LANGUAGE AND LEARNING SKILLS OF HEARING-IMPAIRED STUDENTS

ASHA MONOGRAPHS

NUMBER 23 A PUBLICATION OF THE AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION

LANGUAGE AND LEARNING SKILLS OF HEARING-IMPAIRED STUDENTS

ISSN 0066-071X

LANGUAGE AND LEARNING SKILLS OF HEARING-IMPAIRED STUDENTS

Edited by

Mary Joe Osberger
Boys Town National Institute, Omaha, Nebraska

Editorial Consultants

Patrick E. Brookhouser
David E. Goldgar
Betty Jane Philips
Betty U. Watson
Charles S. Watson
Don W. Worthington
Boys Town National Institute, Omaha, Nebraska

ASHA Monographs Number 23 (ISSN 0066-071X)

AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION

10801 Rockville Pike
Rockville, Maryland 20852

March 1986

Contents

Preface
Mary Joe Osberger and Patrick E. Brookhouser vii

Foreword
S. Richard Silverman ix

Abstract x

Part I. Population Description

Chapter 1. Introduction
Mary Joe Osberger 3

Chapter 2. Medical Evaluation
Patrick E. Brookhouser and Michael Grush 6

Chapter 3. Genetic Evaluation
Shelley Smith and William J. Kimberling 9

Chapter 4. Audiological Evaluation
Don W. Worthington, Patricia Stelmachowicz, and Lori Larson 12

Chapter 5. Vestibular Evaluation
David Cyr, Patrick E. Brookhouser, and Kathryn Beauchaine 21

Chapter 6. Speech Evaluation
Mary Joe Osberger, Amy McConkey Robbins, John Lybolt, Raymond D. Kent, and Jo Peters 24

Chapter 7. Intellectual Evaluation
Betty U. Watson, Patricia Sullivan, John Teare, and Ron Thompson 32

Part II. Language and Learning Skills

Chapter 8. Receptive Language Skills
Mary Pat Moeller, Mary Joe Osberger, and Malinda Eccarius 41

Chapter 9. Expressive Language Skills
Mary Joe Osberger, Mary Pat Moeller, Malinda Eccarius, Amy McConkey Robbins, and Deborah Johnson 54

Chapter 10. Academic Skills
Judith Kroese, Wendy Lotz, Carol Puffer, and Mary Joe Osberger 66

Chapter 11. Visual Processing, Short-Term Memory, and Visual Motor Coordination Skills
Wendy Lotz, Judith Kroese, Carol Puffer, and Mary Joe Osberger 77

Part III. Summary and Conclusions

Chapter 12. Factors Related to Academic Achievement
David E. Goldgar and Mary Joe Osberger 87

Chapter 13. Summary and Implications for Research and Educational Management
Mary Joe Osberger 92

Appendix A. Receptive Language Tests 99

Appendix B. Expressive Language Tests 100

Appendix C. Written Language Samples 101

Appendix D. Academic Tests 104

Appendix E. Visual Processing, Short-Term Memory, and Visual-Motor Coordination Tests 106

Appendix F. Correlation Matrix for the Measures in the Multivariate Analysis 107

Preface

Since 1977, the Boys Town National Institute has employed a multidisciplinary-team approach to evaluate the language and learning problems of hearing-impaired children. The rationale for such an approach is that it affords the opportunity to examine the complex, interrelated factors that can affect a hearing-impaired child's ability to learn language and achieve academic success, most notably, in the area of reading. Emphasis is placed on understanding the nature of a given child's learning problems, as well as establishing performance levels with objective measures. The ultimate goal of the evaluation is to develop intervention and remediation strategies tailored to meet the needs of each child.

This unique clinical service prompted the state of Nebraska to contract with the Institute to perform multidisciplinary evaluations on all the students enrolled in the state residential school for the deaf. In 1980, evaluations were performed on 150 students in the areas of (a) medicine (pediatrics, otolaryngology, and genetics); (b) audiology, including a vestibular evaluation; (c) psychology (intellectual evaluation); (d) speech; (e) language (receptive and expressive); (f) academics (reading, spelling and math); and (g) visual processing, short-term memory, and visual-motor coordination. To our knowledge, there are no studies that have reported performance data in all these areas for a single sample of hearing-impaired children. This situation, and the interest of our professional colleagues in our multidisciplinary assessment procedures, motivated us to analyze the evaluation data and to publish a comprehensive summary of the results.

