better mean scores for three prosodic forms (early pause, 2 and 5 syllables; early stress, 2 syllables) and considerably better scores for one form (early stress, 3 syllables). The pattern of confusions made by the two groups of children was similar for all features except that of late pause. When confusions occurred for early pause, the children seemed to recognize the correct location of the feature, but reported early stress instead. When a question was identified incorrectly, the children often reported some form of stress. Various different responses were chosen when early stress was the test feature. When late stress was produced, stress was often reported, but in the wrong location. It was only when late pause was intended that the deaf and hard-of-hearing children showed obvious differences in the confusions made. When length of utterance was viewed with respect to each feature separately, no consistent pattern favoring longer utterances was found.

Stress/Location Test

Preliminary evaluation of the prosodic-feature reception test taken by the first few subjects prompted the creation of a second more difficult test, which was used only in this study (cf. Appendix F for test items). The test (Stress/Location) was designed to determine if the hearing-impaired child could discriminate place of stress in an utterance, a feature that could easily change meaning. In this test, place of stress was the target in both statements and questions. Most of the questions were of the *wh* type and used the same intonation pattern as the statements. Two of the questions used rising intonation and allowed for a comparison of recognition of place of stress within different intonation contours. In addition to stress, emphasis (extra stress) was used to determine whether greater use of intensity, duration, and/or pitch change would make this feature more easily recognizable to the hearing-impaired population.

The test consisted of 12 simple sentences: six questions and six statements. Within each group of six, three sentences were 3 syllables long and three were 5 syllables long. Each of the simple sentences was presented once with stress and once with emphasis, making 24 items on the test. Stress or emphasis was tested seven times in early location (always sentence initial), eight times in middle location, and nine times in late location in the utterances. The extra item of stress in late position allowed for useful additional comparisons. For each test item, there were three written foils that differed only in place of stress or emphasis. The word group was always the same; stress and emphasis were not compared within a test item.

Four practice items were used to teach the child to associate the auditory stimulus with the written representation. Practice was done without earphones at first and later with the tape-recorded practice items. The children were instructed to circle the sentence they heard. Because the test was introduced after overall testing was begun, only 34 subjects (16 deaf, 18 hard-of-hearing) took it.

Mean scores for the Stress/Location Test were not significantly different for the hard-of-hearing (61.5%) and deaf (51.5%) groups of children. Figure 8.3 shows the confusions for identification of location of stress for 3- and 5-syllable items for the hard-of-hearing and deaf groups. The target location is identified by the vertical arrow in each diagram. Both groups did best on items testing early stress and worst on stress in late position, and differences for the deaf group were significant ($p < .05$). For the most part, regardless of the location of the feature being tested, the children reported early stress as their most common

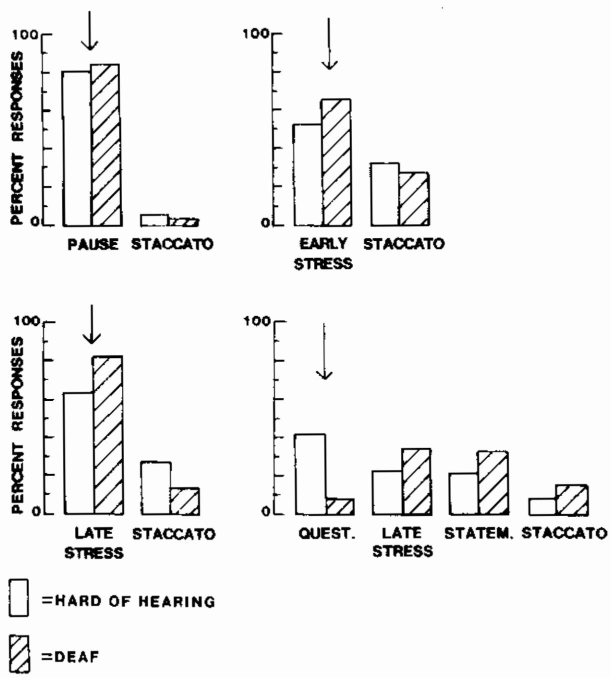

FIGURE 8.3. Data from Prosodic-Feature Production Test, Ppros. The arrow identifies the intended prosodic form. Only the most common productions are shown.

confusion. Both groups of children did better on items testing emphasis rather than stress and better on longer items than on shorter ones, but neither difference was significant.

Due to an error in recording the master tape, one test item was read twice, once with stress and once with emphasis on the same target word. This allowed an opportunity for a direct comparison of stress and emphasis without the effects of sentence length, type, or location of stress. Performance for hard-of-hearing and deaf groups was much better (stress 50%, emphasis 70%) when emphasis was used.

Question intonation was tested in 3-syllable items only. Because this sentence type used a rising intonational pattern, performance for both hard-of-hearing and deaf groups was compared for question intonation and for statements that used a falling intonational pattern. For the hard-of-hearing groups, there were minimal differences in the mean scores for question intonation and statement. The deaf group, however, had lower scores on *yes/no* questions than on statements ($p < .1$).

Prosodic-Feature Production

The test used to evaluate prosodic-feature production (Ppros) is described in Chapter 7. It was created to evaluate the child's ability to use the prosodic features of stress, pause, and rising intonation as in *yes/no* questions. Two groups of experienced listeners analyzed the utterances produced by the children. One set of three listeners knew in advance the prosodic features that the child was attempting to produce on each utterance. The second set of six listeners did not know in advance which prosodic features were intended on individual utterances, although they were familiar with the test materials as a whole.

Prosodic-Feature Production in Context

One of the problems with the test of prosodic-feature production was the artificiality of the utterances. They were created in an effort to test specific prosodic features on identical word groups so as not to confound the results with linguistic differences among sentences. The 2-syllable utterances in particular lend themselves to problems in differentiation of place of stress. This is true because there is a greater chance of confusing location of stress in a 2-syllable item where it is difficult perceptually to differentiate early stress on the first syllable from the normally increased duration on the final syllable. In longer utterances, there is more opportunity to differentiate those features because of the intervening syllables. For this reason, a sequential question and answer series was used in a second test (Contextual Prosodic Production) in an attempt to devise a more natural assessment of prosodic-feature production. This test, created for the present study, was designed to evaluate the children's use of stress, pause, and question intonation in a more natural setting than the one created by the previous test. The target features appeared in the context of a sequential question and answer unit. Each of the three units began with a question that was answered by the second utterance in the unit. If the sentence was read properly as an answer to the question, stress had to fall on a specific syllable. For example,

> What color is the apple?
> The apple is *green*.
> What is green?
> The *apple* is green.

In this way the features of early and late stress and pause in a statement or question were tested. The test materials appear in Appendix G.

A second purpose of the test was to determine the effects of training on the production of the target features. For this reason, the test was administered both before and after training. With the first version, the children were presented with a set of three cards, each having one question and answer unit printed on it. There were no special markings to indicate which features were being tested. The children read the cards to familiarize themselves with the materials, and recordings then were made of the children reading the units aloud. This portion of the test was always administered before the other test of prosodic-feature production described above. After completion of that test, which involved training the children on the specified features, the three test units of the present test were given again. This time, the items were marked by capitals and underlining to indicate stress and by three dots to indicate pause. The test of prosodic-feature production was always administered between the two parts of the Contextual Prosodic Production Test.

TABLE 8.9(A). Means, standard deviations, and ranges of overall test scores for hard-of-hearing, deaf, and both groups of children on the Prosodic-Feature Production Test (CPP). Scores indicated are proportion correct.

Score	*Hard-of-hearing*	*Deaf*	*Both*
Mean	.623	.589	.607
Standard deviation	.184	.089	.147
Range	.315–.926	.370–.704	.315–.926

TABLE 8.9(B). Mean proportion correct for each test feature for hard-of-hearing, deaf, and both groups of children on the Prosodic-Feature Production Test.

Feature	*Hard-of-hearing*	*Deaf*	*Both*
Pause	.888	.917	.901
Late stress	.638	.822	.724
Early stress	.522	.650	.581
Question	.411	.094	.264

Two experienced listeners listened to the tape recordings and noted whether the children produced the features intended and, if not, what features were being produced. No attention was paid to the *wh* questions, because they were not intended as test items but only as prompts to lead into the appropriate responses. Only 32 children took this test because it was added to the test battery after testing had begun.

The listeners who knew the intended utterances rated the children by indicating whether the utterance was characterized by early or late stress, early or late pause, rising intonation as in a question, or falling intonation as in a statement. They could also categorize the utterance as staccato (equal stress on all syllables and equal pause between syllables) or as unintelligible.

The mean scores for the two groups of children were not significantly different: the hard-of-hearing group had a mean score of 62.3%, and the deaf group had a mean score of 58.9% (Table 8.9(A)). The rank order of features produced correctly was the same for the hard-of-hearing and deaf children (Table 8.9(B)). Pause was most often produced correctly (90%), followed by stress (66%) (late stress, 72%; early stress, 58%), and then question (26%). An entirely unexpected finding was that the deaf group had higher mean scores than the hard-of-hearing group for all features except question. Only in the case of late stress was the superior performance by the deaf subjects significant ($t = 2.140$, $df = 34$, $p < .025$).

The errors produced by the two groups of children were similar. There were few errors when pause was intended. When stress was the intended feature, one error, that of staccato production, was significantly more frequent than other errors. Both groups of children were infrequently successful at producing question intonation. They often substituted late stress (hard-of-hearing, 21%; deaf, 32%) or read the utterance in a staccato fashion (hard-of-hearing, 9.2%; deaf, 15.6%). (See Figure 8.4.)

The second set of listeners, who had no prior knowledge of the intended feature, was given nine characteristics from which to choose the one they felt most appropriately labeled the prosodic feature used in the utterance. An analysis of variance was carried out on the data for the two sets of listeners. Of the three main factors, Feature, Listener Group, and Hearing Group (i.e., hard-of-hearing vs. deaf), the Feature difference ($p < .001$) and the Listener difference ($p < .05$) were significant. There was no significant effect of Hearing Group. There was a significant interaction between Feature and Hearing Group ($p < .01$) due to the large differences in performance between the hard-of-hearing and deaf groups on the features of question, late stress, and early stress (Table 8.10). For the features of early pause, late pause, and late stress, there were large differences in the scores given by the two groups of listeners for the deaf children. The listeners who knew the intended feature in advance scored as much as 18 percentage points higher than did the other group of listeners. A look at the pattern of confusions revealed that the group with no prior knowledge of the intended feature had a greater tendency to

TABLE 8.10. Analysis of variance between feature, listener group, and hearing group for the Prosodic-Feature Production Test. Only F values exceeding a level of .10 significance are listed.

Source	*Sum of squares*	*Degrees of freedom*	*Mean square*	F	*Level of significance*
Feature	5.562	4	1.390	174.153	.001
Listener group	0.064	1	0.064	7.959	.048
Feature × hearing group	0.700	4	0.175	21.944	.008
Listener group × hearing group	0.040	1	0.040	5.111	.086

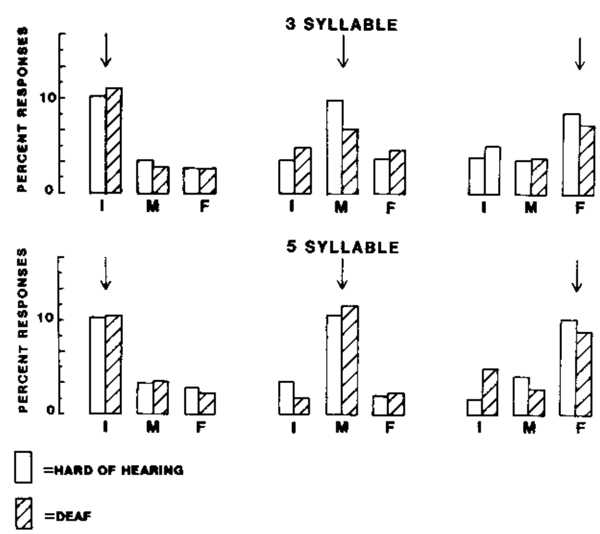

FIGURE 8.4. Response patterns on Stress/Location Test, S/L. The arrow identifies the targeted location of the stress in the initial (I), medial (M), or final (F) portion of the utterance.

TABLE 8.11(A). Means, standard deviations, and ranges of overall test scores pre- and posttraining for hard-of-hearing and deaf children on the Contextual Prosodic-Production Test. Scores indicated are proportion correct.

Score	*Hard-of-hearing* Pre	Post	*Deaf* Pre	Post
Mean	.319	.702	.371	.639
Standard deviation	.166	.194	.166	.217
Range	.000–.778	.222–1.000	.111–.667	.222–.889

TABLE 8.11(B). Mean proportion correct for each test feature pre- and posttraining for hard-of-hearing and deaf children on the Contextual Prosodic-Production Test.

Feature	*Hard-of-hearing* Pre	Post	*Deaf* Pre	Post
Early stress	.365	.771	.479	.844
Late stress	.500	.885	.708	.865
Pause + statement	.328	.859	.219	.781
Pause + question	.000	.125	.000	.031

rate the badly produced utterances as unintelligible, thereby reducing the total number of correct items in the group.

The features tested with the Contextual Prosodic-Production Test were early and late stress, and pause in statement and in a *yes/no* question. The target features appeared in the context of a sequential question and answer group. A second purpose of the test was to determine the effects of training on performance. The test was administered twice, once before and once after the Prosodic-Feature Production Test, for which training was given.

Table 8.11 shows the mean proportion correct, standard deviation, and ranges of scores for the hard-of-hearing and deaf children before and after training. Also shown are the scores for each of the features tested. An analysis of variance (Table 8.12) was carried out for the factors of Training, Hearing Group, Rater, and Feature. The results showed that scores improved significantly with training ($p < .001$). The improvement with training was considerably greater for the hard-of-hearing than for the deaf group ($p < .05$). In addition, the Feature effect was significant ($p < .001$). Performance on pause in a *yes/no* question was much poorer than on any other feature. Late stress items were produced better than early stress, as was true for the Prosodic-Feature Production Test. Also, as was the case for the other prosody test, the deaf did better than the hard-of-hearing children on the production of stress. Once again, the differences between the hard-of-hearing and deaf groups were not significant for overall mean scores. The hard-of-hearing group had a mean score of 51%, and the deaf group had a mean score of 51%. Rater differences were not significant.

Discussion

There were no significant differences in performance for the hard-of-hearing and deaf groups on the test of

TABLE 8.12. Analysis of variance between training, hearing group, listener, and feature for the Contextual Prosodic-Production Test. Only F values exceeding the .10 level of significance are listed.

Source	Sum of squares	Degrees of freedom	Mean squares	F	Level of significance
Training	0.352	1	0.352	189.753	.001
Training × hearing group	0.017	1	0.017	9.449	.053
Feature	1.904	3	0.635	342.089	.001
Training × feature	0.041	3	0.014	7.349	.068
Hearing group × feature	0.049	3	0.017	8.953	.053
Listener × feature	0.035	3	0.012	6.350	.082

prosodic-feature reception. Both groups of children did best on recognition of pause and worst on items testing stress. Scores on rising intonation for question and on early stress were very similar in each test group. The pattern of confusions for errors was essentially the same for the hard-of-hearing and deaf groups.

Late stress in 2-syllable utterances was the most difficult item for the deaf group. The hard-of-hearing children did much better on this item. McGarr (Chapter 7) reported great difficulty on the part of deaf children at schools for the deaf on this test item and noted that question intonation was a common confusion. She explained that similarities in durational and pitch changes might account for this kind of confusion. The mainstreamed deaf children reported question intonation nearly as often as they reported the intended late stress. However, early stress was reported more often. It was also the most common confusion whenever late stress was produced. The subjects seemed to have recognized the presence of stress in the 2-syllable items but could not locate it correctly. If the children confused question with late stress because of similar acoustic cues, why were they so much more succesful at identifying question? Were they able to detect the additional cue of changing pitch, and, if so, why did they have so much trouble producing question intonation? These questions need to be answered if we are to gain further understanding of how the hearing-impaired child is handling prosodic cues.

Another unexplained result was that when early stress was the target feature in 2- and 3-syllable items, the children frequently reported hearing early pause rather than early stress. Because it is not unnatural for a speaker to pause after a stressed word, this may have been the cue that subjects responded to. Scores obtained for the present population for early stress are considerably lower than those reported by McGarr (Chapter 7) for children at schools for the deaf. One interpretation of the differences is that the subjects in the present study were more aware of the acoustic cues available to them than were McGarr's subjects and that, although the former group of children possessed more of the available acoustic cues, their scores were actually lower because of a high rate of confusion between the target and a foil with similar acoustic properties.

One of the purposes of the Stress-Location Test was to determine the effects of the location of the target feature on the child's reception of stress. The results showed that performance was best when stress was early, rather than middle or late in the utterance, although the differences were not significant. This finding is somewhat contrary to those of the Prosodic-Feature Reception Test, where reception of late stress was better, on the average, than reception of early stress. The difference lies in performance on items testing early stress, because the proportion correct for items testing late stress was similar for both tests. A possible explanation for the differences in findings may pertain to the kinds of foils used in the two tests. For the Stress-Location Test, the choice was based solely on location of stress, whereas in the Prosodic-Feature Reception Test, there were also choices featuring pause as the target. Because early pause was frequently confused with early stress, the number of times early stress was correctly identified was significantly reduced. Thus, it is not clear whether there is any advantage to recognition of one place of stress over another.

A second objective of the Stress-Location Test was to determine whether the addition of extra stress (emphasis) on the intended syllable would improve the child's reception of place of stress. When averaged across all test items, there were no statistically significant differences between performance on stress and on emphasis. For one test item that was read once with stress and once with emphasis, because of an error in the original test recording, scores were significantly better when emphasis was used. If this utterance is typical of test items, this finding suggests that any of the other variables tested may have interfered with the child's ability to demonstrate the benefit of emphasis over stress. Another possible explanation lies in the variability of factors used to produce stress or emphasis. Whereas it may be possible to recognize that more stress was used for one utterance than for another, it is not certain that the same cues were being used in each case. Also, because some cues may be more perceptible than others to the normal ear, the same benefit may not exist for the hearing-impaired listener. It would be best to test perception of degree of stress with well-controlled synthesized speech for the hearing-impaired population.

A comparison of scores on place of stress for statements and *yes/no* questions was available for 3-syllable items. Whereas the deaf group did significantly worse overall on question intonation than on statements, there was no significant difference for the hard-of-hearing group. For question intonation, scores were much higher for items in early position than in either middle or late position. This is consistent with the overall findings for recognition of place of stress.

In choosing listeners to evaluate the children's performance on tests of prosodic-feature production, it is necessary to decide whether the listeners should have prior knowledge of which feature is intended for each test item. The disadvantage of prior knowledge is that the listener may be unduly influenced by what is expected. The advantage is that the listener can attend to the target feature without being confused by other features that may be produced simultaneously. In addition, if the listener is told in advance which prosodic feature is intended, there is no need to randomize tape recordings. It seems that, for practical reasons, it would be better to use listeners with a priori knowledge of the test materials. To check against results obtained with listeners having no a priori knowledge, two sets of listeners were used for the test of prosodic-feature production.

The results of the comparison showed that there were large differences in scores given by the two groups of listeners for some of the features produced by the deaf children. Listeners with a priori knowledge of the intended features obtained scores for these features that were as much as 18 percentage points higher than the scores for the uninformed listeners. However, the pattern of confusions revealed that the group with no prior knowledge had a greater tendency to rate the badly produced utterances as unintelligible, thereby reducing the total number of correct items in the group. As a result, it appears that information concerning what confusions were being made was lost due to the large number of unintelligible ratings. Thus, apart from the practiced listeners, there is additional information to be gained from using listeners who know in advance the feature the child is attempting to produce.

In neither test of prosodic-feature production was there a significant difference in the mean scores of the hard-of-hearing and deaf groups. In fact, on both tests, the deaf children as a group scored higher than the hard-of-hearing group on items testing stress. This was an entirely unexpected finding. A more detailed analysis of the utterances produced by the children on the test of prosodic-feature production showed that the problem seemed to be twofold. First, some hard-of-hearing subjects produced utterances with stress placed on syllables other than the target syllable. The utterances were acceptable in normal conversational speech, but were not appropriate for the test. The children seemed to be following their own internalized rules for where stress should occur in a given group of words, which accounted for low scores on production of stress items by the hard-of-hearing group.

Second, the deaf group obtained fairly good scores on production of items testing stress. Analysis of their production showed that they often placed stress on the appropriate syllable, but they frequently exaggerated its production. Excessive intensity, pauses before the target syllable, or excessive duration were cues used by the deaf group to produce stress. The result was that the feature of stress was conveyed, but to the detriment of other features.

In an attempt to verify this interpretation of the data, prosodic-production skills were analyzed again, this time with particular concern for the naturalness of production.

On the test of prosodic-feature production, the six stress items were listened to again by two listeners.

One had not previously served as a listener, and the other was one of the original three who evaluated the test performance. The two listeners indicated whether they believed the utterance sounded natural. If the stress pattern of the utterance sounded as if it might have been produced in ordinary conversation, it was rated "natural" regardless of where the stress occurred in the sentence. If the utterance was produced with excessive stress on a word, or in a way that would seem abnormal in normal conversational speech, it was rated "unnatural." A score was derived for each child from the "natural" ratings given by the two raters relative to the total number of possible ratings.