The monograph has been prepared with two major goals in mind. First, it is intended to provide the reader with a detailed description of how we test hearing-impaired children, including a discussion of some of the issues and problems encountered in this process. This information should be of particular interest to teachers and clinicians who may wish to employ some of the procedures with the hearing-impaired children they evaluate. The second goal is to quantify the performance of the students on a battery of tests in each evaluation area and to identify, through statistical analyses, those variables that appear to have a significant effect on academic performance. In Part I (chapters 1-7), the information obtained from the medical (pediatric, otolaryngologic, and genetic), audiologic, vestibular, speech, and intellectual evaluations is presented to provide the reader with an in-depth description of the sample of hearing-impaired students studied. Part II (chapters 8-11) presents data on the students' language and learning skills, including intercorrelations between measures in each evaluation area, relatively extensive discussions of testing procedures, and interpretation of student performance. Part III (chapters 12-13) presents the results of the multivariate analyses, summarizes the major findings, and discusses the implications of the results for the management of hearing-impaired children and future research.

We recognize that the monograph suffers from a number of shortcomings. First, the major purpose of the evaluation was to obtain information that would assist the staff at the school for the deaf in developing an Individualized Education Plan (IEP) for each student. Thus, the clinicians' main task during testing was to administer procedures that would best yield this information. Because of the disparate abilities of the students, even those who were in the same chronological age range, it was not always practical to administer all tests to each student. This reduced the number of subjects and tests that could be included in the multivariate analyses. Secondly, measures that were both appropriate and practical to administer were not always available to assess the skills of interest. Some measures were developed for the project, but these are lacking reliability and validity data. Further, some areas simply were not assessed (speechreading and pragmatics) because of test limitations, test-development difficulties, or time constraints. Despite these problems, we are hopeful that the monograph will provide useful information to the clinician, teacher, and researcher in understanding the language and learning problems of hearing-impaired children. It also should be stressed that identified deficits in the population studied should not be viewed as an indictment of the particular school they attended, but rather as representative of the problems encountered in educating profoundly hearing-impaired children, at least in comparable educational settings.

The monograph resulted from the close working collaboration between the staff at Boys Town National Institute and the Nebraska School for the Deaf. We wish to express our sincere appreciation to the following individuals who assisted us during the stages of data collection, data analyses, and manuscript preparation: to Charlotte Lieser and Bonnie Boardman for typing the manuscript; to Jinda Skov, Patty Kerrigan, and Joanne Carvalho for proofreading; to Nene Field for conducting the telephone interviews with the families; to Betty Jane Philips for coordinating the evaluations; to Walt Jesteadt and Eric Javel for assistance in data analyses; to Mike Gorga, Mark Horton, Ron Netsell, and Ann Murray for reading and evaluating sections in the monograph; to David Goldgar, who served as statistical consultant and performed the statistical analyses; and, finally, to the staff and administration of the Nebraska School for the Deaf, the Boys Town National Institute, and Father Flanagan's Boys' Home for their ongoing support throughout the project. Data analyses were supported, in part, by grants from the National Institutes of Health and the Easter Seal Research Foundation.

Mary Joe Osberger, *Editor*

Patrick E. Brookhouser, *Director*
Boys Town National Institute

Foreword

S. Richard Silverman

Boys Town National Institute

Out of the effusive rhetoric that marks the seemingly interminable controversies about how profoundly hearing-impaired children should be educated at least one fundamental point of agreement emerges, namely, that primary emphasis on reading and writing the English language is essential. It may, in fact, be reasonably argued that the level and the extent to which these abilities are achieved by students are the indispensable, if not ultimate, tests on which the evaluation of varying techniques, methods, and even philosophies undoubtedly rests. Recognition of this central concern of educators, confronted as they are by amply documented discouraging results, moved Dr. Mary Joe Osberger and her associates, some from allied fields, to investigate the language and learning skills of hearing-impaired students via a comprehensive study of the Nebraska School for the Deaf. The school context afforded a realistic opportunity to examine as thoroughly as possible the variables that bear upon student performance in attaining those skills that equip the student for continued learning.

The research is a significant contribution to the marshalling of extant materials, methods, and procedures relevant to assessment of pertinent abilities, emphasizing quantification of skills and related subskills, and to implications for targeted instruction. The thorough multivariate treatment of results constitutes an advance over the many cited studies that examine controlled isolated factors which may not get at the subtle but important interactions that are likely to affect the total learning picture. Sensitivity to this point pervades the study.

The discussion wisely cautions against literal interpretations of age levels and other data and inferences from isolated aggregate findings. The study carefully delineates the characteristics, as best they can be specified, of the population of the school. Cited agreements with other studies suggested that the Nebraska School population is "representative" or "typical" and thus may point to generalizability of results. This conclusion needs to be tempered by the possible influences of variables beyond the purview of the study. Among these are educational settings, pupil-teacher ratio, availability and use of supportive services, external forces (adult deaf, parents, legislature), and actual communicative environment. Frequently, it is assumptions about these factors that fuel support for projects aimed at improving outcomes. Nevertheless, whatever differences may exist among institutions, the results of the Nebraska status study commend its body of data as an eminently rational point of departure for a disciplined objective approach to the difficult task of improving the language and learning skills of all hearing-impaired students.

The investigation speaks for itself and is refreshingly free of the impassioned "advocacy" and tendentious writing that divert attention from sound deliberation of fundamental questions. The pages that follow reveal convincingly that the toughness of the challenge of amelioration of learning is matched by the possibility of its accomplishment. In my judgment, this is the message of the monograph to all concerned with the education of hearing-impaired children.

S. Richard Silverman

Gainesville, Florida
March 1986

Abstract

The major purpose of this study was to quantify the performance of a large group of profoundly hearing-impaired students on a battery of tests that assessed a wide range of language (receptive and expressive), academic (reading, spelling, math), and related learning (visual perception and short-term memory) skills. The data were then subjected to multivariate analyses to examine the relation between academic achievement and the other skill areas. A secondary goal was to provide a detailed description of the characteristics of the students and the assessment procedures, to discuss the strengths and weaknesses of the measures used, and to identify problems in the application of formal assessment procedures with the hearing impaired. The subjects consisted of 150 students (4-20 years of age) from a residential school for the deaf which employed total communication. The results of the multivariate analyses revealed that language, particularly expressive language, was the major determinant of academic achievement in the sample under study. Visual processing also contributed significantly to academic performance, although to a much lesser extent than language. In contrast, hearing level, speech intelligibility, and short-term memory for linguistic material contributed relatively little information to understanding academic achievement.

Part I

POPULATION DESCRIPTION

Chapter 1

Introduction

Mary Joe Osberger
Boys Town National Institute

PURPOSE

The devastating effect of a profound congenital hearing loss on the development of language and communicative skills has been of concern to parents, physicians, educators, and clinicians for decades. Recent studies (cf. Kretschmer & Kretschmer, 1978; Quigley & Kretschmer, 1982) have continued to demonstrate severe developmental delays and deficits in language acquisition and language-dependent areas of academics in the hearing-impaired population despite major technological advances in education, speech and hearing sciences, and communication engineering. Of particular concern is the consistent finding that most profoundly hearing-impaired children fail to reach the level of functional literacy (fourth-grade reading level) by the time they graduate from high school.

The apparent lack of success in helping hearing-impaired students realize their full potential in language and academics may be due to the fact that the problems in these areas have not been adequately delineated. Little is known about how hearing-impaired children acquire language or the manner in which they learn to read. In addition, the relative importance of the many variables that may affect a hearing-impaired child's ability to learn language and achieve academic success is not well understood. Until some of the questions about the language and learning process in the hearing impaired are answered, more effective remediation procedures cannot be developed.

In general, there is consensus among educators of the deaf that the primary goal of every school program is to teach the profoundly hearing-impaired child to read and write the English language, although there is disagreement about the methods that should be used to achieve this goal. This is a formidable task when one considers that these children must be taught directly most of the speech, language, and reading skills that children with normal hearing acquire effortlessly through their everyday auditory experiences. Further, the language acquisition process in the normal-hearing child is complex and our knowledge in this area is still far from complete. It is well documented (cf. Bloom & Lahey, 1978) that language consists of many component skills—phonology, semantics, syntax, pragmatics—all of which are interrelated and enter into the reading process, some to a greater extent than others (Gibson & Levin, 1975). The area of reading has been a major topic of research with normal-hearing as well as hearing-impaired children because the ability to read well is a prerequisite for most other aspects of academic education. It too involves the mastery of component skills and the use of interrelated processes that are not completely understood in the child with normal hearing (Gibson & Levin, 1975).