Comparisons showed that the mean naturalness score was higher for the hard-of-hearing (50%) than for the deaf group (38%), whereas the correctness scores were higher for the deaf group. Thus, although the deaf children were producing something at the target location, they were not succeeding in producing something that would be acceptable in normal conversational speech. This is consistent with the general observation that training on a specific problem may result in marked improvement in that area at the expense of overall improvement. Stratton (1974) observed that although a tactile feedback display helped to develop intonation control that was clearly evident, improvement in intonation quality was only slight, and, occasionally, "the newly-acquired intonation was heard as being exaggerated, abrupt, or ill-timed" (p. 31).

Although test scores fail to show significant differences between the hard-of-hearing and the deaf groups, the rank order of correct production of prosodic features reported in the present study is in good agreement with findings of Levitt et al. (1976). In both cases, the children produced pause correctly most often, were better at producing stress later rather than earlier in a sentence, and were worst at producing the rising intonation characteristic of *yes/no* questions. The tendency of normal and deaf individuals to prolong the duration of the sentence- or phrase-final syllable (Nickerson, Stevens, Boothroyd, & Rollins, 1974) may account for better scores on items testing stress late in the utterance compared with early in the utterance. Poor production of rising intonation for questions has been noted by McGarr (1976), Phillips, Remillard, Bass, and Pronovost (1968), and Stratton (1974). Phillips et al. also reported the tendency for the deaf to use increased intensity rather than pitch change to mark rising intonation. This is in agreement with the kinds of errors reported for the present test group because they frequently produced late stress for question intonation.

For the Contextual Prosodic Production Test, all nine test items were evaluated by the two listeners for correctness of production of the target feature and for naturalness of production of the utterance. Although there was no significant difference between the deaf and hard-of-hearing groups on correctness of production, the hard-of-hearing children were significantly more natural in their reading than were the deaf children ($F = 149.5$, $df = 1$, $p < .05$).

Scores for correctness improved significantly with training ($F = 768.0$, $df = 1$, $p < .05$) for both the hard-of-hearing and the deaf groups. There were, however, no apparent changes in naturalness as a result of training. This implies that training can be effective in improving performance on a specific feature, but not necessarily on more global characteristics. It seems, however, that more extensive training, or training that is geared specifically toward improving naturalness, may be necessary to incorporate naturalness into the way the feature is produced. When Stratton (1974) used a tactile device for training intonation, he too found no noticeable difference in the quality of his subjects' speech, even though he did find improvement in production of pitch contours after training.

The sequential question and answer series used in the Contextual Prosodic-Production Test was an attempt to devise a more natural test of prosodic-feature production. In the test, each of three groups of questions and answers began with a question that was answered by the second utterance in the group. If the sentence was read properly as an answer to the question, stress had to fall on a specific syllable. In this way, specific features were tested as they might be called for in normal conversational speech. In the future, children must be given contextual materials with which they can familiarize themselves before being asked to read test utterances. If the materials are properly designed, special features would be required for appropriate reading. For example, the question might be, "What is blue?" The response given is, "My *hat* is blue." In this utterance there should be no doubt as to which word receives primary stress. By controlling for specific features being produced, it might be possible to rank order the features that detract most from the deaf speaker's speech intelligibility. This might also be accomplished by giving the listener a system whereby he rates not only correctness of production but naturalness as well.

Speech Intelligibility (Isp)

Three raters, each of whom was experienced in listening to the speech of the deaf, rated the intelligibility of each of the 43 children on each of the two spontaneous speech samples. An average of those six ratings was obtained for each child. There was a significant difference between the mean ratings of the hard-of-hearing and the deaf groups ($t = 2.99$, $df = 41$, $p < .005$). The mean intelligibility ratings were 4.35 for the hard-of-hearing and 3.55 for the deaf children.

Figure 8.5 shows the distribution of intelligibility ratings for the hard-of-hearing and deaf children. The NTID 1–5 rating scale for intelligibility (Johnson, 1975) was used. A rating of 5 represented highly intelligible speech, and a rating of 1 meant that speech could not be understood. The distribution shows a heavy concentration of 4 and 5 ratings for the hard-of-hearing groups, whereas

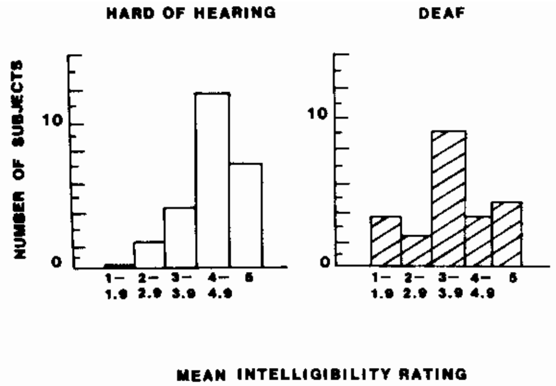

FIGURE 8.5. Distribution of intelligibility ratings, Isp.

there is a wider distribution of ratings for the deaf group. Seventy-five percent of the deaf children had mean ratings between 3 and 5; 40% were between 3 and 3.99, and 35% were between 4 and 5. In comparison, 91% of the hard-of-hearing children had mean ratings between 3 and 5, 17% were between 3 and 3.99, and 74% were between 4 and 5.

The six nonreaders in this study (see this chapter's earlier section on phoneme production) had an average intelligibility rating of 3.97, which was not significantly different from the average rating for the whole group of readers (3.98).

CONCLUSION

Performance for the mainstreamed hearing-impaired children on the phoneme-reception test showed similar kinds of errors for the hard-of-hearing and deaf groups with significantly greater errors for the deaf children. Items testing place and place-manner contrasts were most difficult for both groups of children. A comparison of the mainstreamed deaf children and the children in schools for the deaf showed similar patterns of errors, but scores were lower for those in schools for the deaf.

On the test of phonemic-production ability, the mainstreamed hard-of-hearing and deaf children showed strikingly similar patterns of errors, though significantly more errors occurred for the deaf group. Because the same test materials (Smith's sentences) were used for testing phonemic production in both the mainstreamed children and those not mainstreamed, a comparison of the results was possible. The results showed similar error patterns for both groups with a greater overall proportion of errors for the children in schools for the deaf. There were some differences in the nature of the errors, however; fewer glottal stops and fewer substitutions of /t/, /k/, and /b/ were observed in the speech of the mainstreamed deaf children.

The increased error rate in the group in schools for the deaf might be attributable to the fact that the mainstreamed children are frequently children who are taken out of or never put into schools for the deaf in the belief that they will be able to succeed in the integrated setting. This may be due to other factors (home environment, IQ, etc.), or it may be related to the fact that more of those not mainstreamed might be categorized as totally deaf. This point may be supported by the evidence that nonmainstreamed deaf children had lower overall scores on the Phoneme Reception Test. If it is the case that more of those children who are not mainstreamed belong in the totally deaf category, the children tested might be viewed on a continuum of hearing levels from hard-of-hearing to mainstreamed deaf to deaf children in schools for the deaf—with the last group representing a degree of hearing loss at which more significant breakdowns in phonemic reception and production may occur. However, one must not overlook the differences in educational settings, the opportunity to use manual communication, the need for less perfect oral skills, and the exposure to other deaf or less intelligible speech models in schools for the deaf.

The evidence seems to show that the nature of errors is fairly similar, although the frequency of errors varies with severity of loss. If this is true, the similarities mean that more generalized testing and training techniques might be used. Knowing the underlying pattern of errors leads to generalized handling of the problem.

Performance on the tests of prosodic-feature reception and production showed no significant differences in overall performance for the hard-of-hearing and deaf children. Overall rank order of correct production of features on the prosodic-production test was similar for the hard-of-hearing and deaf mainstreamed children and for the deaf children in schools for the deaf.

Closer observation of that performance for the mainstreamed children revealed two surprising findings:

1. In some instances (e.g., production of late stress) the deaf mainstreamed children did better as a group than did the hard-of-hearing children.

2. Question intonation, which was most difficult for both groups of children to produce, was not most often incorrect on reception tests.

With respect to the first finding, it appears that the deaf children were producing something interpreted as correct, although it would probably not be acceptable in normal conversational speech because of excessive duration or intensity changes to mark stress. With respect to the second finding, it appears that the children may have recognized some cue to changing pitch as opposed to durational and pitch cues that might have assisted them in recognizing stress as accurately as they recognized question intonation. However, they could not produce these subtle cues to changing pitch. For stress, they managed to produce an acceptable marking that the word was different from other words in the sentence, but not stress that is acceptable in normal conversational speech.

Both of these unexpected findings emphasize the need for more appropriate test materials. For this reason, sentence production was reevaluated for naturalness of production. Naturalness scores revealed that the hard-of-hearing children were, in fact, more natural than the deaf children in spite of better production scores for the deaf children. With this in mind, it was anticipated that the test evaluating pre- and posttraining scores for prosodic production would show signs of improvement in production scores. Correctness of production did increase, but naturalness did not. This is consistent with findings by Stratton (1974) that emphasis on one aspect of production may improve production of that feature but not improve overall performance.

This raises the question of whether our tests focus on the appropriate aspects of production. Should a more global approach be used in which one must produce the whole utterance correctly rather than just one feature, or should emphasis be put on success in correctness of production of a feature before training techniques to improve overall naturalness are introduced?

Before focusing on overall production ability, one must also recognize an essential problem in reception; that is, that in spite of fairly good low-frequency hearing for many of the hearing-impaired children, performance on recognition of pause and stress (much of which is thought to be carried by low-frequency information) was poor. It seems that the starting points in dealing with these problems of prosodic-feature reception and production ability might best be with emphasis on better recognition of pause and stress.

One of the overall concerns in dealing with hearing-impaired children is to determine the factors that contribute to their overall intelligibility. In this study it was found that although neither the pure-tone average nor performance on prosodic-feature reception tests correlated well with intelligibility, performance on the phoneme-reception test was a good predictor of a child's intelligibility ratings. In addition, performance on a phoneme-production test correlated highly with intelligibility ratings (.70), whereas performance on a prosodic-production test was not correlated highly with intelligibility ratings. This reinforces the previously described finding that the deaf children scored higher on a number of prosodic features tested, although their overall intelligibility was not better than that of the hard-of-hearing children. When naturalness of production was correlated with intelligibility ratings, correlations were high for pre- and posttraining (.71 and .67 respectively). This also points out the inadequacy of the tests of prosodic production as they exist today and supports the need for design of new contextually based tests to evaluate prosodic-feature production as it contributes to overall speech intelligibility.

ACKNOWLEDGMENT

This study was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Please see the acknowledgment in Chapter 1 for more detailed information on the many individuals and organizations who assisted and whose help is much appreciated.

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Chapter 9

Interrelationships Among the Speech and Language Measures

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The interrelationships among the many variables considered in this study are of interest for several reasons. First, it is of value to know which variables are closely related and which stand apart from the others. Second, this information can be used to develop a concise description of the data in which the major underlying factors are identified, and the relationships between those factors and the variables of interest are exposed. Third, using the underlying structure, it is possible to examine developmental trends, between-group differences, and within-group variations in a precise and systematic way. Finally, the process of examining the data in global terms is likely to provide new insights into language development and its relationship to communication skills in the hearing impaired.

Four types of analysis were employed. The first was the analysis of proximities (Shepard, 1962), which was used to provide a graphical summary of the degree of association between each pair of variables in a set of multivariate data. This method of analysis makes few assumptions about the data and is useful in providing a concise, pictorial overview of the many interrelationships involved.

The second method of analysis was a conventional factor analysis. An inherent and difficult problem in any multivariate correlational study is that of mutual correlations. Factor analysis is well suited to providing a simpler picture of the underlying pattern of mutual correlations, but at the cost of making several specific assumptions about the data. The details of those assumptions depend on which form of factor analysis is used (Lawly & Maxwell, 1963). The principal-components method was used in this study. A key assumption is that the many intercorrelations in the data are a result of mutual correlations with a few underlying factors. The identification of those factors is very much a matter of interpretation by the experimenter.

The third method of analysis was that of examining the scatter plots (or contingency tables) obtained between pairs of variables. This method is relatively free of assumptions, but it is both detailed and cumbersome when many variables are involved. To analyze the effects of interrelated variables in this context, a fourth technique, multiple linear regression, was used. A single, additive effect was assumed for each factor; those effects were then estimated using a least squares procedure.

The analyses that follow begin with a global analysis of all the variables involved using the analysis of proximities. That is followed by an examination of developmental trends using a factor analysis. The nature of the relationship between important pairs of variables is then examined in greater detail using scatter plots and contingency tables. The effects associated with each factor in the scatter plots of greatest interest were then estimated using multiple linear regression.

GLOBAL ANALYSIS

The interrelationships among hearing level, measures of communication, and overall measures of language ability are summarized in Figure 9.1. The diagrams take the form of proximity plots as obtained from an analysis of proximities (Shepard, 1962). The diagram on the left relates to children at schools for the deaf (10–11 years of age), and the one on the right relates to mainstreamed children of comparable age. Each point represents a measured variable. (In addition to the information provided in the caption, a glossary is provided in Appendix H that identifies the symbols used.) The distance between any two points is inversely related to the correlation between the variables represented by the two points. For example, the point W represents the ratings obtained

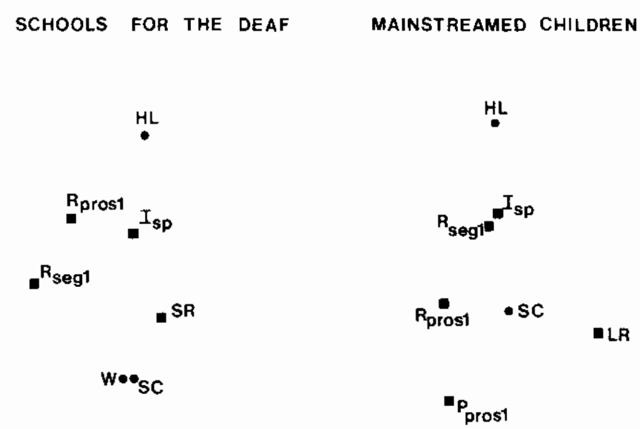

FIGURE 9.1. Proximity plots for communication and language measures. Each point represents one of the measures used. The distance between any two points is inversely related to the correlation between the measures represented by the two points (i.e., closely spaced points represent highly correlated measures).
HL = hearing level
Isp = speech intelligibility rating
$Ppros_1$ = production of prosodic features (1st version of test)
$Rpros_1$ = reception of prosodic features (1st version)
$Rpros_2$ = reception of prosodic features (2nd version)
$Rseg_1$ = reception of segmental characteristics (1st version)
SC = syntactic comprehension (average score, Test of Syntactic Abilities)
SR_1 = speechreading (Myklebust and Neyhus, 1970, test)
W = written language rating

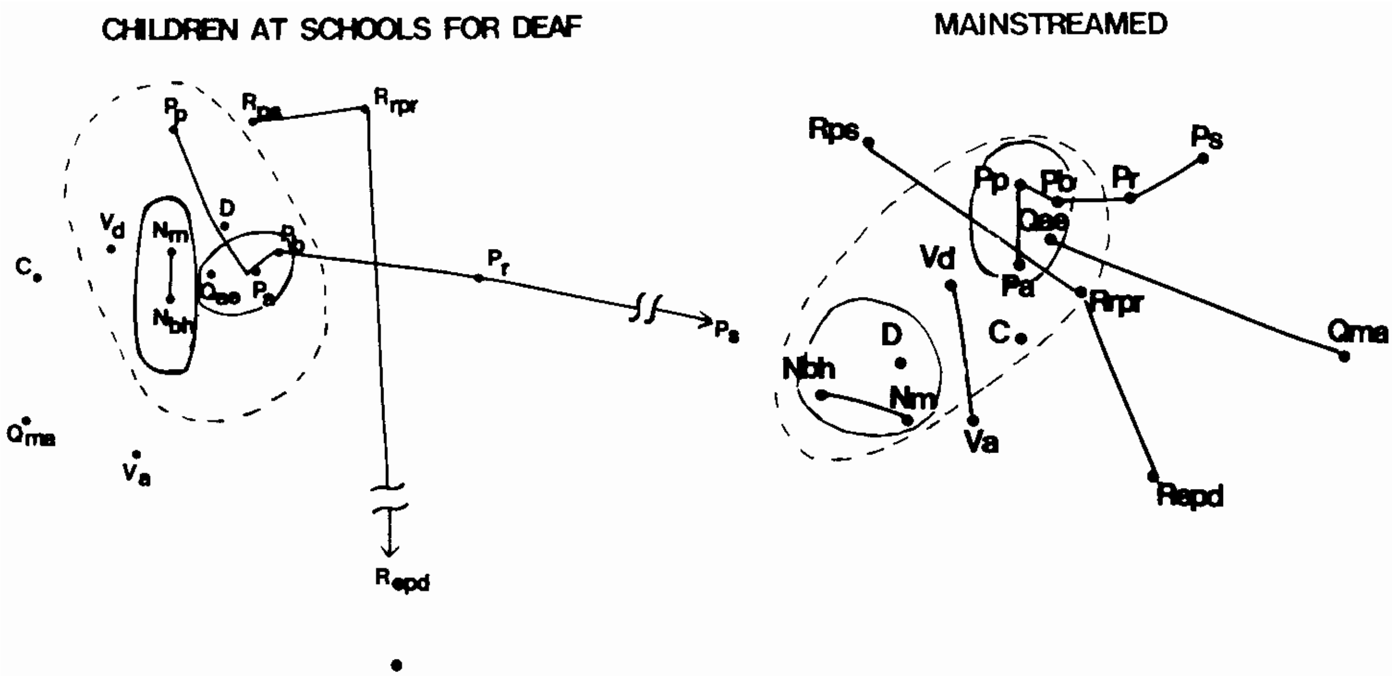

FIGURE 9.2. Proximity plots for subtests of Test of Syntactic Abilities (experimental edition). Each point represents a different subtest. The distance between any two points is inversely related to the correlation between the subtests represented by the two points. The two small regions encircled by solid curves contain subtests that are highly correlated with each other (ρ av = .72). The region encircled by a dashed curve contains subtests that are moderately correlated with each other (ρ av = .59).

C = conjunction
D = determiners
Nbh = negation, *be/have* forms
Nm = negation, modals
Pa = pronominalization, possessive adjectives
Pb = pronominalization, backwards pronominalization
Pp = pronominalization, personal pronouns
Pr = pronominalization, reflexive pronouns
Ps = pronominalization, possessive pronouns
Qae = questions, answer environment
Qma = questions, modals and auxiliaries
Repd = relativization, embedded and relative pronoun deletion
Rps = relativization, processing of an embedded sentence
Rrpr = relativization, relative pronoun referents
Va = verbal auxiliaries
Vd = verb deletion

on the written language samples, and the point SC represents syntactic comprehension, as measured by the Test of Syntactic Abilities (Quigley, Wilbur, Power, Montanelli, & Steinkamp, 1976). The points W and SC are close to each other, indicating a relatively high correlation between these two variables (p = .83). In contrast, the point HL, which represents hearing level, is some distance from both SC and W indicating a relatively low correlation between either SC and HL or W and HL. As the left diagram indicates, the correlation between hearing level and either of the two language measures, W or SC, is essentially zero (ρ = .002 and ρ = −.003, respectively).

The two proximity plots show essentially the same pattern for both groups of children although there are several important differences. The two plots have these common aspects:

1. Hearing level (HL) is much more closely correlated with measures of communication skill ($Rpros_{1\&2}$,[1] $Rseg_1$, Isp, SR_1) than with the measures of language ability (W, SC).

2. Of the communication measures, speech reading (SR_1) shows the highest correlation with the language measures and correlates least well with hearing level.

3. The intelligibility of a child's spontaneous speech production (Isp) correlates moderately well with his or her hearing level, but shows a higher correlation with measures of speech reception, such as $Rpros_{1,2}$ (reception of prosodic features) and $Rseg_1$ (reception of segmental features).

4. The relative degree of correlation among the various communication measures is much smaller, on the average, than among the language measures (see also Figure 9.2).

The main difference between the two sets of data is that the measure of syntactic comprehension (SC) shows a higher degree of correlation with hearing level (HL) for the mainstreamed children (ρ = .25) than for children at schools for the deaf (ρ = .003). The mainstreamed children also show a correspondingly higher degree of corre-

[1]The suffix identifies the version of the test that was used. $Rpros_1$ was used in the first year of the longitudinal study (children at schools for the deaf, 10–11 years of age). The improved version of the test, $Rpros_2$, was used with the mainstreamed children and in subsequent years of the longitudinal study. Aside from this difference, the same tests were used with the mainstreamed children and those at schools for the deaf. See Appendix H for a glossary of the symbols used.

lation, on the average, between SC and the various measures of communication skill. There were also differences in the plots resulting from changes in the test battery administered to the two groups of children, but the differences appear to be small and not consequential.

The information summarized in the proximity plots is consistent with that obtained in related studies. Smith (1975) reported that the intelligibility of a child's speech showed a higher degree of correlation with speech-discrimination ability than with the traditional measure of hearing loss, the pure-tone average at three selected frequencies. Essentially the same result was obtained here. For both groups of children, Isp was more highly correlated with the two speech reception measures, $Rseg_1$ and $Rpros_{1\&2}$, than with hearing level, HL.

Published data on speechreading ability do not show a strong link between speechreading ability and hearing level (Erber, 1975). Both normal-hearing and hearing-impaired persons have speechreading skills, although there is little need for the former to use those skills except under noisy or other difficult listening conditions. It is thus to be expected that the correlation between hearing level and speechreading ability (visual cues only) should be low. A slightly higher correlation is to be expected between speechreading ability and the two measures of speech reception ($Rseg_1$, $Rpros_{1\&2}$) because those children who are able to make good use of limited auditory cues are likely to be the same children who are able to make good use of limited visual cues.

The close association between written language ability and syntactic comprehension has already been established by Quigley and others (Quigley et al., 1976; Stuckless & Marks, 1966). The data obtained here show that of the many different measures obtained on the children (including reading level, IQ, and related measures, as discussed shortly), the highest correlation of all was obtained between the written language measure, W, and the measure of syntactic comprehension, SC.

Although other studies have examined the association between specific pairs of variables, the data reported here provide new information and new insights in that the interrelationships among a wide range of variables have been obtained for different groups of hearing-impaired children. Figure 9.1 provides a concise, graphical summary of the interrelationships for the communication measures, hearing level, and gross language measures.

The many subtests of the Test of Syntactic Abilities provide a rich source of information on how the various aspects of syntactic comprehension interrelate. Figure 9.2 shows the proximity plots for children at schools for the deaf (10–11 years of age) and mainstreamed children of comparable age. Each subtest is represented by a separate point. The points indicating subtests dealing with similar syntactic forms (e.g., the subtests on pronominalization) are joined together by a solid line.

As before, there are major similarities, as well as several differences, between the two proximity plots. Each plot consists of four regions: two regions of high correlation (enclosed by solid curves) within which the correlations between variables are relatively high (ρ av = .72), a region enclosed by a dashed circle within which moderately strong correlations exist between the variables (ρ av = .59), and an outer region where the correlations are relatively low (ρ av = .33). Essentialy the same variables fall into these four regions for the two groups of children. One region of high correlation includes the easier of the question subtests (questions in an answer environment, Qae) and the easier pronominalization subtests (possessive adjectives, Pa, and backwards pronominalization, Pb, for children at schools for the deaf; Pa, Pb, and personal pronouns, Pp, for mainstreamed children). The second region of high correlation includes the two subtests on negation (modals, Nm, and *be/have* forms, Nbh) and, for the mainstreamed children, the subtests on determiners, D.

The region of moderately high correlations, encircled by the dashed line, includes all of those subtests plus the subtest on verb deletion, Vd, and, for the mainstreamed children, the subtests on conjunction, C, and processing of relativized sentences, Rps.

For both groups of children, the outer region consists of subtests on which the children did not do well. Specifically, the subtests on verbal auxiliaries, Va; modal/auxiliary question forms, Qma; reflexive pronouns, Pr; possessive pronouns, Ps; and the more difficult subtests on relativization (embedding and pronoun deletion, Repd, and relative pronoun referents, Rrpr). For children at schools for the deaf, the subtest on processing of relativized sentences, Rps, and on conjunction, C, fell in the outer area.

The common pattern exhibited by the two proximity plots reveals several new facets of the data. The grouping of subtests into regions according to degree of mutual correlation shows that the subtests with the highest average scores were also the ones showing the greatest degree of mutual correlation. It is to be expected that subtests with very low scores would not correlate well, either with each other or with other subtests, because most of the children were guessing on most of the items in those tests. The subtests with very low scores (Repd, Ps, and Qma) thus fall on the outer periphery in each diagram. The points are far from each other, indicating low mutual correlations, (ρ av = .28) and, to a lesser extent, are relatively far from the central portion of the diagram, which contains the regions of high correlation.

Superimposed on this pattern is a second pattern showing links between the types of syntactic structure being tested and the format used in testing them. The relatively easy subtests not only correlate highly with each other, but also fall into two groups. One group contains the subtests on negation, the other contains the easier of the subtests on pronominalization and question formation. An important difference among the subtests in the two groups relates to their format. The subtests on negation involve judgments of grammaticality, whereas the subtests in the second group involve some processing of the syntactic form being tested, for example, responding to questions or selecting one of several pronoun forms.

The distinction between these two groups of subtests extends beyond the two regions of high correlation. All of the subtests involving judgments of grammaticality (i.e., Nm, Nbh, D, Vd, Va, and, to a lesser extent, Qma) are more highly correlated with each other than with those subtests involving some degree of processing (Qae, Pa, Pb, Pp, Pr, Rps, Rrpr). The latter subtests, in turn, are more highly correlated with each other. The points representing these subtests lie to the upper right of each proximity plot; the points representing the subtests involving judgments of grammaticality lie to the lower left in each diagram. The only exceptions to this trend involve subtests for which relatively low scores were obtained (Repd, Ps, and, for the mainstreamed children, Qma).

A third trend was also evident in that subtests of similar format involving similar syntactic forms were more highly correlated with each other than with other subtests. Note the close correlation between Nm and Nbh, between Vd and Va, and between the easier of the subtests on pronominalization. This trend is maintained even within the region of relatively low correlation. The point representing the subtest on reflexive pronouns, Pr, for example, is fairly close to both Pb (backwards pronominalization) and Ps (possessive pronouns) as well as to Rrpr (relativization using relative pronouns referents). The average correlation between Pr and the other pronoun forms is .52, whereas that between Pr and other subtests in the outer region not involving pronouns is .31.

In summary, the proximity plots exhibit three basic trends:

1. The easier subtests group together, whereas the most difficult subtests are widely spaced along the periphery of the diagram. This trend is, in part, a result of a statistical artifact in that the subtests with the lowest scores involve a good deal of random guessing, and correlations are thus lower as a result of the random variability in the measurements.
2. The subtests divide into two broad groups according to the test format. Subtests involving judgments of grammaticality fall to one side of the proximity plot, but those involving some degree of processing of the syntactic form being tested fall to the other side.[2]
3. Subtests involving similar syntactic forms correlate more highly with each other, on the average, than with other subtests.

The trends observed were the same for both the mainstreamed children and those attending schools for the deaf. The major difference between the two groups was the degree of correlation observed between the many variables. Correlations were slightly higher, on the average, for the mainstreamed children, and, as a result, the regions of high correlation included more points for the mainstreamed children.

A third aspect of the data that is of particular interest involves the interrelationships among background variables. Figure 9.3 shows a proximity plot for the major background variables. Because it was difficult to obtain

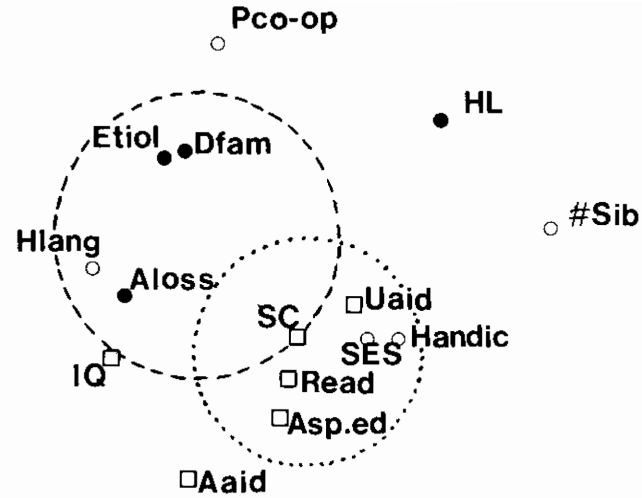

FIGURE 9.3. Proximity plot for background variables. Each point represents a separate variable. The distance between any two points is inversely related to the degree of interdependence between the two variables (i.e., closely spaced points show a high degree of interdependence). The variables enclosed within each of the circles show a statistically significant interdependence with each other (as obtained from chi-square contingency tables).

Aaid	= age hearing aid first fitted
Asp.ed	= age special education began
Aloss	= age at onset of loss
Dfam	= deafness in family
Etiol	= etiology
Handic	= other handicaps
HL	= hearing level
Hlang	= home language (includes sign)
IQ	= intelligence quotient
Pco-op	= parental cooperation
Read	= reading score
SC	= syntactic comprehension
SES	= socioeconomic status
Uaid	= use of hearing aid
#Sib	= number of siblings
●	= etiological variable
□	= educational variable
○	= other variables

reliable information on early audiological and educational history for the mainstreamed children, the diagram relates only to children at schools for the deaf. The variables shown have been subdivided into three groups: *etiological* variables, *educational* variables, and *other* variables. The subdivision of the variables into these three groups is necessarily arbitrary in a few cases, but useful overall for interpreting the results.

The etiological variables are: etiology (Etiol), age at onset of hearing loss (Aloss), deafness in the family (Dfam), and hearing level (HL). The educational variables are: age when hearing aid first fitted (Aaid), age at onset of special education (Asp.ed), intelligence quotient (IQ), reading score (Read), syntactic comprehension (SC), and use of hearing aid (Uaid). The other variables are: other handicapping conditions (Handic), home language (Hlang), parental cooperation (Pco-op), socioeconomic status (SES), and number of siblings (#Sib).

The background data were obtained from school records and from assessments provided by the teachers. For

[2]Note that an experimental version of the Test of Syntactic Abilities was used. The final version uses a common format for all of the subtests.

example, additional handicapping conditions included children identified as "minimally brain damaged" or "retarded" according to school records, as well as children rated by their teachers as having severe (disruptive) behavioral or emotional problems. Children with correctible visual defects were not included in this category. Because the background variables involve discrete categories (e.g., home language is either English, sign, or other), for the most part a contingency-table analysis was used for each pair of variables. The distance between any two points in this case is inversely related to the normalized chi-square measure of contingency. The closer any two points, the larger the value of chi-square and the greater the degree of contingency between the two variables.

The proximity plot shown in Figure 9.3 appears to consist of two clusters of points and several outlying points. The first cluster, encircled by a dashed line, includes most of the etiological variables (Etiol, Dfam, Aloss), as well as home language (Hlang) and syntactic comprehension (SC). With a few exceptions, all of the points within that cluster are significantly interrelated with each other (significance level less than .05), but show a small to negligible relationship with variables outside of the dashed circle.

The second cluster, encircled by a dotted line, is centered roughly on the points representing the two performance measures (Read, SC). Most of the variables represented in this cluster interrelate significantly with each other and show a small to negligible correlation with variables lying outside of the encircled area. The variables represented by points lying outside of the two clusters do not correlate significantly with each other or, for the most part, with other variables. There are a few exceptions to this pattern; specifically, age at which hearing aid first fitted (Aaid) is closely related to age at commencement of special education (Asp.ed.). There is also some degree of association between hearing level (HL) and etiology (Etiol), between parental cooperation (Pco-op) and hearing-aid use (Uaid), and between parental cooperation (Pco-op) and deafness in the family (Dfam).

The statistically significant relationships observed were generally consistent with expectation. For example, children commencing special education at an early age showed higher reading scores, on the average, than those beginning special education later in life. Similarly, children with good reading scores also scored well on the Test of Syntactic Abilities. One of the less obvious associations was that between home language and age at onset of hearing impairment. A statistically significant interrelationship between these two variables was observed because all of the children with sign as their home language were born of deaf parents and were diagnosed as being deaf early in life.

A revealing aspect of the proximity plot is that one of the clusters includes variables that are beyond the control of educators and clinicians, whereas the other cluster includes variables well within their control. For example, there is nothing that educators or clinicians can do about the etiology of hearing impairment, the age at onset of the hearing impairment, whether or not other members of the family are deaf, or the child's home language. All of these are variables in the first cluster. On the other hand, clinicians and educators have considerable influence over the age at which special education is initiated, reading score, the child's use of a hearing aid, and, to a lesser extent, those aspects of socioeconomic status that are associated with the child's ability to learn. The latter variables belong to the second cluster. Syntactic comprehension shows a significant interaction with both groups of variables, but the degree of association is greater with the variables under the educator's control. One exception is the degree of association with additional handicapping conditions (Handic); children with additional handicaps scored consistently lower on the Test of Syntactic Abilities, as well as on almost all other measures of performance.

These observations emphasize the important role of special education. Although the data are essentially correlational in form and do not necessarily imply causal relationships, there is good reason to believe that the good scores on the various measures are the direct result of good teaching, and in particular, they are the result of early, effective intervention. This issue is addressed again later in the chapter.

DEVELOPMENTAL TRENDS

Developmental changes are best summarized through use of a factor analysis. This method of analysis presents the structures uncovered in Figures 9.1 and 9.2 in a new light. The results of the factor analysis of the first and last years of the longitudinal study are shown in Figure 9.4. In the scores for both years, the same two factors accounted for the bulk of the variance.

The first factor, shown on the horizontal, appears to be related directly to language ability. The written language samples (W) and virtually all of the subtests in the Test of Syntactic Abilities show a high positive value (i.e., weight) for this factor. The only subtests for which this did not occur were those on which the children did particularly poorly (relativization involving embedding and pronoun deletion, Repd, and possessive pronouns, Ps). The first factor is referred to as the Language Factor because of its close association with the various language measures.

The second factor, shown on the vertical axis, appears to relate to that aspect of communication ability most closely related to residual hearing. Hearing level, as measured by the pure-tone averages of 500, 1000, and 2000 Hz, has a large negative weighting on this factor. This is to be expected because the larger the hearing level, the poorer the hearing-related component of the child's communication skills. All of the measures of communication ability show a large positive weighting on the second factor. Of these, the tests measuring reception and production of segmental features ($Rseg_{1\&2}$, and $Pseg_{1\&2}$, respectively) showed the highest weighting. The tests measuring reception and production of prosodic features ($Rpros_{1\&2}$, and Ppros, respectively) also show a

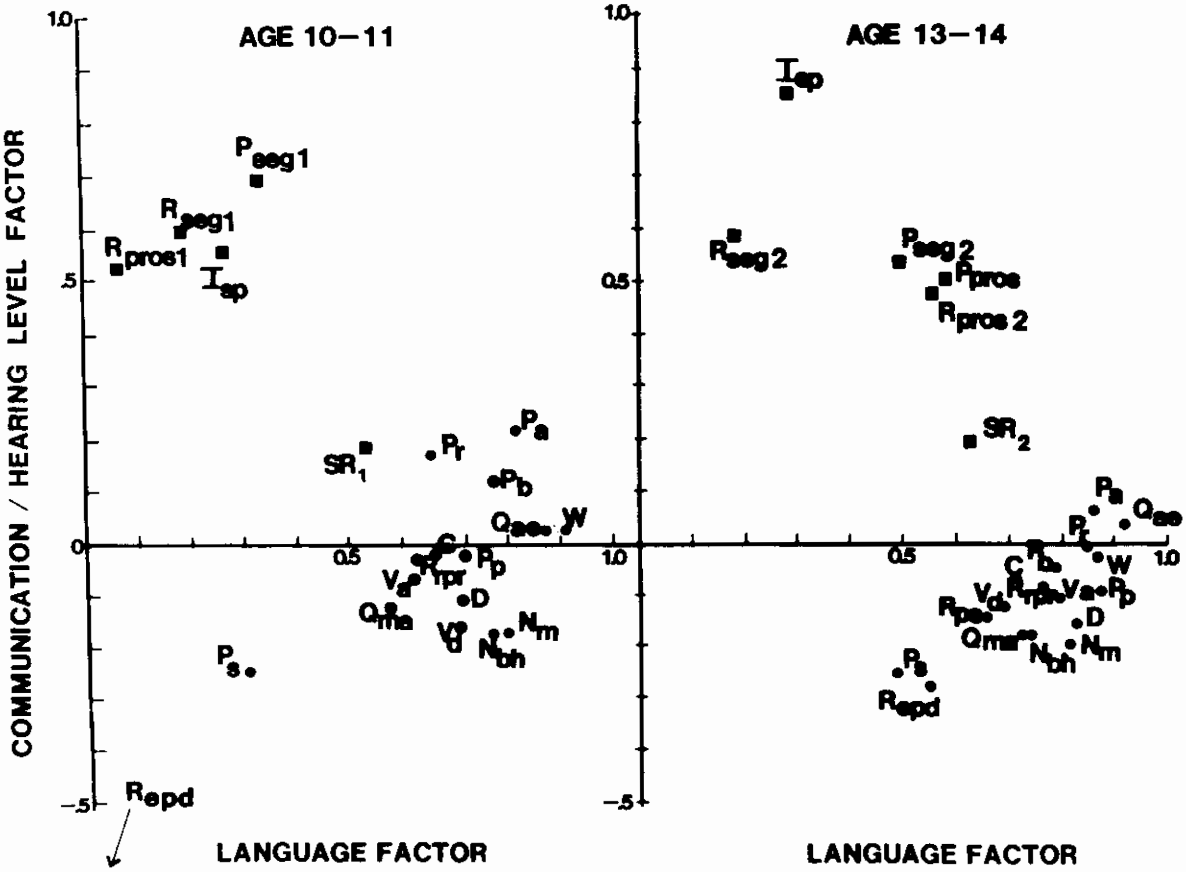

FIGURE 9.4. Factor analysis for first and last years of longitudinal study. Two factors accounted for almost all of the variance. Factor 1, the Language Factor, is shown on the horizontal axis. Factor 2, the Communication/Hearing-Level Factor is shown on the vertical axis. The solid rectangles represent communication measures, the solid discs represent language measures.

C	= conjunction
D	= determiners
HL	= hearing level
Isp	= speech intelligibility rating
Nbh	= negation, *be/have* forms
Nm	= negation, modals
Pa	= pronominalization, possessive adjectives
Pb	= pronominalization, backwards pronominalization
Pp	= pronominalization, personal pronouns
Pr	= pronominalization, reflexive pronouns
Ps	= pronominalization, possessive pronouns
Ppros	= production of prosodic features
$Pseg_1$	= production of segmental characteristics, 1st test version
$Pseg_2$	= production of segmental characteristics, 2nd version
Qae	= questions, answer environment
Qma	= questions, modal and auxiliaries
Repd	= relativization, embedding and relative pronoun deletion
Rps	= relativization, processing of an embedded sentence
Rrpr	= relativization, relative pronoun referents
$Rpros_1$	= reception of prosodic features, 1st version of test
$Rpros_2$	= reception of prosodic features, 2nd version
$Rseg_1$	= reception of segmental characteristics, 1st version
$Rseg_2$	= reception of segmental characteristics, 2nd version
SR_1	= speechreading, Myklebust and Neyhus test
SR_2	= speechreading, LCS test
Va	= verbal auxiliaries
Vd	= verb deletion
W	= written language rating

heavy weighting on this factor. Note that Ppros was not measured in the first year of the study. Note also that although the tests on communication skills were modified during the course of the longitudinal study (hence the suffixes 1 & 2), the changes did not produce significant changes in the location of these tests in the factor diagrams. The second factor is referred to as the Communication/Hearing-Level Factor because of its close association with these measures.

There is a clear link between the proximity plots of Figure 9.2 and the factor diagrams in Figure 9.4. The variables falling within the two high correlation regions in the proximity plots have the highest values (i.e., weights) on the Language Factor. In particular, the subtest on questions in an answer environment (Qae), which lies roughly at the center of the larger of the two high correlation regions, shows the highest weighting on the Language Factor. It should also be noted that the subtests involving some processing of the syntactic forms being tested (as opposed to judgments of grammaticality) have a small positive weighting on the Communication/Hearing-Level Factor. This may be because the hearing-impaired children who have better speech communication skills are slightly better at those syntactic forms that occur more frequently in spoken language (e.g., responding to questions and the much heavier use of first-person pronoun forms).

The factor analysis shows a clear separation between the Language and the Communication/Hearing-Level factors. With few exceptions, the language measures are heavily weighted on the Language Factor but show small weights on the Communication/Hearing Level Factor. The exceptions are those measures for which the average scores were close to random guessing in the first year of the longitudinal study (Repd, Ps). The heavy weights shown by these variables on the Communication/Hearing-Level Factor during the first year are believed to be a chance effect caused by random guessing. One of the strengths of the analysis of proximities over factor analysis is that it helps separate low correlations due to random variability from low correlations due to other causes. (Variables subject to the former are widely dispersed around the periphery of the proximity plot.)

The communication measures, in contrast to the language measures, show a significant amount of weighting on both factors; that is, in addition to showing large weights on the Communication/Hearing-Level Factor, they also show some positive weighting on the Language Factor. This may be because good communication skills are not essential in order to do well on the language tests, but some language skills are essential in order to communicate effectively.

Of the communication skills evaluated, speechreading showed the largest weighting on the Language Factor and the smallest weighting on the Communication/Hearing-Level Factor. This result is consistent with that observed in the proximity plots of Figure 9.1 in which speechreading was found to straddle the region between the communication and language measures.

The effect of developmental changes on the interrelationships between variables should show up as changes in the structure of the factor diagram. The two diagrams cover the first and last years of the longitudinal study and therefore encompass any major changes that took place over the 4-year period. For the most part, the changes observed were small and evolved gradually over the 4 years. Two exceptions to this process of gradual change involved the measurement of prosodic feature reception ($Rpros_{1\&2}$) and the subtest on relativization by means of embedding and relative pronoun deletion (Repd).