Even though it is commonly acknowledged that the reading and academic difficulties of the hearing impaired are due largely to language deficits, few studies have documented this relation with quantitative data. Additionally, it is not known if some components of language are relatively more important than others in the development of reading skills in the hearing impaired. The literature contains a relatively large collection of studies on the language and academic skills of hearing-impaired students, but these studies generally have examined isolated areas of performance. Research with normal-hearing subjects has shown that selected learning abilities such as various forms of visual processing, memory, and visual-motor coordination can affect reading and academic achievement (cf. Bryan & Bryan, 1975). Whereas a number of studies have examined memory processes in the hearing impaired, these investigations have been directed toward understanding their cognitive abilities or their use of coding strategies. In general, the results of such experiments provide little insight into the relation between learning skills such as visual processing and overall language and academic performance.

The major purpose of this study was to quantify the performance of a large group of severely and profoundly hearing-impaired students on a battery of tests that assessed a wide range of language, academic, and related learning skills. These data then were used to examine the relationship between academic achievement and the other skill areas with multivariate analyses. Academic achievement was selected as the dependent variable for two major reasons. First, the success of educating hearing-impaired children generally is judged by their academic achievement. Secondly, academic achievement—in particular, reading—appears to be dependent on language and the other skills assessed in this study. The relative effect of these skills on academic performance in the hearing impaired has not been quantified or investigated systematically.

A secondary goal was to provide a detailed description of the assessment procedures, to discuss the strengths and weaknesses of the measures used, and to identify problems in the application of formal procedures with the hearing impaired. Thus, this report is intended to provide the clinician and teacher with information on how to test the hearing impaired and with normative data to compare the performance of other samples of hearing-impaired students. Because of these goals, detailed information about the students and their performance on the various measures is included. The monograph also includes data on the students' performance on tests, particularly in the area of language, which were not included in the multivariate analyses. This information also is intended for the clinician and teacher.

The monograph consists of three parts. Part I reports the results of the medical (pediatric, otolaryngologic, genetic), audiological, vestibular, speech production, and intellectual evaluations. This information is descriptive in nature and, with the exception of portions of the audiological, speech production, and intellectual data, was not subjected to statistical analyses. Part II consists of four chapters that report the data on the language and learning skills of the students, including intercorrelations between measures in each area as well as correlations between hearing level, speech intelligibility, and nonverbal intelligence. Part III presents the results of the multivariate analyses, summarizes the major findings, and discusses the results of the study in relation to the educational management of hearing-impaired children and future research.

METHOD

Subjects

The subjects consisted of 150 students (90 boys, 60 girls) from the state residential school for the deaf. Total communication had been used in the school for approximately 9 years. The students ranged in age from 4 years 6 months to 20 years 2 months, with a mean age of 13 years 5 months. Approximately 75% attended the school on a residential basis.

For purposes of data analyses, the students were divided into the eight age groups shown in Table 1. To form age groups with similar sample sizes, the number of yearly intervals in each group could not be kept constant. Thus, some groups have a 1-year age interval (Groups 5, 6, and 7), whereas the others have an interval of 2 years or more. This situation was unavoidable because of the unequal distribution of students as a function of age. Keeping the yearly interval constant would have resulted in groups with large differences in sample size with the number of subjects in some groups too small to permit meaningful application of statistical procedures.

TABLE 1. Distribution of students as a function of age and sex.