The location of Repd in the factor diagram moved from a negligibly small weighting on the Language Factor and a relatively large negative weighting on the Communication/Hearing-Level Factor to moderate weightings on both, as shown by the location of Repd in the right-hand diagram. Repd was a relatively difficult test, and it was evident that most of the children were guessing at random on most of the test items during the first year of the longitudinal study. Average performance on the test improved over the years from almost random guessing to well above the chance level of performance. As performance improved above chance, the location of Repd in the factor diagram moved closer to that of the other language subtests.

The weighting of $Rpros_1$ on the Language Factor increased dramatically from .07 to .56 after the first year. $Rpros_1$ was a difficult test, and there was also a good deal of random guessing on this test during the first year. The format of the test was subsequently modified ($Rpros_2$ was administered during the third and fourth years of the longitudinal study), but there were no marked changes in the location of $Rpros_2$ in the factor diagram associated with the change in format.

In short, the largest changes that were observed in the structure of the factor diagram appear to be a result of the fact that excessively variable data were obtained on two tests during the first year of the study and not to any major developmental changes affecting the interrelationships among variables.

Three gradual changes in the structure of the factor diagram were observed over the years. The first showed a systematic increase in the weighting of the overall measure of speech intelligibility, Isp, on the Communication/Hearing-Level Factor. The second showed a gradual increase in the weightings of the language measures on the Language Factor. The third gradual change was a reduction in the spread of weightings of the language measures.

A possible explanation for the first effect is that speech intelligibility improved gradually over the years for those children with better residual hearing. This resulted in a systematic increase in the correlation between overall speech intelligibility and the Communication/Hearing-Level Factor.

The second effect appears similar in form. As language skills improved, the correlation between the language measures and that factor associated with language increased. The increase in weighting on the Language Factor appears to be less than the increase in weighting of speech intelligibility on the Communication/Hearing-Level Factor, but this may be a result of a ceiling effect in that measures with a relatively high weighting at the outset can only show a small further increase in weighting. For example, the weighting of Qae on the Language Factor increased from .87 in the first year to .92 in the fourth year of the study, an increase of only .05. However, given the inherent variability of the test scores, a weighting much in excess of .92 would be difficult to achieve. In contrast, the subtest on possessive pronouns, Ps, increased its weighting on the Language Factor from .31 to .49 over the 4-year period of the study. Note that this was one of the more difficult subtests and that initially the range of scores on this subtest was small; not many of the children scored significantly above the chance level in the first year of the study.

The third observed change, the reduction in the spread of weighting of the language measures on the Language Factor, appears to be a concomitant of the preceding two effects. That is, as speech and language skills improve, the association of the first factor with language ability and the second factor with hearing/communication ability becomes stronger. A related effect is that the proportion of the variance accounted for by the two factors increased as the spread of the weightings decreased. At the beginning of the longitudinal study, the first two factors accounted for 76% of the variance. By the fourth year, those two factors accounted for 90% of the variance.

In summary, although the longitudinal study showed marked developmental effects, particularly among the language measures, those developmental changes had only a secondary effect on the interrelationships between the measured variables. A factor analysis on all of the measures showed that two major factors accounted for the bulk of the variance. The first factor was related to language, the other to communication and hearing ability. With the exception of tests that had high test-retest variability, the weightings of the various measures on these two factors changed only slightly over the years. The slight changes that were observed were in the direction of increasing the weighting of the language measures on the Language Factor and increasing the weighting of the communication measures on the Communication/Hearing-Level Factor. Concomitantly, the proportion of the variance accounted for by the two factors increased over the years.

SYNTACTIC COMPREHENSION, SPEECH INTELLIGIBILITY, AND HEARING LEVEL

Hearing level is a traditional audiological measure that is commonly used as part of a larger test battery for assessing degree of hearing impairment. The most common form of this measure is the average hearing loss for tonal stimuli at 500, 1000, and 2000 Hz. Although hearing level by itself provides an incomplete picture of the hearing-impaired person's auditory processing capabilities, it is nevertheless widely used as a gross indicator of degree of impairment. It is thus of particular interest to examine how language and communication skills relate to hearing level and how other relevant factors influence this relationship.

The two measures chosen for detailed consideration are syntactic comprehension (SC), as measured by the average score on the Test of Syntactic Abilities, and overall speech intelligibility (Isp). The former, being an average of all the language subtests, showed a higher average weighting on the Language Factor and was also highly correlated with the written language measure. Isp was chosen because it showed the highest weighting over the years on the Communication/Hearing-Level Factor.

Figures 9.5(A) and (B) show the overall measure of syntactic comprehension, SC, plotted against hearing level. Two diagrams are used to emphasize the differences between children who are typically included in studies of this type and those who are often excluded to maintain "homogeneity" in sampling. Specifically, Figure 9.5(A) shows data for prelingually hearing-impaired children with no additional handicapping conditions and whose first language was either English or sign. In contrast, Figure 9.5(B) shows data for children who do not meet these criteria. The children are further subdivided according to those factors found to be significant in the preceding correlational analysis. Children who received special education from age three or younger are identified by the symbol E, and children of deaf parents are identified by the symbol D. Children at schools for the deaf who have not received special education from an early age and whose parents are not deaf are represented by open circles. Mainstreamed hearing-impaired children are represented by solid discs. Note that information on early special education and parental hearing was not available on the mainstreamed children. A child rated as a poor hearing-aid user is identified by a horizontal bar through the symbol representing that child. Similarly, a bar under a symbol indicates that the child is from a disadvantaged home (low socioeconomic status). A symbol encased with a U indicates that the child had a U-shaped audiogram with some high-frequency residual hearing.

The rationale for treating children with high-frequency residual hearing as a separate group is based on the findings of Berlin and colleagues (Berlin, Berlin, & Halperin, 1977; Berlin, Wexler, Jerger, Halperin, & Smith, 1978) and Collins, Cullen, & Berlin (1978), who reported superior speech skills for persons with profound hearing loss in the middle frequencies but only moderate hearing loss in the high frequencies (above 8 kHz). Unlike the subjects in the above-mentioned studies, the children with high-frequency residual hearing in this study had severe hearing losses in the high frequencies. The important audiological characteristic demonstrated by these children is that their hearing loss at 8 kHz was less than that at 4 kHz.

The average relationship between syntactic comprehension and hearing level is shown by the solid line in Figure 9.5(A) . This average relationship was obtained empirically by computing the mean score for each decade of hearing level and joining the means by a solid line.

The data in Fig. 9.5(B) are for groups of hearing-impaired children known to differ significantly from the general average. In this figure, postlingually hearing-impaired children are identified by the symbol P, those from non-English-speaking homes (mostly Spanish-speaking) by an N, those with additional handicapping conditions by an H (most of these children were identified in their school records as being either "retarded" or "minimally brain damaged"), and children with severe behavioral or emotional problems by a B.

Children falling into two or more such categories are identified by all the relevant symbols enclosed in a circle. Mainstreamed children from non-English-speaking homes are identified by a small solid disc above the symbol N. As in the previous figure, children from disadvantaged homes are identified by a small horizontal bar under their symbols. A horizontal through the middle of the symbol indicates a poor hearing-aid user. To provide a common reference between the two figures, the curve

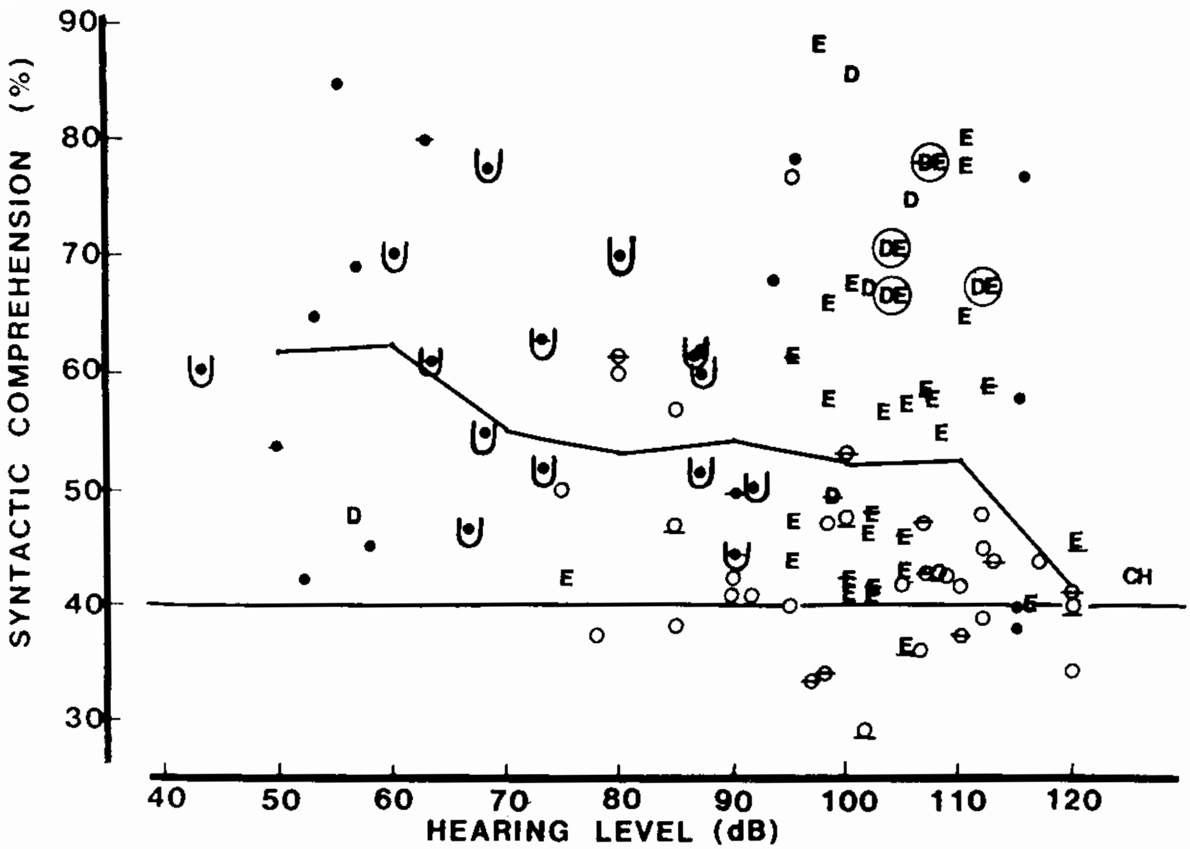

FIGURE 9.5(A). Syntactic comprehension as a function of hearing level—"typical" deaf children. The solid curve shows mean score for children averaged over each decade of hearing levels (e.g., mean score at 60 dB is the average score for children with hearing levels between 55 and 65 dB).
D = deaf parents
E = early special education
U = high-frequency hearing (U-shaped audiogram)
O = children at schools for the deaf and neither of above
● = mainstreamed children
bar below symbol = low socioeconomic status
bar through symbol = poor use of hearing aid
A circle encloses two or more characteristics associated with a single child.

showing the general average in Figure 9.5(A) is reproduced in Figure 9.5(B).

Speech intelligibility, Isp, is plotted against hearing level in Figures 9.6(A) and 9.6(B). These figures are analogous in form to Figures 9.5(A) and 9.5(B).

Both sets of data show a reduction in average performance with increasing hearing level. The extent of the reduction, however, is much greater for speech intelligibility. The average intelligibility rating, Isp, decreased steadily from close to the maximum at a hearing level of 50 dB to close to the lowest rating (unintelligible speech) at a hearing level of 120 dB. In contrast, the average score on the Test of Syntactic Abilities decreased only slightly with increasing hearing level.

The average curve relating syntactic comprehension to hearing level is relatively flat over the region from 80 to 110 dB. This region includes almost all of the children at schools for the deaf, and, as reported earlier in this chapter, the correlation between the average measure of syntactic comprehension and hearing level is essentially zero for this group of children. There appears to be a sharp drop in relative performance for hearing levels in the vicinity of 120 dB. There were, however, only five children with such profound hearing losses, and the reliability of this last point on the average curve is well below that of other points on the curve.

The curve relating speech intelligibility to hearing level shows some evidence of leveling off in the vicinity of 100 and 110 dB, followed by a further drop at 120 dB. As noted above, there were relatively few children with hearing levels in the vicinity of 120 dB. These observations are supported by data obtained independently by Boothroyd (1970, 1984) and by Smith (1975). (See also Stark, 1974, pp. 35–47, for a summary and discussion of the Boothroyd, 1970, and Smith, 1975, data.) In both the Boothroyd and Smith studies, the curve relating speech intelligibility to hearing level shows a leveling off at about 90 or 100 dB. Smith did not consider children with extremely poor audiograms, hence her data provide no information on speech intelligibility for the most pro-

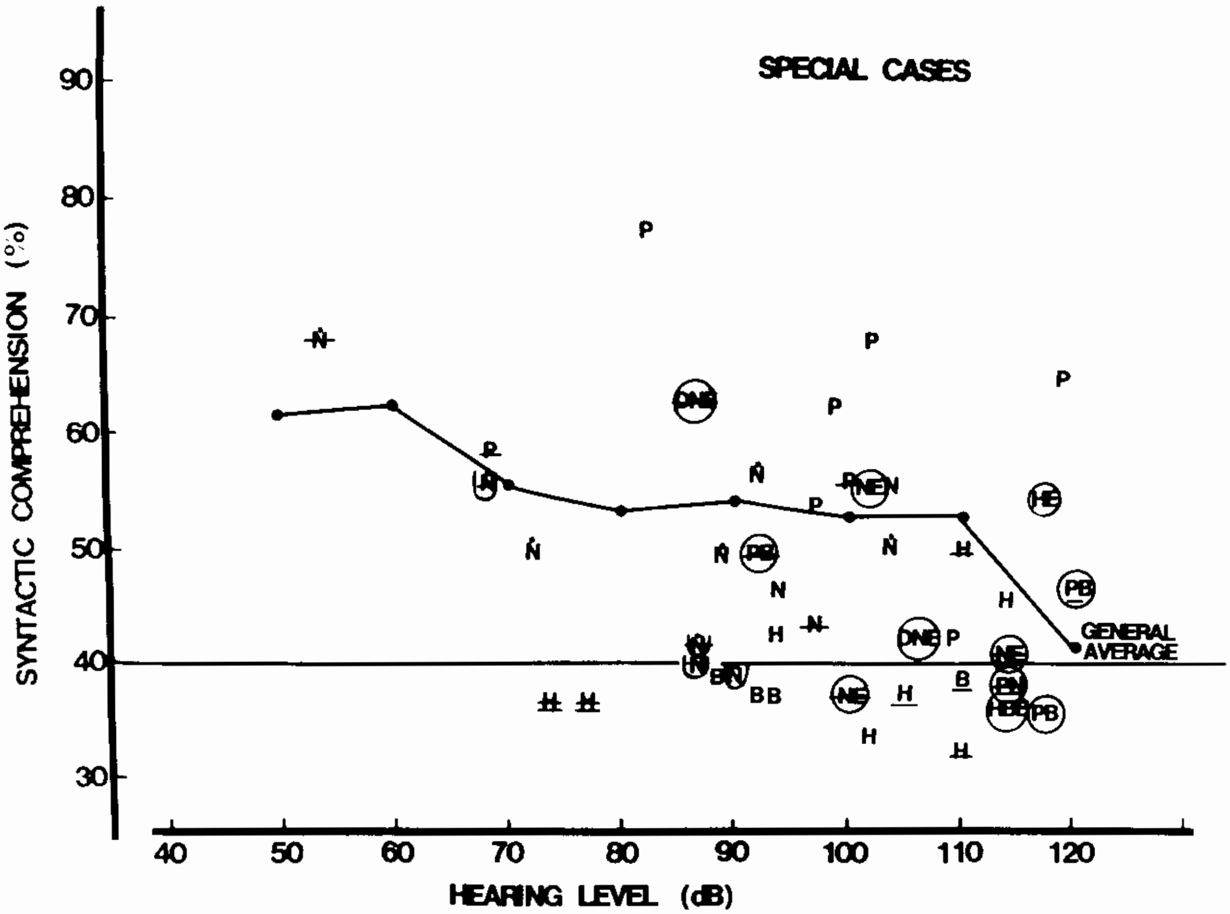

FIGURE 9.5(B). Syntactic comprehension as a function of hearing level—special cases. The solid curve shows the average score for "typical" deaf children taken from Figure 6.5(A).
B = severe behavioral/emotional problems
D = deaf parents
E = early special education
H = other handicaps ("minimally brain damaged"; "retarded")
N = non-English-speaking home (not including sign language)
P = postlingually hearing impaired
U = high-frequency hearing (U-shaped audiogram)
● = mainstreamed
bar through symbol = low socioeconomic status
bar below symbol = poor use of hearing aid
A circle encloses two or more characteristics associated with a single child.

foundly hearing impaired. Boothroyd (1984), however, reported that although there is little change in average speech intelligibility with hearing levels in the vicinity of 100 and 110 dB, there is a marked drop in intelligibility for the most profoundly impaired children. Here again, the number of children with hearing losses of this severity was small (seven children).

A striking feature of the data is the large dispersion of both the intelligibility data and the data on syntactic comprehension about their respective average curves. In many instances, extremes of performance were obtained for children with the same hearing level. For example, several children with hearing levels of 100 dB obtained close to the maximum score on syntactic comprehension, whereas others with the same hearing level were close to the chance level of performance. Similarly, several children with a hearing level in the vicinity of 80 to 90 dB obtained the maximum intelligibility rating while others with the same hearing level obtained the minimum rating.

It is likely that a significant reduction in the spread of the intelligibility data can be obtained by using an improved measure of residual hearing, one that takes into account the processing of speech by the impaired auditory system. Levitt, Smith, and Stromberg (1974) have shown that improved predictions of speech intelligibility can be obtained using relative performance on a speech-discrimination test as a measure of residual hearing. Alternative methods of classifying hearing impairment on the basis of speech-pattern audiometry have also been suggested by Erber (1974), Fourcin (1976), Martony, Risberg, Spens, and Agelfors (1972) and others.

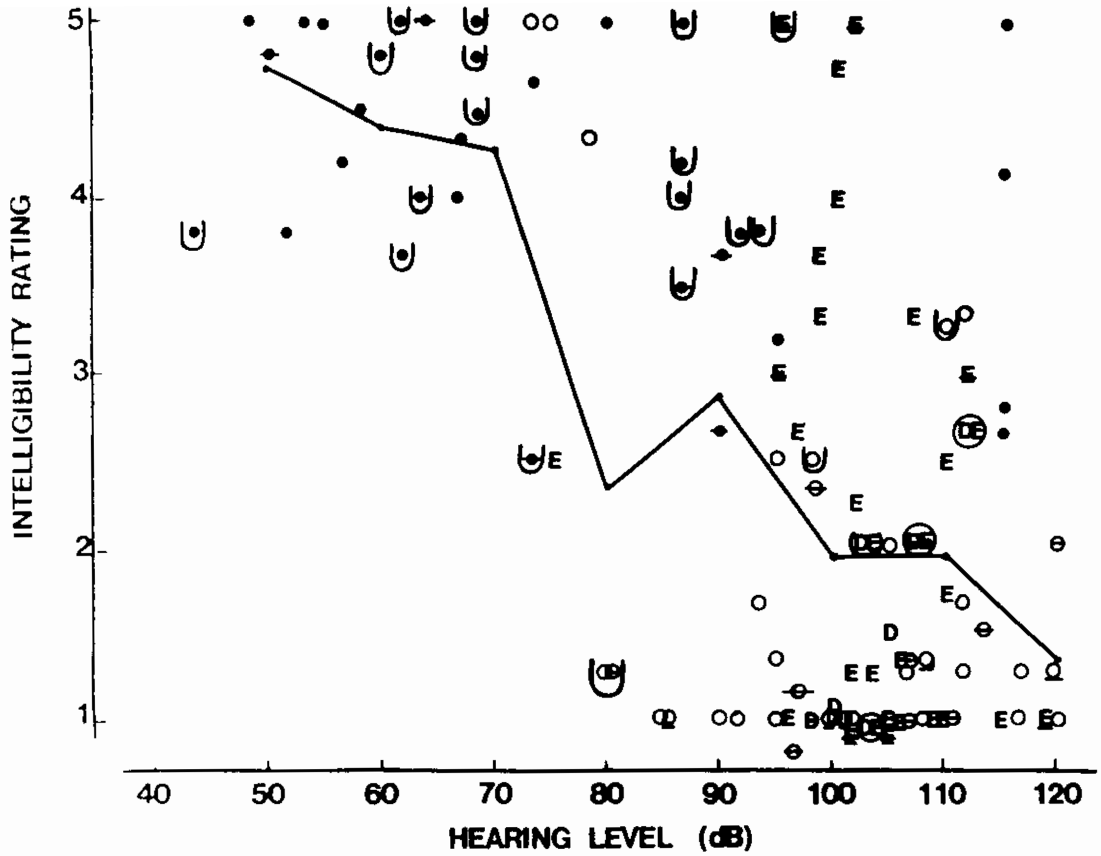

FIGURE 9.6(A). Speech intelligibility as a function of hearing level—"typical" deaf children. The solid curve shows the mean intelligibility rating for children averaged over each decade of hearing level. See Figure 6.5(A) for legend.

Although improved methods of specifying hearing impairment are likely to improve the correlation between speech intelligibility and measures of residual hearing, it is important to bear in mind that residual hearing is only one of many factors influencing the intelligibility of a hearing-impaired child's speech. Similarly, it may be possible to show a greater degree of association between language measures and measures of residual hearing by improving the methods used to specify residual hearing. However, it is likely that much more of the variance can be accounted for by identifying and evaluating those factors in addition to residual hearing that affect language development in the hearing impaired.

Of the factors considered in this study, age of onset of hearing impairment shows a significant positive correlation with both speech and language skills. As is evident from Figure 9.5(B), syntactic comprehension for the postlingually hearing-impaired children, P, is well above the general average. Other groups of children who showed better than average performance on the language measures are hearing-impaired children of deaf parents, D, and children who had the benefit of special education from a very early age, E. Note that although the data in Figures 9.5(A) and 9.5(B) relate specifically to syntactic comprehension, the ratings of written language show similar trends because of the high correlation between the syntactic comprehension scores and written language ratings. At the opposite extreme, children from non-English-speaking homes, N; children with additional handicapping conditions, H; or children with severe behavioral or emotional problems, B, show lower than average performance on the language measures.

Similarly, Figures 9.6(A) and (B) show that postlingually hearing-impaired children and children with high-frequency residual hearing have better than average speech intelligibility, whereas children of deaf parents, children from non-English-speaking homes, and children with severe behavioral or emotional problems received poorer than average intelligibility ratings. It should be remembered that better than average performance implies better than average skills, but the reverse does not necessarily hold. A lower than average test score may be because the child either has poorer ability or does not test well. It is believed, for example, that the low scores obtained by the children with behavioral problems were largely a result of a lack of cooperation by those children during testing rather than lack of ability.

The children shown in the second of each pair of diagrams (i.e., part B) show large between-group differences. This is to be expected for they are the children typically excluded or treated separately in studies of this type because they are so different from the average. An

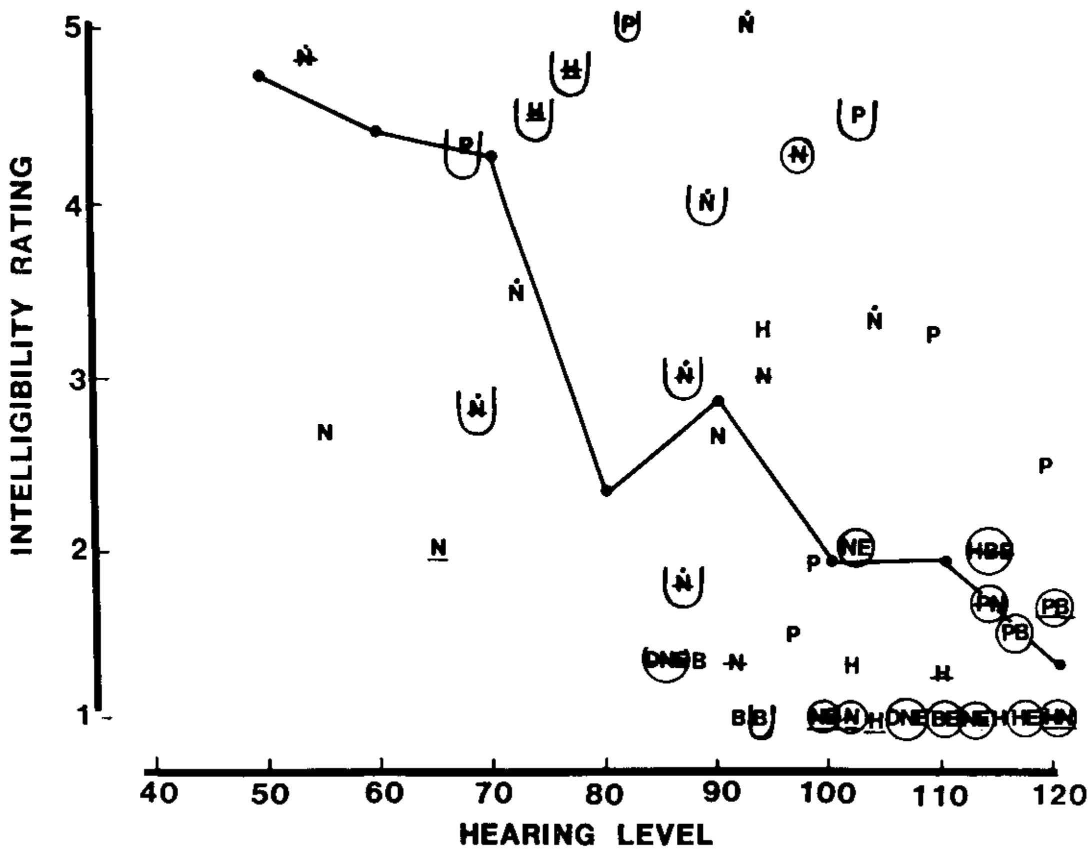

FIGURE 9.6(B). Speech intelligibility as a function of hearing level—special cases. The solid curve shows the average intelligibility rating for "typical" deaf children taken from Figure 9.6(A). See Figure 9.5(B) for legend.

unexpected finding was the heterogeneity of the children shown in the first of each pair of diagrams [i.e., Figures 9.5(A) and 9.6(A)]. It is not the usual practice to treat separately or exclude children from studies of this type on the basis of parental hearing, age at start of special education, or audiogram shape, yet the between-group differences for such children were almost as large as for those groups known to be highly heterogenous.

Figures 9.5(A) and 9.6(B) provide a detailed picture of the relationships between syntactic comprehension and hearing level and between intelligibility and hearing level. They also show the influence of other relevant factors on those relationships. Although visual inspection of these diagrams provides a clear indication of the major trends, it is relatively difficult to assess in this way the magnitude of the effect associated with each factor or the joint effects of two or more factors. An estimate of the relative effect (in a correlational sense) of each factor has been obtained from a multiple regression analysis. To do this it has been necessary to make a few assumptions. The key assumption is that each observation is the sum of several additive effects; that is, it is assumed that:

$X_i = \bar{X}_{hl} + A + B + C + \ldots I + J + e_i$ where
X_i is the observed test score for a given child,
$\bar{X}_{hl}$ is the average score at the child's hearing level,
A,B,C,. . .I,J are the effects associated with each of the 10 factors identified in Figures 9.5 and 9.6. (Specifically postlingual impairment, parental hearing, special education at an early age, mainstreaming, use of hearing aid, significant high-frequency hearing [U-shaped audiogram], socioeconomic status, home language, behavioral problems, and other handicaps), and
e_i is the residual error; that is, the difference between the observed score and the predicted score taking into account all of the above effects.

The values for the effects A through I were estimated using a least-square criterion for minimizing e_i. These effects are listed in Table 9.1 together with their estimated standard deviations. Since the unit of measurement for syntactic comprehension (percentage correct) differs from that used in measuring speech intelligibility (a 5-point rating scale), a third column in the table shows the proportion of the range accounted for by each factor. In this way, it is possible to compare the relative effects associated with each factor with respect to both speech and language skills.

Three factors showed a significant positive relationship with both speech and language. These were postlingual impairment, mainstreaming, and early special education. Of these three factors, postlingual impairment showed the largest effect. Although it is well known that postlingually hearing-impaired children have superior speech and language skills, there are relatively few data on the magnitude of this effect. The data obtained here provide

TABLE 9.1 Relative effects: Linear additive model.

Factors	Change in score	SD	Proportion of range
Syntactic comprehension, SC			
Deaf parents	+14.2	3.5	0.24
Postlingual impairment	+11.9	3.3	0.20
Mainstreamed	+8.2	2.7	0.14
Early special education	+6.6	2.0	0.11
High-frequency hearing[a,b]	+0.2	3.0	0.00
Low socioeconomic status[b]	−2.9	2.0	0.05
Poor use of hearing aid[b]	−4.5	3.1	0.08
Other handicaps	−6.4	3.7	0.11
Non-English-speaking home	−7.5	2.7	0.13
Behavioral problems	−10.4	3.9	0.17
Speech intelligibility rating, Isp			
Postlingual impairment	+1.2	0.3	0.30
Mainstreamed	+1.0	0.2	0.25
High-frequency hearing[a]	+0.7	0.3	0.18
Early special education	+0.5	0.2	0.13
Other handicaps[b]	+0.6	0.4	0.15
Low socioeconomic status[b]	−0.1	0.2	0.03
Poor use of hearing aid[b]	−0.2	0.3	0.05
Deaf parents[b]	−0.3	0.4	0.08
Non-English-speaking home	−0.4	0.2	0.10
Behavioral problems	−1.0	0.4	0.25

[a]Children with significant high-frequency hearing at schools for the deaf only.
[b]Not statistically significant (.05 level).

only a rough estimate of that relationship because only 12 of the children were postlingually impaired. Further, only postlingually impaired children at schools for the deaf were evaluated. It is extremely difficult to obtain a representative sample of mainstreamed postlingually hearing-impaired children because of their sparse distribution throughout the regular school system. Age of onset of the impairment is clearly a critical factor, and it is believed that many mainstreamed, postlingually hearing-impaired children have speech and language skills far superior to those reported here because their speech and language skills were already fairly well developed at the onset of the hearing impairment.

The second largest factor showing a positive relationship with both speech and language was mainstreaming. The mainstreamed children did relatively well in syntactic comprehension (and other language measures) and extremely well in speech intelligibility. As noted earlier, the effects reported here are correlational and not necessarily causal. It is possible that the good speech intelligibility shown by the mainstreamed children could be a result of the criteria used in selecting children for mainstreaming rather than the effects of mainstreaming itself.

The distributions of test scores for the mainstreamed children were also revealing. The test scores for syntactic comprehension were widely distributed, suggesting the possibility of a bimodal distribution. Those who did well did very well, but many of those who did not do well did very poorly. This was not the case for the speech intelligibility ratings. All of the mainstreamed children received relatively good ratings for their speech intelligibility, including those with poor hearing levels. As a result, the distribution of intelligibility ratings was clearly unimodal with a relatively small dispersion.

Early special education was the third factor showing a positive relationship with both speech and language. Hearing-impaired children who had received special education from age 3 years or younger had much better syntactic comprehension (and, correspondingly, better written language) than their peers who had not received early special education. The magnitude of this effect was smaller, but not significantly different from that associated with mainstreaming.

The speech intelligibility of those children receiving special education from an early age was also better than that of their peers, but, in this case, the magnitude of the improvement was significantly smaller than that shown by the mainstreamed children. In its range of measurement, the effect of early special education was about the same for both speech and language; that is, the estimated effect varied from .11 to .13 of the overall range of measurement.

Hearing-impaired children of deaf parents showed a large positive component for syntactic comprehension (and language, in general) but a negative component for speech intelligibility. The magnitude of that negative component was not statistically significant (at the .05 level). It should be noted, however, that children of deaf parents who had the benefit of early special education had better speech skills than those who did not. Thus, although hearing-impaired children of deaf parents had only slightly lower speech ratings on average, there were several such children with very poor speech skills. They included all of the hearing-impaired children of deaf parents who had not received special education (including speech training) from an early age.

The same caveat applies to those children as to the sample of postlingually impaired children. The number of hearing-impaired children of deaf parents in this study was small; specifically, 10 children, or roughly 8% of the children in the longitudinal study. Although the effect was large enough to be statistically significant in a small sample, estimates of the magnitude of the effect should be interpreted with caution because of the small sample size. It should also be remembered that only a small proportion of hearing-impaired children have deaf parents, and hence it is inherently difficult to obtain precise estimates of the effects of parental hearing.

Children with better hearing in the high frequencies had significantly better speech intelligibility than their peers with the same hearing level (i.e., the pure-tone average at 500, 1000, and 2000 Hz, respectively). Children with some high-frequency hearing were not significantly better than their peers in language skills. The importance of high-frequency hearing has clearly been underestimated in the education of the hearing impaired. Few schools or clinics test for hearing at frequencies above 8000 Hz, and many places do not even test above 4000 Hz. The measurement of hearing at frequencies of 8000 Hz and higher involves serious technical problems (such as standing waves in the ear canal) and is not easily done in the field. The problems of high-frequency audiometry and practical approaches to their solution are currently being investigated (Stevens, 1986).

It is also unfortunate that the vast majority of conventional hearing aids do not provide amplification above about 5000 Hz. Here again, there are technical problems in providing high-gain amplification at high frequencies, but those problems can be resolved. It may seem odd that children with some high-frequency hearing have such good speech intelligibility when their hearing aids do not amplify high-frequency sounds. As noted earlier, it is important to bear in mind the correlational nature of the observed "effects." A likely possibility is that children with significant high-frequency residual hearing also have better resolution for suprathreshold signals in the middle and low frequencies, although thresholds may be the same at those frequencies for children with negligible high-frequency hearing.

A significant interaction was observed between high-frequency residual hearing and mainstreaming. Those children at schools for the deaf with significant high-frequency hearing (i.e., hearing level at 8 KHz better than at 4 KHz) also had much better speech intelligibility. In contrast, all of the mainstreamed children had relatively good speech intelligibility, and there was no significant difference in either intelligibility ratings or syntactic comprehension between mainstreamed children with significant high-frequency hearing and mainstreamed children with similar hearing levels but relatively poor high-frequency hearing. It should also be noted that the proportion of children with significant high-frequency hearing was much greater for the mainstreamed group (approaching 50%) than for children at schools for the deaf (roughly 10%). Averaging the effect over both groups would thus hide the magnitude of the effect for children at schools for the deaf; and hence Table 9.1 shows the effect separately for that group of children.

A possible cause of the observed interaction between mainstreaming and high-frequency hearing is that the selection procedure by which children are mainstreamed may be heavily weighted in favor of children with good speech skills. If this is the case, it is to be expected that a larger proportion of mainstreamed children would have significant high-frequency hearing while at the same time the speech skills of mainstreamed children would be uniformly good, including those mainstreamed children without significant high-frequency hearing.

The largest negative effects were associated with severe behavioral or emotional problems. There are two reasons for the relatively poor performance shown by such children. One is that speech and language development may have been seriously impeded as a result of their problems. The other is that the children were especially difficult to test, and the resulting measurements may present a much poorer picture of their actual abilities.

Children from non-English-speaking homes, N, showed a significant negative component for both syntactic comprehension and speech intelligibility. Many of them were from disadvantaged homes. Their relative performance was extremely poor, whereas those hearing-impaired children from non-English-speaking, middle class homes did only slightly less well than their peers.

Children with other handicaps, H, were primarily children labeled "minimally brain damaged" or "retarded" in their school records. Several of them did very poorly on the language tests, although their speech intelligibility was no worse than average. At the same time, there were a few children whose level of performance on both the speech and language tests was comparable to that of their peers, which raises the possibility that they may have been misdiagnosed. The estimated effect of other handicaps shown in Table 9.1 is probably an underestimate because it is believed that several of the children with higher scores may have been misdiagnosed. One child, in particular, did remarkably well for one labeled "minimally brain damaged." On being informed that the child had probably been misdiagnosed, several of the teachers were quite surprised because the child had behaved much according to expectation in the classroom.

The dangers of mislabeling are both real and most serious. It is not only iniquitous for a child to be labeled as having a nonexistent impairment, but the problem is seriously compounded by the tendency of many children to conform to their teacher's expectations. The current trend towards labeling children who perform below expectation as "learning disabled" raises the same concerns. The frequency of mislabeling and the unfortunate long-term problems produced by such errors should not be underestimated.

A factor that was found to have a negative correlation with both speech and language is poor use of hearing aid. Although this effect just failed to reach statistical significance, it is not a negligible effect in that, in combination with other factors that fall just below the level of statistical significance chosen for this study (.05), the net effect may prove to be of importance for specific children. It is important to bear in mind that an additive model has been assumed, and that the cumulative effect of several small effects in the same direction is not to be overlooked.

Unfortunately, reliable information on how well a hearing aid is working is difficult to obtain. In this study we relied on teachers' ratings of gross, overt signs of misuse; for example, not coming to school with a hearing aid, constant breakdowns or damage to the aid, or inability to respond to sounds that should be clearly audible on amplification. Nevertheless, despite the crudeness and subjectivity of the rating procedure, there is evidence of a correlation between poor hearing-aid use and poor performance.

Other evidence on the poor use of hearing aids is provided by the data on prosodic-feature reception (See Chapters 7 and 8). A significant proportion of the children were unable to distinguish such gross prosodic characteristics as the number of syllables in a short sentence, or the location of a distinct pause. Many such cues can be perceived tactually, which raises the possibility that the hearing aid may be providing misleading auditory cues. Children with severe to profound hearing losses have a very limited dynamic range, and not all of the sounds in the test stimuli may have been amplified sufficiently to lie above the threshold of audibility but below the level of discomfort. If all the sounds in a sentence are not audible, then misleading information will be provided on syllable number, location of pauses, and other prosodic characteristics.

A factor that is beyond the control of educators but within the purview of society as a whole, is socioeconomic status. Hearing-impaired children from disadvantaged homes had slightly poorer language skills, on the average, although their speech intelligibility was about average. Although the negative effect on language development of poor socioeconomic status was not statistically significant (roughly 2.9 percentage points on the tests of syntactic comprehension), this average figure can be misleading. Many children from disadvantaged homes did quite well on the language tests, but others did extremely poorly. It appears that there are additional factors involved, because socioeconomic status per se cannot account for the bimodal distribution of the observations. The available data are too few to allow for a reliable identification of other possible factors; these are considerations to be taken into account in future studies and in the development of more effective remedial programs for this important group of hearing-impaired children.

CONCLUSIONS

There are distinct patterns to the interrelationships between speech and language in the hearing impaired. Further, despite major developmental changes, the nature of these interrelationships remains relatively unchanged in form, at least for the children considered in the 4-year longitudinal study. Language and communication skills were found to be relatively, but not wholly, independent of each other. The nature of this relationship is neatly illustrated by the factor analysis that shows the language measures to be heavily weighted on the Language Factor with relatively light weighting on the Communication/Hearing-Level Factor. The communication measures, in contrast, show a heavy weighting on the Communication/Hearing-Level Factor and also a moderate weighting on the Language Factor. Speechreading stood apart from the other communication measures and showed a much higher degree of correlation with the language measures.

All of the relationships obtained in this study are correlational and are not necessarily causal. The link between speechreading ability and language is a case in point. The two are clearly correlated, but a causal relationship has yet to be demonstrated. It may well be that the relationship is symbiotic, good speechreading skills facilitating language development and good language facilitating the development of speechreading skills.

The low correlation between hearing level and language skills should be interpreted with caution. Residual hearing is clearly important for language development. If this were not the case, hearing-impaired children would develop language normally. The data obtained here, however, show that for hearing levels in excess of 40 to 50 dB there is only a modest decrease in language skills with increasing hearing level; above about 80 dB, hearing level and language skills appear to be uncorrelated except for that small group of children with no measurable hearing.

The few children with hearing levels in the vicinity of 120 dB were found to have markedly poorer speech and language skills. Although this observation is based on a small number of children with no measurable hearing, it is supported by similar data obtained independently by Boothroyd (1984). Taken together, these studies indicate a pattern that has important implications for education of the profoundly hearing impaired and, in particular, for the development of prosthetic aids for such children.

First, it is essential to distinguish reliably between children who have some residual hearing and those who are totally deaf. This distinction has often been referred to as the difference between "hearers" and "feelers," because the latter (the totally deaf) feel the vibrations of their hearing aid rather than hearing the amplified acoustic signals. Despite the importance of this distinction, it is not a common practice to identify routinely which children are feelers as opposed to hearers. This may be due to the lack of practical, sensitive tests for making the distinction and the associated difficulties involved in separating the two groups reliably.

Second, the tactile sense has much poorer temporal and frequency resolution than the auditory sense, and, as a result, amplified low-frequency signals that can be heard as well as felt are perceived with far greater resolution by the profoundly hearing-impaired child with some residual hearing than by the totally deaf child. It is thus particularly important to provide additional sensory cues to the totally deaf child as a supplement for the limited information being received tactually via the hearing aid. A vibrotactile sensory aid designed specifically for speech is an obvious choice. Experiments with relatively simple vibrotactile aids have already shown significant improvements in the development of communication skills among young profoundly hearing-impaired children (Friel-Patti & Roeser, 1983; Goldstein & Stark, 1976).

Third, it is important to recognize that the majority of profoundly hearing-impaired children (e.g, children with hearing levels poorer than 100 dB) have some residual hearing, and that limited residual hearing, if utilized properly, plays an important role in their speech and language development. New types of prosthetic aids, such as the cochlear implant, which involves the placement of electrodes in the cochlea, may be of benefit. This method of intervention is controversial, however, particularly in its use with children. Careful long-term experiments on the efficacy of cochlear implants with children and the long-term effects on speech and language development are needed, but unfortunately this type of research is not without hazard. A crucial question is whether long-term stimulation received from a cochlear implant is more effective than long-term stimulation provided by a noninvasive prosthesis, such as a wearable tactile aid.

The studies reported here provide no direct information on the effects of mild hearing loss on speech and language development. However, if normal-hearing children have better language skills than do hearing-impaired children with hearing losses of as little as 40 to 50 dB, then children with mild hearing losses (between 0 and 40 dB) are likely to show a significant negative correlation between language skills and mild hearing loss. More attention needs to be paid to this group of children.

A second important group of children not considered in our series of studies is those with fluctuating hearing loss (a common problem with many children because of middle ear infections). If moderate hearing impairment is a problem, then fluctuating hearing loss is also likely to have a negative effect on language development. The cumulative effects of fluctuating hearing loss on speech and language development is another problem area warranting serious investigation.