Group	*Age range (years)*	*Number of males (n)*	*Number of females (n)*	*Total*
1	4.5– 7.5	11	2	13
2	7.6– 9.5	5	9	14
3	9.6–11.5	6	6	12
4	11.6–13.5	16	7	23
5	13.6–14.5	10	9	19
6	14.6–15.5	23	10	33
7	15.6–16.5	7	4	11
8	16.6–20.0	12	13	25
	Total	90	60	150

Table 2 summarizes the distribution of students in terms of age group, hearing level, pure-tone average (dB HL in the better ear), and nonverbal intelligence (performance IQ as measured by the WISC–R). There is a relatively even distribution of students as a function of age group with the exception of the slightly larger proportion of students in Groups 5 and 6. These two groups reflect the increased incidence of deafness in the mid 1960s due to the maternal rubella epidemic. The distribution of hearing levels shows that roughly 60% of the students are profoundly hearing impaired. The IQ data show a relatively normal distribution of nonverbal intelligence with a slight skewing toward the high end (PIQ > 115).

Note that nonverbal IQ data are missing for 5 of the students. This was due to student absences, largely the result

TABLE 2. Distribution of students as a function of age group, hearing level (PTA, dB HL), and performance IQ.

	n	*Frequency (%)*
Age group		
1 and 2	28	18.7
3 and 4	34	22.7
5 and 6	52	34.6
7 and 8	36	24.0
Total:	150	100.0
PTA		
≤ 70 dB	25	16.7
71 – 90 dB	36	24.0
> 90 dB	89	59.3
Total:	150	100.0
PIQ		
< 85	18	12.0
85 – 115	89	59.3
> 115	38	25.3
Missing	5	3.3
Total:	150	100.0

of illness. Because of this problem, which affected all testing, it is noted throughout the monograph that the number of students administered a given procedure may total less than 150. Further, the disparate abilities of the students, wide age range, time limitations, and the need to obtain information relevant to the educational management of each student made it impractical to administer every test to each student. This was particularly true for the language measures that generally were designed to assess linguistic skills within restricted age ranges. Because the number of students tested within each age category varied widely on any given instrument, standard chi-square goodness-of-fit procedures were used to determine if the sample tested on each measure differed significantly from the entire population with respect to age, hearing level, and performance IQ (as shown in Table 2). The subset of students tested on any individual measure did not differ significantly from the entire population with respect to hearing level and performance IQ. In contrast, significant age differences were found between the sample tested and the entire population for all the language measures but not for the measures in any other area. This was to be expected because the language tests assessed developmental skills and were given to children within relatively well-defined age intervals. Thus, tests designed for preschool children were not administered to high-school students and vice versa. Also, students within an age group might not have received all of the same measures because of disparate language abilities. The criteria used to determine which age groups received a particular test are noted where appropriate in the chapters on language assessment (chapters 8 and 9).

Procedure

Each student received a 15-hr multidisciplinary evaluation. The majority of this time (10 hr) was devoted to the assessment of language, academic, and related learning skills. Information obtained from the other evaluation areas (medicine, audiology, speech, and psychology) are used to present a detailed description of the population studied. Performance in the majority of areas was assessed with a battery of tests rather than isolated measures. This approach was used because of the need to assess a broad range of skills, which also entailed using many procedures that had not been previously standardized with hearing-impaired students. Measures selected were ones previously shown to be sensitive in identifying language and learning difficulties in the hearing impaired, if not by formal standardization with hearing-impaired children, at least through several years of clinical experience at the Institute. The rationale for the selection of particular measures, as well as detailed information about our approach to assessing hearing-impaired children, is reported elsewhere (Moeller & Eccarius, 1980; Moeller, McConkey, & Osberger, 1983; Moeller, Osberger, Eccarius, & McConkey, 1981).

All test instructions and test items were administered in total communication by a clinician, who was fluent in sign, or by an interpreter. Prior to the evaluation, the clinicians met with the students' teachers to ensure that the signs used in the testing sessions were the same as those used by the students in their school. Unless otherwise stated, all tests were administered individually.

All correlations calculated were partial correlations adjusted for both age and Wechsler Performance Intelligence Quotient (IQ). This was necessary because many of the measures used did not have adequate age or IQ norms for the hearing-impaired population. When possible, the performance of the hearing-impaired students in this study was compared to other populations of hearing-impaired children. These comparisons, however, are few because only a limited number of investigations have employed the same measures used in this study. Because this study did not assess the skills of interest in a comparable sample of students with normal hearing, the standardization data reported in the various test manuals were used to compare the performance of the hearing-impaired subjects to their hearing peers. These comparisons are largely descriptive, and, in general, tests of significance between the normal-hearing standardization data and the data obtained from the hearing-impaired students were not performed. For those measures where the relationship between performance and age appeared to be of considerable clinical significance, analyses of variance as well as correlations were performed.

REFERENCES

BLOOM, L. L., & LAHEY, M. (1978). *Language development and language disorders*. New York: Wiley & Sons.

BRYAN, T. H., & BRYAN, J. H. (1975). *Understanding learning disabilities*. Sherman Oaks, CA: Alfred Publishing.

GIBSON, E. J., & LEVIN, H. (1975). *The psychology of reading*. Cambridge: MIT Press.

KRETSCHMER, R., & KRETSCHMER, L. (1978). *Language development and intervention with the hearing impaired*. Baltimore: University Park Press.

MOELLER, M. P., & ECCARIUS, M. (1980). Evaluation and intervention with hearing-impaired children. *Journal of the Academy of Rehabilitative Audiology, 13*, 13-31.

MOELLER, M. P., MCCONKEY, A. J., & OSBERGER, M. J. (1983). Evaluation of the communicative skills of hearing-impaired children. *Audiology, 8*, 113-127.

MOELLER, M. P., OSBERGER, M. J., ECCARIUS, M., & MCCONKEY, A. J. (1981). Some language skills of the students in a residential school for the deaf. *Journal of the Academy of Rehabilitative Audiology, 14*, 84-111.

QUIGLEY, S. P., & KRETSCHMER, R. E. (1982). *The education of deaf children*. Baltimore: University Park Press.

Chapter 2

Medical Evaluation

Patrick E. Brookhouser Michael Grush

Boys Town National Institute

PEDIATRIC EVALUATION

Each student received a screening physical and neurological examination. The major purpose of this exam was to confirm that each student was in good general health. Because a more thorough examination was not performed, no attempt was made to analyze the relation between physical findings and the other variables of interest in this report. The screening included examination of the head, eyes, ears, nose, throat, lungs, abdomen, and a cursory check for dysmorphic features. An attempt was made to screen visual acuity, but technical difficulties precluded securing reliable information in this area. If, however, reports from teachers, clinicians, or parents suggested that a child was experiencing visual acuity problems, s/he was referred for an ophthalmology exam. A history was obtained, which was a composite of information from parents, medical records, and the students themselves. Because the majority of students were residents at the school, information was secured from the parents via a telephone interview conducted by a speech-language pathologist prior to the time each student was evaluated. More complete medical histories might have been obtained had the physician been able to question the parents at the time of the physical exam. Some information was obtained from the students themselves, but those questioned, even the teenagers, demonstrated an amazing lack of knowledge about their past medical histories. It should be noted, however, that an interpreter was not always available when the medical examination was performed. Thus, failure to obtain more accurate information from the students might reflect communication problems between them and the medical staff.

RESULTS

The physical abnormalities with the highest frequency of occurrence are summarized in Table 3. As the results show, the highest incidence involved dental problems, which included dental caries, thick dental plaque, malocclusion, and gingivitis. The next highest incidence consisted of the presence of three or more minor anomalies, including clinodactyly, simian crease, frontal bossing, narrow palates, and arachnodactyly. Congenital heart disease and microcephaly occurred with roughly the same frequency. In addition, the medical examination revealed 6 cases of obesity, 2 cases of short stature, and severe scoliosis, 3 cases of cerebral palsy, and 1 case of cleft lip and cleft palate.

TABLE 3. Incidence of physical abnormalities on the pediatric examination (n = 150).

Abnormality	*n*	%
Dental problems	27	18
Minor anomalies (3 or more)	22	15
Congenital heart disease	9	6
Microcephaly	8	5

The most common physical abnormalities also were examined in terms of the eight age groups. These results are shown in Table 4. There appears to be no clear-cut trend with respect to age except for a slightly higher incidence of dental problems in Groups 2 and 3 and a lower incidence of minor anomalies in Groups 1, 7, and 8 than in the other groups.

TABLE 4. Incidence of physical findings expressed in terms of age group.