Hearing level is only one of many factors affecting speech and language development. These factors can be subdivided into two groups, those over which educators and clinicians have no direct control and those over which clinicians and educators have a direct influence. The former include the degree and nature of the hearing impairment, age of onset of hearing impairment, other additional impairments, parental hearing, home language, and socioeconomic status. The latter include age at which special education is initiated, use of hearing aid, and educational environment.

The factor with the largest overall effect (in a correlational sense) was age at onset of the hearing impairment; postlingually hearing-impaired children clearly showed superior speech and language skills. Hearing-impaired children of deaf parents also showed superior language skills, but their speech skills were inferior except in those instances where special education was provided at an early age.

A second factor associated with both superior speech and superior language skills is early special education. Hearing-impaired children who had received special education from age 3 or younger had better speech and language than their peers. The provision of early special eduation is, of itself, no guarantee of superior speech and language development, but lack of such early intervention is highly correlated with poor speech and language skills (exceptions to this trend were the rather special cases of postlingual impairment and children of deaf parents).

A third factor associated with improved speech and language skills is mainstreaming. Almost all of the mainstreamed children had relatively good speech skills. Language skills were significantly better on the average, but there was also a fair proportion of mainstreamed children with very poor language skills. This may be a reflection of the selection process.

A factor associated with substantially better speech skills but no significant improvement in language skills is high-frequency residual hearing. Conversely, factors associated with poor language skills, but not necessarily poor speech skills, include low socioeconomic status and additional impairments (correctible visual impairments and motor impairments excluded). Factors associated with both poor language skills and below average speech skills include poor use of hearing aid, home language other than English (sign language excluded), and behavioral or emotional problems. The last factor showed the largest negative effects.

Of the factors within our control, early special education shows the highest positive correlation with improved speech and language development. In contrast, a relatively neglected factor that is well within our control is poor hearing aid use. The magnitude of this problem may be larger than indicated because, for want of a better measure, only gross manifestations of poor hearing-aid use were used to identify children in this category. A related problem is less than full utilization of a child's residual hearing. This is particularly true of children with some high-frequency hearing. Conventional hearing-aids have a limited frequency range, and, as a result, hearing-impaired children typically do not receive amplification above about 5000 Hz. The importance of high-frequency residual hearing is clearly demonstrated by those children with relatively good high-frequency hearing, yet, in practice, little effort is made to identify children with high-frequency hearing and to utilize this residual hearing effectively in planned programs of intervention.

The fact that so many factors interrelate with speech and language development in the hearing impaired has important implications for future studies of this type. The factors typically considered in sample selection (e.g., age at onset of impairment, additional handicapping conditions) are entirely reasonable, but other important factors are often overlooked (e.g., parental hearing, age at initiation of special education, high-frequency residual hearing, use of hearing aid). Having identified which factors are significant, it is possible in subsequent investigations to focus on specific factors of interest and to obtain much more reliable estimates of the effects associated with those factors.

It is important to bear in mind that the statistical considerations involved in designing a study to identify which factors are significant are different from those involved in designing a study to measure the magnitude of the effect(s) associated with one or more specific factors. Thus, for example, the studies reported here were not designed to evaluate differences in educational philosophy (oral, manual, total), and reliable information on the effect of that factor could not be extracted from the available data. The fact that educational philosophy did not stand out as a highly significant factor, despite the vagaries of the sampling process, suggests that educational philosophy, per se, may be a less important factor than believed by partisans of the different philosophies.

It is possible to design a study to evaluate specifically the effects of educational philosophy, but in view of the large number of ancillary factors that need to be controlled, such a study is likely to be extremely large and complex. Another difficult problem is that the results of such a study will reflect the combined effect of educational philosophy and how it is practiced at the participating schools. A negative result is thus unlikely to influence a true believer, because any negative findings easily can be ascribed to improper implementation of a given educational philosophy rather than to the philosophy itself.

ACKNOWLEDGMENT

This study was supported by the State of New York Education Department, Bureau for Special School Supervision, Office for the Education of Children with Handicapping Conditions. Please see the general acknowledgment in Chapter 1 for more detailed information on the many individuals and organizations who assisted in this project and whose help is much appreciated.

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Chapter 10

Concluding Commentary

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GENERAL TRENDS

The data reported in this monograph cover a wide diversity of children. In some cases it was possible to reach a comprehensive sample of children (e.g., children at schools for the deaf, 6 years of age and 10 to 14 years of age); in other cases, representative samples of children were studied (e.g., mainstreamed children, preschool hearing-impaired children). Although the ideal of a comprehensive sample of children at all age levels and for all types of school settings was not achieved, the sample was both large enough and broad enough to allow several important general conclusions to be drawn. Similarly, although the data obtained on each child covered a wide range of skills, it was not possible to obtain a completely comprehensive profile of each child's speech and language development. The language measures, for example, concentrated on syntactic ability. The communication measures were broader in scope, primarily because many practical tests were already available or could be developed in the time available. Despite these practical limitations, the range of measures obtained and the size of the sample were large enough to allow drawing reasonably strong conclusions regarding the interrelationships between language and communication abilities in hearing-impaired children and their mutual relationships with relevant audiological and educational factors.

Perhaps the most important observation of all is the positive correlation between early intervention and speech and language development. The importance of early intervention has long been espoused by educators and clinicians, and the data presented here provide strong quantitative evidence of the association between superior speech and language skills and early intervention. This finding was obtained for each of the three age groups studied. The correlation was especially strong for the oldest group of children, indicating that the positive effects of early intervention are maintained well beyond the early years of life.

The importance of early intervention cannot be denied, but there are two important caveats to bear in mind. First, early intervention of itself is insufficient to guarantee good speech and language skills. This is clearly evident from the data obtained in the longitudinal study, in which it was found that most, but not all, of the children who had received special education at or before age 3 scored well above the average on the Test of Syntactic Abilities. Although the children in this group who scored at or below the average level were a minority, they were nevertheless a significant minority.

A much stronger statement can be made regarding the lack of early intervention. The speech and language skills of those children who did not receive special education at an early age were well below average, as a group. Further, in the case of the longitudinal study, few of the children who had not received special education early in life (excluding the postlingually hearing-impaired) scored significantly above the average level of performance. In short, early intervention appears to be necessary but, of itself, insufficient for long-term gains in speech and language development. There are factors in addition to early intervention that play an important role in facilitating the development of speech and language.

The second caveat is that all of the relationships reported here are correlational. Corresponding causal relationships may well exist, but they can only be inferred from the data with great caution. For example, the positive correlation between speech-language skills and the provision of special education at a very young age does not necessarily mean that early intervention was the cause of the measured improvement. Other factors which, in turn, are correlated with early intervention may also have contributed. Specifically, the child who has received special education from a very early age is also likely to come from a home where there is great concern for the child, an awareness of what can be done, and a good deal of motivation on the part of the parents as well as the child. These are factors that do not operate independently of each other, and it is difficult to assess the role of each in facilitating speech and language development. From a pragmatic point of view, it is not important to separate out these effects since they appear to operate symbiotically, and it is their combined effect on speech and language development that is of practical concern. Early intervention is one facet of the whole, and, in encouraging early intervention, it is important not to lose sight of other potentially important factors.

The longitudinal study, because of its greater power, provides a unique opportunity to investigate developmental differences as a function of both the syntactic structures tested and the child's relative level of performance. It was found that for those syntactic forms that are acquired earliest, negligible developmental differences (other than differences in rate of development) were observed either in the sample of children studied or in comparison with other studies. Small, but measurable, developmental differences were observed for slightly more complex forms (e.g., various question forms) for the children with the poorest language skills. The differences were found to be much larger on more advanced forms (e.g., pronominalization), and substantial differences were observed for all of the children on complex sentence forms.

An issue of great interest is whether language development in hearing-impaired children is delayed or deviant. The bulk of the published experimental data appear to support the view that, with a few exceptions, hearing-impaired children follow the same sequence of development as normal-hearing children but at a much slower rate. The data obtained in the investigations reported here provide a much more subtle interpretation of this issue. Delay and deviance are not independent effects. Although delay predominates, there is also evidence of systematic patterns of deviant development. Two distinct trends were observed. Manifestations of deviance increased with increasing language complexity, and children with the poorest language skills were more likely to show deviant patterns of development. In both cases, delay and deviance are correlated if not causally dependent. The children showing the largest developmental delays are also the ones showing the most evidence of deviant development. For the more advanced syntactic forms, some of the deviant patterns appear to be the cumulative result of many years of delayed development.

It is to be expected that as language develops, the opportunities for developmental differences to emerge increase among normal-hearing children as well as among hearing-impaired children. Although it is known that differences in normal language development increase with increasing language complexity, it is not known what constitutes a normal range of difference or what may be regarded as an abnormally large deviation at any given level of development. As a result, it is extremely difficult to set the boundary between normal and deviant patterns of development for the more advanced syntactic forms. Even if the exact location of the boundary between delayed and deviant development cannot be identified reliably, it is clear that the developmental differences exhibited by hearing-impaired children are greater for the children with poorer language skills. A major cause of those differences is that the extremely slow rate of development shown by the children with the poorest language skills results in a cumulative blurring of normal developmental sequences as well as deviant patterns of interaction between incompletely developed early forms and emerging more complex forms.

LANGUAGE, COMMUNICATION, AND HEARING LEVEL

The interrelationships between the variables considered in this study show distinct patterns that are relatively stable despite developmental changes. A factor analysis on all of the speech and language measures obtained in the longitudinal study showed two major factors. The first, labeled the Language Factor, was found to correlate highly with all the language measures (i.e., tests of syntactic comprehension, written language). The second factor, labeled the Communication/Hearing-Level Factor, was found to correlate with hearing level and with the measures of communication ability. The language measures showed low correlations with the Communication/Hearing-Level Factor, but the communication measures showed a moderate degree of correlation with the Language Factor.

Of the communication measures, speechreading ability was found to be relatively highly correlated with both the Language and the Communication/Hearing-Level factors. As noted earlier, all of the relationships revealed by the data are correlational and not causal. Good speechreading ability may contribute significantly to the development of language; alternatively, good speechreading ability may be a concomitant of good language skills. The two may, in fact, act symbiotically. In our view, the latter interpretation appears most reasonable.

The growth in speech and language skills over the years does not produce any basic change in the pattern of interrelationships described above. A small trend was observed (over the 4-year period of the longitudinal study) toward an increase in the separation between the factors; that is, the degree of correlation of the language measures with the Language Factor increased while the communication measures increased their degree of correlation with the Communication/Hearing-Level Factor.

A matter of great concern is the relationship between hearing level and speech and language skills. Whereas there is a relatively strong association between hearing level and speech-communication skills, the degree of association is not quite as marked between hearing level and language skills. The data show a small average reduction in language skills with increasing hearing level up to about 80 dB. For hearing levels in excess of 80 dB, there is no significant change in language skills with increasing hearing level, except possibly for hearing levels in excess of 115 dB. The few children with such profound losses showed extremely poor speech and language skills.

Almost all of the children at schools for the deaf had hearing levels in excess of 80 dB. It is thus not surprising that the correlation between hearing level and language skills was found to be insignificant for this group of children. In contrast, the hearing levels for the mainstreamed children cover a much wider range, and for those children the correlation between hearing level and language skills was small but significant.

The studies reported in this monograph provide no information on the effects of mild hearing loss on speech and language development. If speech and language skills are already well below normal for children with hearing losses of 40 to 50 dB, as shown in the studies reported here, then children with less severe hearing losses should show a significant negative correlation between speech and language skills and hearing level over the range 0 to 40 dB. More attention should be paid to this group of children who are typically not thought of as being seriously impeded by their hearing impairment. A second important group of hearing-impaired children not considered in this monograph is those with fluctuating hearing losses (a common problem with many children because of middle-ear infections). Here again, more attention needs to be paid to the cumulative effects of fluctuating hearing loss on speech and language development.

From a practical perspective, the association between hearing level and language skills suggests that although hearing impairment is a major impediment to normal language development, it is primarily the steps taken to remedy the situation that are critical to the child's acquisition of language. It is thus of great importance to know which additional factors can influence speech and language development. Of the many factors considered in the studies reported here, several stand out as being significantly correlated with speech and language development. They include etiology and degree of impairment, age of onset of hearing impairment, parental hearing, home language, age at start of special education, type of special education (mainstreaming vs. school for the deaf), use of hearing aid, socioeconomic status, and additional handicapping conditions.

Several of these factors are well known and are routinely taken into account in the design of special programs of intervention. Other factors are either not widely known or are often overlooked. Thus, for example, it is a common practice to consider the postlingually hearing impaired and multiply handicapped separately in studies on the effects of hearing impairment. Such constraints on sample selection make sense given the large differences between these groups. However, other factors that also have a significant effect, such as parental hearing, age at start of special education, socioeconomic status, and use of a hearing aid, are often not considered.

The factors found to have a significant relationship with speech and language development can be subdivided into two groups, those that can be modified by the educational process and those that are beyond our control. Unfortunately, the factors with the greatest effect are typically those beyond our control (e.g., etiology, degree of impairment). At the same time, many of these factors are limited, for better or worse, to small but important subgroups of the hearing-impaired population (e.g., postlingually impaired children, hearing-impaired children of deaf parents, multiply handicapped children). Factors under the direct control of educators and clinicians are not limited to any specific subgroup of children. The factors include age at start of special education, type of special education, and use of hearing aid. The use of special-purpose sensory aids (in addition to the hearing aid) was not considered in these studies, but it also is an important factor.

A factor that many consider to be of great importance in facilitating speech and language development is educational philosophy (oral, total, manual). Despite the size of the studies reported here, it was not possible to assess the effect of this factor reliably. Although these studies were not designed to investigate the effect of educational philosophy, it is significant that even for the large, longitudinal study, which involved a comprehensive sample of children attending schools for the deaf throughout the state, the effects of educational philosophy could not be isolated. The essential problem is that there are only a limited number of schools in the state, and there is a high degree of confounding between the different educational philosophies practiced by the schools and demographic variables. For example, the differences in average performance between children attending an inner-city school and middle-class children attending a suburban school cannot be attributed solely to the differences in educational philosophy practiced by the two schools. It is possible to design a study to focus on the effect of educational philosophy, but such a study is likely to be very large, and it would be necessary to balance out all of the major factors identified in this study.

Although the studies reported in this monograph did not attempt to assess different educational philosophies, or differences between individual programs, the data do suggest that no one approach or program is uniformly better than any other. The children who did best of all came from a variety of programs. Similarly, the children who did worst of all were distributed among all of the schools. Certain schools had a higher proportion of poor performers, but demographic factors were also weighted against those schools.

The differences between mainstreamed children and those attending schools for the deaf are especially revealing. It is to be expected that mainstreamed children would perform at a higher level than children at schools for the deaf since the selection process whereby children are mainstreamed is designed to place those children who do not need the special services provided by a school for the deaf into the regular school system. The data show that communication skills of the mainstreamed children are much superior to those of children at schools for the deaf. With few exceptions, the communication skills of the mainstreamed children were well above the average level of performance for children at schools for the deaf.

In contrast, the language skills of the mainstreamed children were not uniformly better than those for children at schools for the deaf. Whereas, on the average, the mainstreamed children obtained higher scores on the tests of syntactic comprehension and on the measures of written language, there were many mainstreamed children whose performance was below the average for children at schools for the deaf. In particular, there were several mainstreamed children who were not profoundly hearing impaired, but whose level of performance was below that of profoundly hearing-impaired children at schools for the deaf. With respect to language skills, it appears that the mainstreamed children who do well, do very well, and those who do not do well, do rather poorly. This result is consistent with the theme outlined above. That is, there does not appear to be a single or blanket approach to the education of hearing-impaired children that is uniformly superior for all children.

THE SPECIAL HEARING-IMPAIRED CHILD

A special concern of educators and clinicians is the special hearing-impaired child. At least nine types of special hearing-impaired children can be identified: those with additional impairments, children with emotional/behavioral problems, children from disadvantaged homes, children whose home language is not the language of instruction, children of deaf parents, children who have not had the benefit of early intervention, children with no measurable hearing, children with significant high-frequency hearing, and the postlingually hearing-impaired child. The groups are not mutually exclusive, and, unfortunately, there are many hearing-impaired children who belong to more than one group. Examples include the disadvantaged child who has not received special education until school-going age, or the postlingually hearing-impaired child with severe emotional/behavior problems.

On the positive side, there is much that can be done. Perhaps the most special of the special children are those with additional impairments, particularly those children identified as "retarded" or "minimally brain damaged." Test scores for such children were among the lowest recorded for all the children considered, but the data nevertheless showed that steady, consistent progress in language development can be achieved, albeit at a very slow rate. Intensive special education can yield positive results, but it must be recognized that, given the slow rate of progress, there are severe limits to how much language can be acquired. An important consideration in dealing with children believed to have additional impairments is the danger of mislabeling. Teachers and clinicians should be sensitive to the possibility that such errors can occur and that these errors can be self-sustaining; that is, lower expectations often lead to poorer performance.

Another type of challenge is provided by children with behavioral or emotional problems. In such cases, it is important to develop programs of intervention in close consultation with the school psychologist. In this study, only those children with severe behavioral/emotional problems were identified. The proportion of hearing-impaired children having some form of behavioral, emotional, or psychological problem is, of course, much higher than the proportion of those with severe problems. Although problems may not manifest themselves as severe behavioral disturbances, they nevertheless can interfere seriously with the learning process and need to be taken into account in any program of intervention.

As is evident from the above, the various groups of special children require special intervention that is individually tailored to their needs. In particular, large individual differences have been observed for children from disadvantaged homes. This emphasizes the need for careful testing and evaluation before instituting a program of intervention for such children. Similarly, children who have not had the benefit of early special education need an immediate, intensive program of intervention, but such a program must be carefully tailored if it is to remediate the effects of early neglect. Some of these children may show no more than a delay in their acquisition of normal speech and language forms, others may already be showing deviant patterns of development.

Children with no measurable hearing are another relatively neglected group. They are sometimes referred to as "feelers" because they feel rather than hear the intense low-frequency sounds produced by their hearing aids. In this sense, the hearing aid is serving as a vibrotactile aid. Hearing aids, however, are not designed to operate as vibrotactile aids, and, although useful, they do not operate as effectively as they might. Tactile stimulation to supplement that being received through the hearing aid is a relatively simple and safe way to increase the sensory input to the child. An alternative is the cochlear implant. Although good results have been obtained with postlingually deafened adults, the use of a cochlear implant with young, prelingually deafened children is highly controversial.

It is important to bear in mind that the proportion of hearing-impaired children with no measurable hearing is very small. Only five children in the large longitudinal study were found to fit this category. Those children had "hearing levels" of 120 dB, presumably as a result of feeling the test stimuli in the lower frequencies. Both their speech and language skills were well below those of their peers with slightly less profound hearing losses (e.g., 100 to 115 dB). These data emphasize the importance of having some residual hearing to facilitate speech and language development.

A comparatively unknown and, concomitantly, a comparatively neglected group of hearing-impaired children is those with measurable high-frequency hearing. Those children with hearing levels at 8 kHz that are equal or better than those at 4 kHz were found to have better speech skills and, to a lesser extent, better language skills than children with no significant hearing in the high frequencies. Unfortunately, it is not always the practice to measure residual hearing above about 4 kHz for so-called deaf children, although a fair proportion of children at schools for the deaf (roughly 10% in this study) and a relatively high proportion of mainstreamed children (nearly 50% in this study) had measurable hearing at 8 kHz or at even higher frequencies. There are serious practical problems, such as standing waves in the ear canal, in the measurement of high-frequency hearing. A related problem is that most conventional hearing aids do not provide high-frequency amplification; this is particularly true of those instruments designed for severely or profoundly hearing-impaired children.

Children with residual high-frequency hearing are thus subject to two unnecessary, additional problems. First, many of them are simply not recognized as having significant high-frequency hearing although such hearing can be of great value in speech and language development. Second, many, if not most, of the children with some high-frequency hearing are simply not trained to make efficient use of all their residual hearing. The latter problem is due in large part to the combined effects of lack of information about the child's range of hearing and the limited frequency response of most conventional hearing aids. The technical problems involved in measuring and utilizing high-frequency residual hearing are not beyond a practical solution, and immediate steps should be taken to remedy the situation.

Children whose home language is other than English represent a distinct group for whom improvements in speech and language development involve more than educational considerations. It is beyond the scope of this monograph to get into the problematical issue of which language of instruction is most appropriate for the bilingual child. It should be noted, however, that of the children from non-English-speaking homes, those who performed well below average were also inner-city children. Hearing-impaired children from non-English-speaking, middle-class homes were close to the average level of performance. It is also relevant to note that children whose first language was sign, and for whom English was a second language, did relatively well on the language tests.

Postlingually hearing-impaired children are not usually considered as having special problems. As is evident from this study, their speech and language skills are much superior to those of prelingually hearing-impaired children, although well below those of normal-hearing children. Postlingually hearing-impaired children are often excluded from studies of the type reported here (to obtain relatively homogenous samples), and, as a result, there is a paucity of data on such children. It is thus not known, for example, whether the postlingually hearing-impaired children in the studies reported here, who were all at schools for the deaf, performed as well or developed as rapidly as other populations of postlingually hearing-impaired children.

Much more research is needed on the effects of postlingual hearing impairment to determine realistic goals for such children, to develop more effective programs of intervention, and to obtain basic information on the effects of hearing impairment on speech and language development. A basic consideration in such studies is the child's level of speech and language development at the onset of the hearing impairment. Another issue to be addressed is the possibility of a regression in speech and language development subsequent to the occurrence of the impairment.

Children of deaf parents are of particular interest because, as a group, they did relatively well on the language measures. The number of such children is small, and hence the observations relating to them must be interpreted with caution. The most striking finding was the relatively high scores obtained by the majority of the children on the language measures. Seven of the 10 children scored well above the average level of performance. The same children performed relatively poorly on the speech-communication measures, except for three who received special training at an early age and whose speech skills were at or above average.

There are several possible reasons for the better than average performance of hearing-impaired children of deaf parents. First, the advent of a hearing impairment is less likely to be unexpected, the effects of hearing impairment are already known to the family, and, as a consequence, fewer problems of adjustment are likely to occur. Second, inherited hearing impairment is usually entirely peripheral whereas other forms of hearing impairment, such as that resulting from rubella during pregnancy, often involve additional central impairments. Perhaps the most important reason is that the deaf infant is immersed in an environment where some form of signing is the home language, and hence the earliest stages of language are acquired without impediment.

It is important to bear in mind that the acquisition of sign language as a first language is very different from learning sign language at a later stage in life. It is also relevant to note that although children of deaf parents had superior language skills, on the average, the language skills of the best of them were no better than the best of those hearing-impaired children who had the benefit of effective special education at an early age. Exposure to language at an early age thus appears to be the critical factor, rather than the type of language.

A VIEW TO THE FUTURE

What can be done to facilitate the development of speech and language in hearing-impaired children? The data provided in this monograph show that there are vast differences in relative level of development among hearing-impaired children, that rates of development are extremely slow, that deviant patterns of development are evident among some children at fairly early levels of development (primarily among the poor performers), and that the proportion of children showing deviant patterns increases as the complexity of their speech and language increases. Further, the diversity in relative development is linked to many different factors. In view of the complexity of the problem, it is not surprising that no single approach to the education of hearing-impaired children has emerged as being clearly superior to any other.

To intervene effectively, it is necessary to reach the hearing-impaired child as early as possible and to match the program of intervention to the needs of the child. To do this it is important to determine the child's level of development and whether or not the child has any special problems. This should be done with due appreciation for the child's home environment, the nature of the impairment, and other relevant factors. It is important to know, for example, the age at onset of the hearing impairment, whether the impairment is purely peripheral, whether there is deafness in the family, the child's first language (English, sign, other), the age at which special education was first provided, the form of such special education, the use made of hearing aids (and the quality of the acoustic amplification thus provided), and the existence of additional handicaps or other problems, such as poor motivation or emotional/behavioral problems. It is also incumbent upon professionals in the field to reach out into their communities to those hearing-impaired children who, because of the family's socioeconomic circumstances, would not otherwise have the benefit of early, effective intervention.

More effective tests are needed to determine the child's level of development, to diagnose any special problems, and to assess the effectiveness of the intervention program. Although the situation has improved somewhat since the initiation of the studies reported here, there is much that still needs to be done. In addition to the Test of Syntactic Abilities (and other tests, introduced since these studies were performed), there is a pressing need for additional standardized tests that tap other aspects of language ability in the hearing impaired. The use of a computer to assist in the analysis and assessment of a child's spoken and written output opens up new possibilities that should be pursued aggressively.

The most difficult problem is to develop effective tests for very young children. Unlike tests for older children, those for the very young must cover a much smaller range of speech and language abilities, and consequently tests of great sensitivity are needed to measure subtle changes in performance. Most of the existing tests on speech and language development provide only gross estimates of the earliest stages of development; much more refined techniques are needed. The problem is confounded by the difficult additional problem of matching the test to the young child's cognitive abilities.

Despite these difficulties, it is extremely important that practical tests for measuring speech and language development in the young hearing-impaired child be developed. As noted earlier, early intervention is of critical importance. It is not known with any degree of certainty which type of intervention is best suited for a given hearing-impaired child. It is thus essential to be able to evaluate at a very early age the type of intervention needed and to monitor closely the effects of such intervention.

It is unfortunate that the areas of greatest need are also those in which the problems are most difficult. In addition to the assessment problem with very young children, there is also the great difficulty of (and corresponding lack of appropriate test instruments for) assessing speech and language development in the multiply handicapped. The danger of mislabeling hearing-impaired children with additional impairments, and the extremely damaging long-term consequences of such errors, would be greatly reduced if effective tests of this type were available.

Practical test instruments have yet to be developed for the two most important aspects of speech and language, overall communication ability and the pragmatic use of language. The latter problem is not limited to hearing-impaired children. There is a marked lack of such assessment tools for normal children as well as for hearing-, speech-, and language-impaired children.

Given more effective assessment tools, the much more difficult problem of using those tools effectively to improve speech and language development in hearing-impaired children still remains. Identifying a child's level of development and the existence of any special problems is only the first step in planning a truly effective program of intervention. There is a corresponding need to develop curricula appropriate to each child's needs. The difficulty of developing effective curricula should not be underestimated. Further, the problems are compounded by a tendency to think of teaching, assessment, and the use of modern technological aids as separate entities.

The close association between assessment and teaching is obvious. To know what to teach it is necessary to know what the child does or does not know, and, in turn, the effectiveness of the curriculum needs to be assessed at regular intervals, if not on a continuous basis. Teachers should become more involved in the evaluation process because, in effect, it is an integral part of their teaching.

The need to adapt curricula to take advantage of modern technological aids is perhaps also obvious, but it is clear from the results in this monograph that effective use is not being made of available technology. The data on the perception of the prosodic characteristics of speech, for example, show that relatively few children are making efficient use of their hearing aids. The cues that were missed by many of the children were well within the range of their residual hearing. Either the hearing aids have not been prescribed properly, they are not being used effectively, or insufficient attention has been paid to auditory training in the classroom. Similarly, children with significant high-frequency hearing are either not being identified as such or are not being trained to make the fullest use of their residual hearing.

It is important for a teacher to know what a child can and cannot perceive in order to develop effective instructional techniques. Similarly, relatively little effort is being made to utilize other forms of sensory input involving visual, tactile, or electrical stimulation. There is much that needs to be done in improving prosthetic devices for the young hearing-impaired child.

The use of technological aids is not limited to facilitating communication. The use of a computer in analyzing the syntactic structures produced by hearing-impaired children has already been demonstrated in the evaluation of the written language samples. The intelligent application of computers in this context opens up new possibilities for the development of more effective teaching and evaluation strategies.

It is hoped that the recent introduction of microcomputers into the classroom will serve as a catalyst in making effective use of other technological aids for assisting the hearing-impaired child. From our experience, the most effective way of doing this is to develop teaching strategies in which objective assessment and the effective use of technological aids are integrated into the regular curriculum to meet each child's individual needs.

APPENDIX A

THE SYNTAX SCREENING TEST

Syntax Test

Section I

1. Show me: There is no child.
2. Show me: There is no cat.
3. Show me: The boy does not want a bath.
4. Show me: The girl does not want the juice.
5. Show me: The toothbrush is not broken.
6. Show me: The boy is not asleep.
7. Show me: The girl is pushed by the boy.
8. Show me: The baby is kissed by the mother.
9. Show me: Mother touches father.
10. Show me: The cat chases the sheep.
11. Show me: The fish bites the hook.
12. Show me: The pencil broke.
13. Show me: The sheep run.

Section II

PICTURE A

14. Does the girl brush her teeth in school?
15. Whom is mother helping?
16. Is mother brushing her teeth?
17. Who is wearing a dress?
18. What is the girl brushing?
19. What is yellow?
20. Where is the cup?
21. Why is the girl brushing her teeth?
22. When does mother brush her teeth?

PICTURE B

23. Whom is father helping?
24. Is the boy eating a banana?
25. Who is eating a banana?
26. Does father eat a banana?
27. What is father pouring?
28. Where is the flower?
29. What is blue?
30. Why is father helping the boy?
31. When does father drink his milk?

Note. From "Comprehension of Syntax by Six Year Old Deaf Children," unpublished doctoral dissertation by R. Gaffney, 1977, City University of New York Graduate Center.

APPENDIX B

Complete List of Structures That May Be Identified by PERC

Word Classes

Determiner singular
Determiner plural
Determiner
Adjective
Intensifier
Count noun plural
Count noun singular
Collective noun
Nominal pronoun plural
1st person pronoun
Nominal pronoun singular
Preposition
Adverb
Nominal includer
Adverbial includer
Infinitive
"Having"
"Being"
Present participle
Interrogative
"Am"
"Is"
"Are"
"Was"
"Were"
Modal
"Ought"
"Do"
"Did"
"Does"
"Had"
"Has"
"Have"
Verb plural
"Be"
Verb past
"Been"
Past participle
Expletive
Conjunction
Relative pronoun
Objective pronoun

Phrase Types

Noun phrase
Verb phrase
Prepositional phrase
Infinitive phrase
Participial phrase
Adjectivial phrase
Adverbial phrase
Gerund phrase

Sentence Parts

Sentence modifier
Subject
Predicate
Complement
Predicate modifier
Relative clause
Included clause
Nested clause

Sentence Types

Declarative
Interrogative
Imperative
Expletive
Inverted

APPENDIX C

Tests of Speech Reception and Speech Production Skills

Children's Nonsense Syllable Test ($Rseg_2$)

1.	SHOO	*BOO*	NOO	36.	*GAA*	MAA	SAA
2.	OOSH	OOB	OON	37.	*GOO*	MOO	SOO
3.	SHEE	*BEE*	NEE	38.	MEE	*SEE*	GEE
4.	*SHAA*	BAA	NAA	39.	*AAS*	AAG	AAM
5.	*AASH*	AAB	AAN	40.	OO	EE	*AA*
6.	EESH	EEB	*EEN*	41.	*SEE*	GEE	MEE
7.	EES	EEG	*EEM*	42.	MAA	*SAA*	GAA
8.	*SAA*	GAA	MAA	43.	*AAG*	AAM	AAS
9.	EE	*AA*	OO	44.	EE	AA	*OO*
10.	OOS	*OOG*	OOM	45.	OOM	OOS	*OOG*
11.	EES	*EEG*	EEM	46.	*MEE*	SEE	GEE
12.	SOO	*GOO*	MOO	47.	GAA	MAA	*SAA*
13.	OOG	*OOM*	OOS	48.	AAS	AAG	*AAM*
14.	AAS	*AAG*	AAM	49.	EEG	EEM	*EES*
15.	*SOO*	GOO	MOO	50.	MEE	SEE	*GEE*
16.	GEE	*MEE*	SEE	51.	AAG	*AAM*	AAS
17.	*AA*	EE	OO	52.	GOO	MOO	*SOO*
18.	EEM	*EES*	EEG	53.	EEG	*EEM*	EES
19.	*MAA*	GAA	SAA	54.	AA	OO	*EE*
20.	*OOS*	OOG	OOM	55.	*EES*	EEG	*EEM*
21.	GEE	MEE	*SEE*	56.	SEE	GEE	*MEE*
22.	SAA	GAA	*MAA*	57.	*OOG*	OOM	OOS
23.	MOO	GOO	*SOO*	58.	MOO	*SOO*	GOO
24.	*OO*	EE	AA	59.	AAG	AAM	*AAS*
25.	*OOM*	OOS	OOG	60.	*EEM*	EES	EEG
26.	*EEG*	EES	EEM	61.	*AAM*	AAS	AAG
27.	*EE*	AA	OO	62.	AA	*OO*	EE
28.	SEE	*GEE*	MEE	63.	*GEE*	MEE	SEE
29.	*GOO*	MOO	SOO	64.	MOO	SOO	*GOO*
30.	GAA	*MAA*	SAA	65.	AAM	AAS	*AAG*
31.	OOG	OOM	*OOS*	66.	SOO	GOO	*MOO*
32.	*EEG*	EEM	EES	67.	MAA	SAA	*GAA*
33.	SAA	*GAA*	MAA	68.	AAM	*AAS*	AAG
34.	OO	*EE*	AA	69.	OOM	OOS	*OOG*
35.	OOS	OOG	*OOM*				

Test of Segmental Production ($Pseg_2$)

Consonant	*Stimulus Word*	*I*	*M*	*F*	*Vowel*
p	piece, happy, keep				i
b	box, rabbit, Bob				ɪ
m	movies, Mommy, swim				
w	weak, away				
n	name, anybody, man				
l	laugh, yellow, cool				
r	read, bathroom, after				
h	he, who, behave				
t	tell, painted, fat				ɛ
d	deep, anybody, food				
k	cat, takes, cake				æ
g	good, wagon, dog				ʊ ɔ
f	feed, after, reef				
v	very, leaves, love				
s	see, Lassie, piece				
z	zipper, easy, these				ɝ
tʃ	chocolate, matches, beach				
ʤ	Jack, pages, huge				eɪ jɝ
ʃ	shopping, dishes, wish				ɑ
θ	think, toothpaste, teeth				u
ð	that, other, smooth				
j	yellow				oʊ
ŋ	moving				
	house, boy				aʊ ɔɪ
st	step, last				
sk	school, ask				
ps	cups				ʌ
ts	boots				
sp	spoons				
ks	leaks				
str	stripes				
θr	thruway				
kr	cream, cry				aɪ
dr	dress				
tr	tree				
fr	front				
fl	floor				

Examples from Revised Prosodic-Feature Reception Test (Rpros$_2$)

1. Come here?
COME here.
Come . . . here.
Come *HERE.*

2. I want to *SEE* it.
I *WANT* to see it.
I . . . want to see it.
I want . . . to see it.

3. I want . . . to see it.
I want to *SEE* it.
I *WANT* to see it.
I . . . want to see it.

4. Come *HERE.*
Come here?
Come . . . here.
COME here.

5. *OH* boy.
Oh . . . boy
Oh *BOY.*
Oh boy?

6. *I* can run.
I . . . can run.
I can *RUN.*
I can . . . run.

7. Bob eats . . . cake.
BOB eats cake.
Bob . . . eats cake.
Bob eats *CAKE.*

8. He has one *BIG* dog.
He has . . . one big dog.
He *HAS* one big dog.
He has one . . . big dog.

9. I can . . . run.
I can run.
I can *RUN.*
I . . . can run.

10. Bob eats *CAKE.*
BOB eats cake.
Bob eats . . . cake.
Bob . . . eats cake.

11. *COME* here.
Come . . . here.
Come *HERE.*
Come here?

12. He *HAS* one big dog.
He has one . . . big dog.
He has . . . one big dog.
He has one *BIG* dog.

13. My new hat . . . is blue.
My *NEW* has is blue.
My new hat is *BLUE.*
My . . . new hat is blue.

14. I can . . . run.
I can *RUN.*
I can run.
I . . . can run.

15. John drinks *MILK.*
JOHN drinks milk.
John . . . drinks milk.
John drinks . . . milk.

16. Oh . . . boy.
OH boy.
Oh *BOY.*
Oh boy?

17. Bob eats *CAKE.*
Bob . . . eats cake.
Bob eats . . . cake.
BOB eats cake.

18. Thank . . . you.
Thank you?
Thank *YOU.*
THANK you.

19. My new hat . . . is blue.
My new hat is *BLUE.*
My . . . new hat is blue.
My *NEW* hat is blue.

20. Bob eats *CAKE.*
Bob . . . eats cake.
Bob eats . . . cake.
BOB eats cake.

21. He has . . . one big dog.
He has one . . . big dog.
He *HAS* one big dog.
He has one *BIG* dog.

22. I can . . . run.
I . . . can run.
I can *RUN.*
I can run.

23. I *WANT* to see it.
I . . . want to see it.
I want to *SEE* it.
I want . . . to see it.

24. Thank *YOU.*
Thank . . . you.
Thank you?
THANK you.

25. My new hat is *BLUE.*
My *NEW* hat is blue.
My . . . new hat is blue.
My new hat . . . is blue.

26. I want to *SEE* it.
I *WANT* to see it.
I . . . want to see it.
I want . . . to see it.

27. My new hat . . . is blue.
My new hat is *BLUE.*
My . . . new hat is blue.
My *NEW* hat is blue.

28. *JOHN* drinks milk.
John . . . drinks milk.
John drinks . . . milk.
John drinks *MILK.*

29. John drinks *MILK.*
John drinks . . . milk.
JOHN drinks milk.
John . . . drinks milk.

30. *COME* here.
Come *HERE.*
Come . . . here.
Come here?

31. John drinks . . . milk.
John drinks *MILK.*
JOHN drinks milk.
John . . . drinks milk.

32. Oh *BOY.*
Oh . . . boy.
Oh boy?
OH boy.

33. *THANK* you.
Thank you?
Thank *YOU.*
Thank . . . you.

34. He *HAS* one big dog.
He has one *BIG* dog.
He has one . . . big dog.
He has . . . one big dog.

35. Oh . . . boy.
OH boy.
Oh *BOY.*
Oh boy?

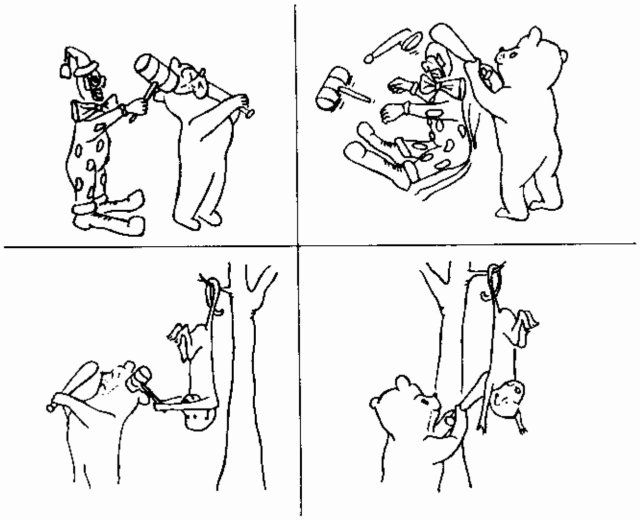
36. *THANK* you.
Thank *YOU.*
Thank . . . you.
Thank you?

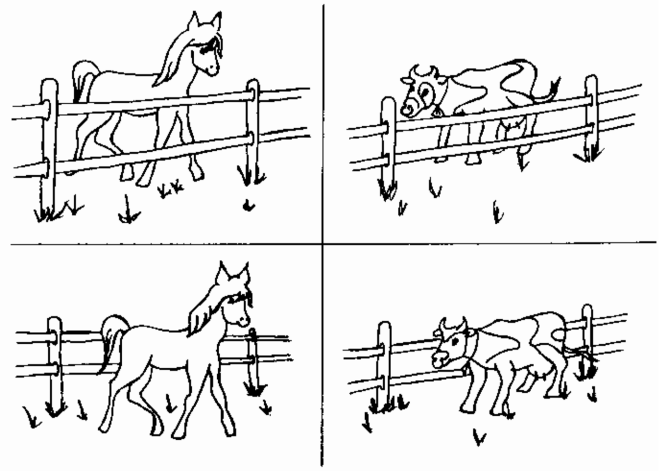
LCS Speechreading Test (SR_2)

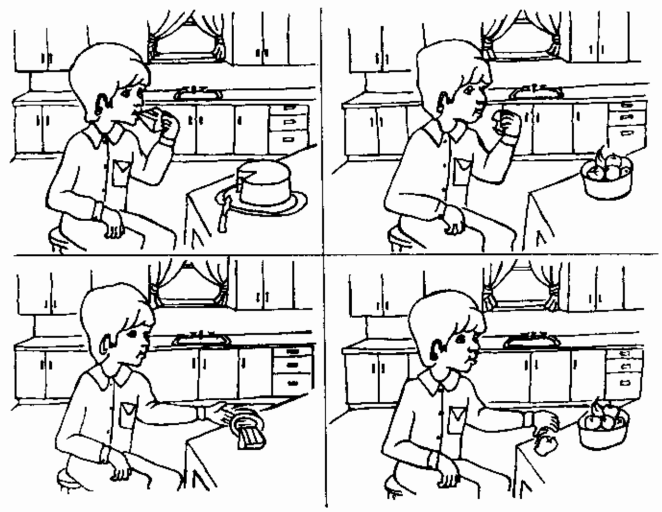
The following sentences are the six practice items and 32 test items that make up the stimuli sequence of the LCS Speechreading Test. The first four of the picture sets that follow are the practice items; the remaining eight are the picture sets for the test items. Each picture in these eight plates becomes, in turn, the test item. Additional details concerning the experimental design and administration of the test are found in Chapter 7.

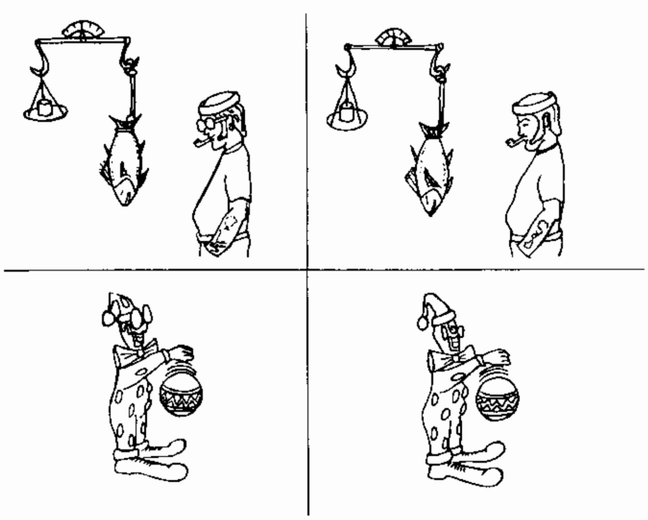
1 The clown hits the bear.
2 The girl washes the baby.
3 The clown with glasses bounces the ball.
4 The cow is behind the fence.
5 The man looks at the fish.
6 The girl washes the car.

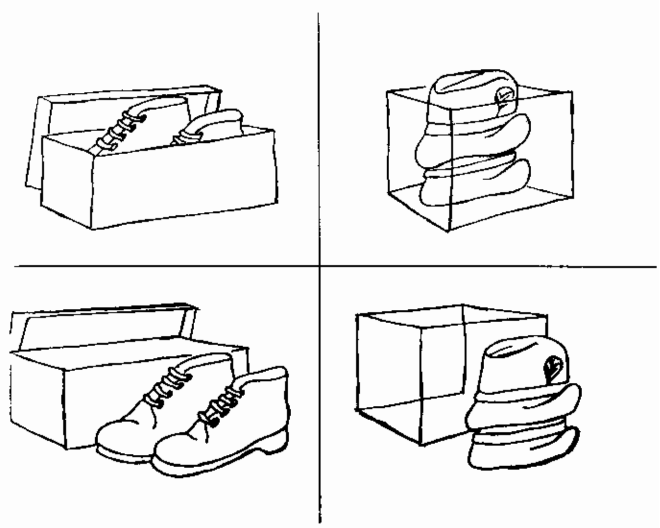
7 The cat with the ball runs after the mouse.
8 The girl jumps rope.
9 The boy drops the cake.
10 The cat chases the dog.
11 The baby drinks the milk.
12 The girl wearing a hat jumps rope.
13 The shoes are next to the box.
14 The baby spills the milk.
15 The boy chases the dog.
16 The baby feeds the fish.
17 The boy eats the apple.
18 The book is on the chair.
19 The man eats ice cream.
20 The baby feeds the mother.
21 The hats are in the box.
22 The dog chases the boy.
23 The book is under the table.
24 The man drinks the milk.
25 The lady wearing a hat talks to the man.
26 The boy eats the cake.
27 The father feeds the baby.
28 The book is under the chair.
29 The hats are next to the box.
30 The man spills the milk.
31 The dog chases the cat.
32 The mother feeds the baby.
33 The book is on the table.
34 The boy drops the apple.
35 The man with the ball eats ice cream.
36 The lady talks to the man.
37 The shoes are in the box.
38 The cat runs after the mouse.

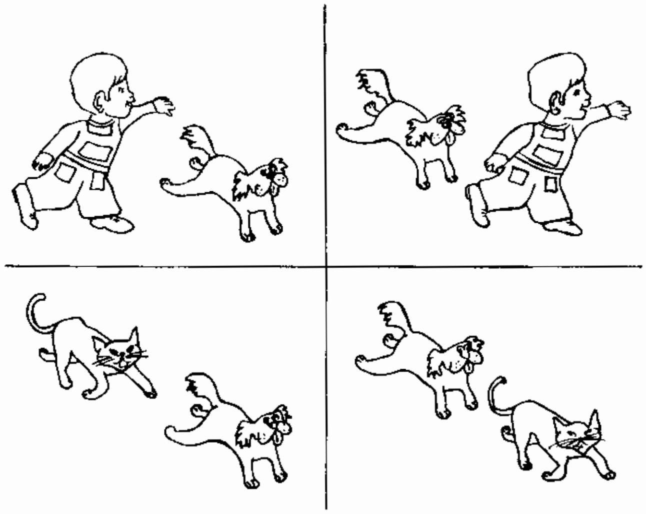


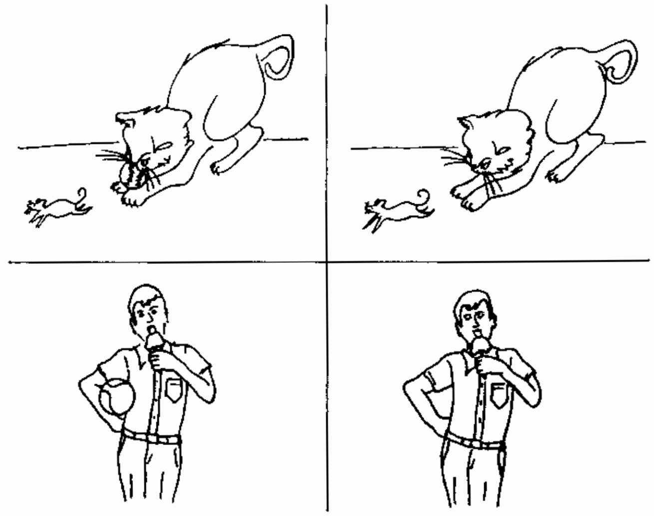


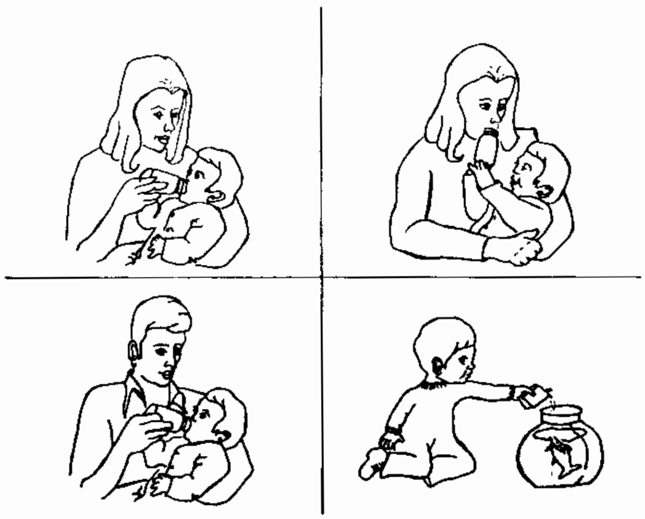


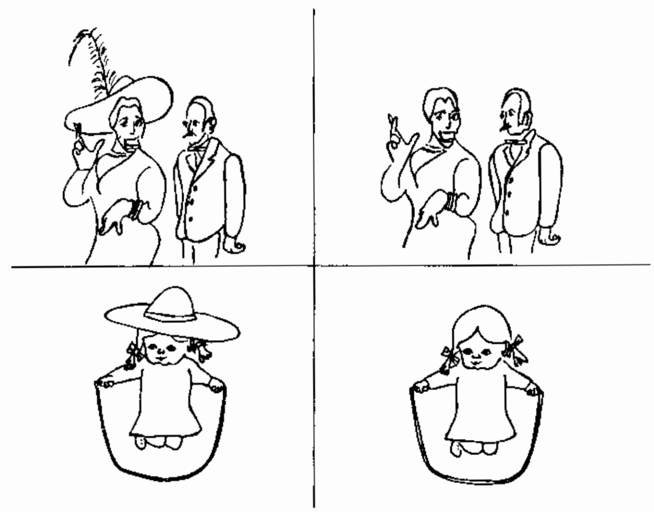


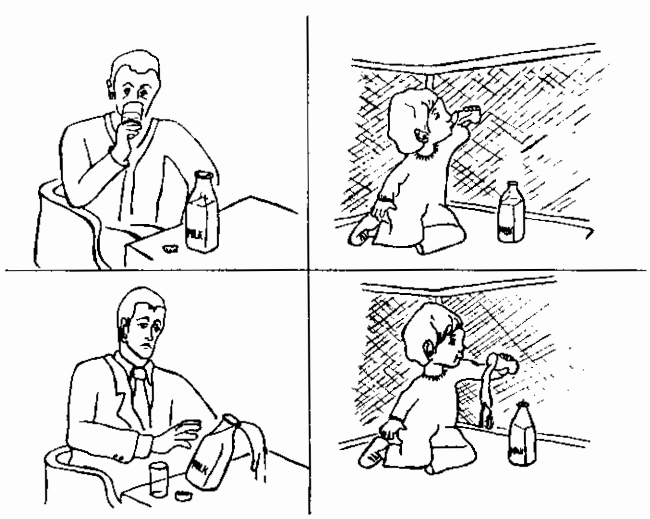


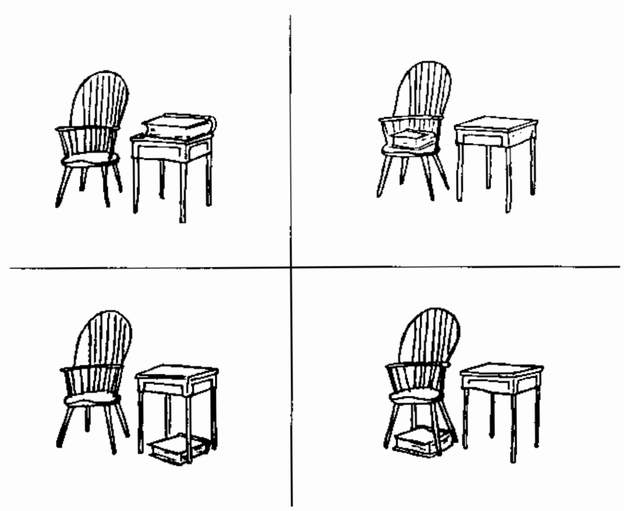












APPENDIX D

PURE-TONE AVERAGES AND THRESHOLDS AT 500, 1000, AND 2000 HZ FOR MAINSTREAMED HARD-OF-HEARING AND DEAF CHILDREN.

Hard-of-hearing		*Threshold at*			*Deaf*		*Threshold at*		
Subject	*PTA*	*500*	*1000*	*2000*	*Subject*	*PTA*	*500*	*1000*	*2000*
1	43.3	25	45	60	19	80.0	70	85	85
2	50.0	40	45	65	20	86.7	90	90	80
3	51.7	45	55	55	21	86.7	90	90	80
4	53.3	20	65	75	22	86.7	85	85	90
5	53.3	50	55	55	23	86.7	85	95	80
6	55.0	35	60	70	24	86.7	70	85	105
7	56.7	50	60	60	25	86.7	80	90	90
8	58.0	60	55	60	26	88.3	85	85	95
9	60.0	20	55	105	27	90.0	85	90	95
10	61.7	65	65	55	28	90.0	85	100	85
11	63.3	60	65	65	29	91.7	85	100	90
12	63.3	65	65	60	30	91.7	85	95	95
13	66.7	55	75	70	31	93.3	90	100	90
14	68.3	50	75	80	32	95.0	80	100	105
15	68.3	55	70	80	33	103.3	95	105	110
16	68.3	65	70	70	34	110.0+	55	NR	NR
17	71.7	75	75	65	35	110.0+	NR	NR	NR
18	73.3	70	75	75	36	110.0+	25	NR	105
					37	110.0+	100	105	NR

APPENDIX E

Test Scores—Phonemic, Prosodic, and Intelligibility Ratings

ID #	Ppros	CPP_1	CPP_2	$Rpros_2$	*S/L*	$Pseg_3$	Isp	$Rseg_1$
1	0.630	−1.000	−1.000	0.639	−0.999	0.784	3.830	0.500
2	0.648	−1.000	−1.000	0.722	−0.999	0.805	5.000	0.620
3	0.574	−1.000	−1.000	0.639	−0.999	0.745	3.830	0.480
4	0.426	0.220	0.220	0.667	−0.999	0.793	4.500	0.760
5	0.370	0.330	0.280	0.389	−0.999	0.535	2.670	0.300
6	0.463	−1.000	−1.000	0.417	−0.999	0.821	3.830	0.660
7	0.370	−1.000	−1.000	0.361	−0.999	−0.999	4.170	0.580
8	0.407	−1.000	−1.000	0.472	−0.999	0.746	3.830	0.660
9	0.630	0.500	0.890	0.472	0.500	0.773	4.000	0.440
10	0.630	0.170	0.830	0.361	0.500	0.719	4.170	0.460
11	0.593	0.280	0.670	0.278	0.291	0.544	1.670	0.220
12	0.500	0.390	0.500	0.639	0.583	0.754	3.330	0.380
13	0.667	0.330	0.560	0.667	0.500	0.595	3.830	0.340
14	0.648	0.610	0.890	0.611	0.833	0.713	3.170	0.280
15	0.556	−1.000	−1.000	0.833	0.750	−0.999	2.500	0.760
16	0.704	0.330	0.670	0.750	0.750	0.908	5.000	0.840
17	0.796	0.220	0.610	0.778	0.666	0.804	5.000	0.740
18	0.667	0.450	0.720	0.778	0.500	0.786	4.330	0.660
19	0.315	−1.000	−1.000	0.444	−0.999	−0.999	4.830	0.620
20	0.519	0.500	0.830	0.444	0.458	0.556	1.830	0.380
21	0.648	0.280	0.780	0.472	0.583	0.816	4.000	0.440
22	0.833	0.170	0.720	0.444	0.500	0.771	4.500	0.760
23	0.611	0.280	0.830	0.444	0.458	0.806	4.670	0.560
24	0.463	0.450	0.390	0.417	0.417	0.681	3.000	0.460
25	0.593	0.330	0.560	0.500	0.291	0.675	3.830	0.660
26	0.741	0.450	0.830	0.389	0.500	0.675	4.830	0.520
27	0.481	0.170	0.670	0.444	0.583	0.746	2.670	0.620
28	0.630	0.170	0.780	0.861	0.708	0.753	4.000	0.680
29	0.556	0.450	0.420	0.556	0.542	0.692	2.830	0.460
30	0.648	0.220	0.610	0.389	0.542	0.543	1.830	0.360
31	0.352	0.610	0.830	0.583	0.750	0.863	4.170	0.760
32	0.741	−1.000	−1.000	0.444	0.250	−0.999	3.670	0.540
33	0.852	0.330	0.500	0.556	0.791	0.896	4.830	0.800
34	0.833	0.170	0.670	0.639	0.750	0.871	5.000	0.860
35	0.889	0.450	0.950	0.694	0.708	0.853	4.830	0.820
36	0.926	0.170	0.890	0.833	0.916	0.896	5.000	0.820
37	0.574	0.500	0.670	0.417	0.625	0.859	5.000	0.740
38	0.648	−1.000	−1.000	0.611	0.625	−0.999	3.670	0.640
39	0.704	0.390	0.670	0.639	0.750	0.697	3.500	0.440
40	0.500	0.330	0.440	0.639	0.666	0.850	5.000	0.720
41	0.704	0.500	0.560	0.667	0.750	0.852	5.000	0.660
42	0.593	0.330	0.780	0.639	0.625	0.899	5.000	0.800
43	0.481	−1.000	−1.000	0.500	0.500	−0.999	5.000	0.700

Ppros—Prosodic production test
CPP_1—Contextual prosodic production (pretraining)
CPP_2—Contextual prosodic production (posttraining)
$Rpros_2$—Prosodic reception test
S/L—Stress/location test
$Pseg_3$—Phonemic scores for sentences
Isp—Spontaneous speech ratings
$Rseg_1$—Phonemic reception scores

APPENDIX F

Stress/Location Test

1. *JOHN* ran home.
   John *RAN* home.
   John ran *HOME*.
2. Which *BOOK* did you read?
   WHICH book did you read?
   Which book did you *READ?*
3. The boys walked to *SCHOOL*.
   The boys *WALKED* to school.
   The *BOYS* walked to school.
4. *JOHN* ran home.
   John *RAN* home.
   John ran *HOME*.
5. How *BIG* is your dog?
   How big is your *DOG*?
   HOW big is your dog?
6. Who is *SMALL*?
   WHO is small?
   Who *IS* small?
7. Who *IS* small?
   Who is *SMALL*?
   WHO is small?
8. What *COLOR* is your hat?
   WHAT color is your hat?
   What color is your *HAT*?
9. My new hat is *BLUE*.
   My new *HAT* is blue.
   MY new hat is blue.
10. He is *FIVE*.
    HE is five.
    He *IS* five.
11. *I* can run.
    I can *RUN*.
    I *CAN* run.
12. Which book did you *READ*?
    Which *BOOK* did you read?
    WHICH book did you read?
13. He is *FIVE*.
    HE is five.
    He *IS* five.
14. *I* can run.
    I can *RUN*.
    I *CAN* run.
15. *CAN* you sing?
    Can *YOU* sing?
    Can you *SING?*
16. The dog *CHASED* the cat.
    The dog chased the *CAT*.
    The *DOG* chased the cat.
17. The boys *WALKED* to school.
    The *BOYS* walked to school.
    The boys walked to *SCHOOL*.
18. Can you *SING*?
    Can *YOU* sing?
    CAN you sing?
19. What *COLOR* is your hat?
    WHAT color is your hat?
    What color is your *HAT*?
20. Are you *TIRED*?
    ARE you tired?
    Are *YOU* tired?
21. The dog *CHASED* the cat.
    The dog chased the *CAT*.
    The *DOG* chased the cat.
22. *ARE* you tired?
    Are you *TIRED*?
    Are *YOU* tired?
23. *MY* new hat is blue.
    My new *HAT* is blue.
    My new hat is *BLUE*.
24. How big is *YOUR* dog?
    How *BIG* is your dog?
    How big is your *DOG*?

Practice Items:

A. *I* am big.
   I *AM* big.
   I am *BIG*.

B. Did John hit the *DOG*?
   DID John hit the dog?
   Did *JOHN* hit the dog?

C. Can *YOU* come?
   CAN you come?
   Can you *COME*?

D. *JOHN* hit the big dog.
   John hit the *BIG* dog.
   John hit the big *DOG*.

APPENDIX G

CONTEXTUAL PROSODIC PRODUCTION TEST (CPP)

Pretraining

Prompt Questions	*Test Items*
What color is the apple?	The apple is green.
What is green?	The apple is green.
	This apple is green, the other one is red.
Who ran home?	The boys ran home.
Where did the boys run?	The boys ran home.
Where is John?	John is home.
Who is at home?	John is at home.
	John is at home, Mary is in school.
	John is at home, Mary is in school?

Posttraining

Prompt Questions	*Test Items*
What *COLOR* is the apple?	The apple is *GREEN*.
WHAT is green?	The *APPLE* is green.
	This apple is green . . . the other one is red.
Who ran home?	The *BOYS* ran home.
WHERE did the boys run?	The boys ran *HOME*.
WHERE is John?	John is *HOME*.
WHO is at home?	*JOHN* is at home.
	John is at home . . . Mary is in school.
	John is at home . . . Mary is in school?

APPENDIX H
GLOSSARY
Tests and Measures Used With Older Children
(Chapters 1, 5, 7, 8, and 9)

Tests of Communication Skills

Symbol	*Name of Test*	*Chapter Containing Description of Test*
CPP	Contextual Prosodic Production	8
Isp	Ratings of Speech Intelligibility	1, 7
Pros	Prosodic Feature Production Test	7
$Pseg_1$	Production of segmental features, Photo Articulation Test	7
$Pseg_2$	Production of segmental features, articulation test using vocabulary selected from Smith's (1975) sentences	7
$Pseg_3$	Phoneme production score for Smith's (1975) sentences	8
$Rpros_1$	Preliminary Prosodic-Feature Reception Test	7
$Rpros_2$	Revised Prosodic-Feature Reception Test	7
$Rseg_1$	Phoneme Reception Test (Smith, 1975)	7
$Rseg_2$	Children's Nonsense Syllable Test	7
S/L	Stress/Location Test	8
SR_1	Myklebust and Neyhus Diagnostic Test of Speechreading	7
SR_2	Language Communication Skills (LCS) Speechreading Test	7

Language Tests

Symbol	*Name of Test*	*Chapter Containing Description of Test*
C	Conjunction	5
D	Determiners	5
Nbh	Negation, *Be/Have* Forms	5
Nm	Negation, Modal Forms	5
Pa	Possessive Adjectives	5
Pb	Backwards Pronominalization	5
Pp	Personal Pronouns	5
Pr	Reflexive Pronouns	5
Ps	Possessive Pronouns	5
Qae	Questions, Answer Environment	5
Qma	Questions, Modals and Auxiliaries	5
Repd	Relativization—Embedding and Pronoun Deletion	5
Rps	Relativization—Processing	5
Rrpr	Relativization—Relative Pronoun Referents	5
SC	Test of Syntactic Comprehension (average score on all subtests)	5
Va	Verbal Auxiliaries	5
Vd	Verb Deletion	5
W	Rating of Written Language	1

Other Variables

Symbol	*Variable*	*Relevant Chapter*
Aaid	Age hearing aid first fitted	9
Asp.ed	Age special education began	9
Aloss	Age at onset of loss	9
B	Behavioral problem	9
D	Child of deaf parents	9
Dfam	Deafness in family	9
E	Special education initiated early in life	9
Etiol	Etiology	9
H or Handic	Additional or other handicaps	9
Hlang	Home language	9
HL	Hearing level	9
IQ	Intelligence quotient	9
N	Non-English-speaking home	9
P	Postlingually deafened	9
Pco-op	Parental cooperation	9
PTA	Pure-tone average	9
Read	Reading score	9
SES	Socioeconomic status	9
#Sib	Number of siblings	9
U	U-shaped audiogram	9
Uaid	Use of hearing aid	9