		Dental problems		*Minor anomalies*		*Congenital heart disease*		*Microcephaly*	
Group	*Age*	*n*	%	*n*	%	*n*	%	*n*	%
1	4.7– 7.5	1	8	1	8	0	0	2	15
2	7.6– 9.5	5	36	3	21	0	0	1	7
3	9.6–11.5	4	33	3	25	2	17	0	0
4	11.6–13.5	3	14	4	18	1	5	1	5
5	13.6–14.5	3	16	4	21	0	0	0	0
6	14.6–15.5	6	18	4	12	4	12	1	3
7	15.6–16.5	2	18	1	9	1	9	2	18
8	16.6–20.0	3	13	2	8	1	4	2	8

The findings with respect to the etiologies of the hearing losses are presented in chapter 3 with the results of the genetic evaluation.

OTOLARYNGOLOGIC EVALUATION

The medical evaluation also included a comprehensive otolaryngologic examination. Positive findings were categorized according to the classification scheme in Table 5.

TABLE 5. Scheme used to classify otolaryngologic abnormalities.

Category	*Physical abnormality*
Acute or subacute middle-ear disease	Opacified/retracted TM Reddened TM Injected TM Eustachian tube dysfunction (intermittent or other) Middle-ear effusion
Chronic middle-ear disease	Thickened/scarred TM Myringo-incudo-stapediopexy Monomeric TM/atrophic changes/retraction pockets Perforation of TM Chronic otitis media with or without TM perforation Adhesive otitis/tympanosclerosis
Otitis externa	External canal drainage Exfoliation
Evidence of possible congenital ear anomaly	Small auditory canals Deformity of external ears Possible ossicular anomaly
Soft palate pathology	Bifid uvula Palatal notching Other evidence of submucous clefting History of cleft palate repair
Nasopharyngeal pathology	Adenoid mass—enlarged or obstructive
Nasopharyngeal pathology: nasopharyngitis	Nasopharyngeal mucosa inflammation Inflammatory changes Pharynx reddened, or streaking present Postnasal drainage
Tonsil pathology	Enlarged Obstructive Chronically infected Includes all positive findings for tonsils
Neck pathology: lymphadenopathy	Includes all findings pertaining to cervical adenopathy or anomalies
Nasal obstruction with and without septal deviation	Inferior septal spur Obstructed airway Deviated septum with obstruction
Anatomical deformity including nasal septal deviation without obstruction	Deviated septum
Rhinitis, allergic and nonallergic	Inflamed mucosa Excoriated mucosa Edema Polypoid changes

RESULTS

Of the 150 students evaluated, 53 (35%) demonstrated one or more otolaryngologic findings. Not unexpectedly, the relative frequency of occurrence of otolaryngologic abnormalities was higher in the younger than the older students. Forty-nine percent (19/39) of the students in Groups 1–3 (4.5–11.5-year olds) showed one or more positive findings, whereas the relative incidence in the older students (Groups 4–8: 11.6–20.0-year olds) was 28% (34/111). Acute/subacute or chronic middle-ear disease was the most common finding and occurred in 28% (11/39) and 15% (17/111) of the younger (4.5–11.5-year olds) and older (11.6–20.0-year olds) students, respectively. The incidence of otolaryngologic findings is summarized in Table 6 for the younger students, and in Table 7 for the older students. Note that although the relative frequency of the abnormalities is lower in the older students, they demonstrate a wider range of problems than the younger students.

DISCUSSION

The results of the pediatric evaluation revealed the presence of physical abnormalities in addition to a hearing handicap in some of the students. The most common ones were dental problems and the presence of three or more

TABLE 6. Incidence of otolaryngologic findings in Groups 1–3 (4.5–11.5 years).

Abnormality	*n*	%
Acute/Subacute ear disease	12	31
Chronic middle–ear disease	9	23
Otitis externa	2	5
Congenital ear deformity	1	3
Soft palate anomaly	1	3
Nasopharynx: Enlarged or infected	5	13
Tonsil pathology	3	21
Adenopathy/Adenitis	1	3

TABLE 7. Incidence of otolaryngologic findings in Groups 4–8 (11.6–20 years).

Abnormality	*n*	%
Acute/Subacute ear disease	12	11
Chronic middle-ear disease	17	15
Otitis externa	4	4
Congenital ear deformity	8	7
Soft palate anomaly	3	3
Nasopharynx: Enlarged or infected adenoids	7	6
Tonsil pathology	7	6
Adenopathy/Adenitis	6	5
Nasal obstruction (with and without septal deviation)	4	4
Nasal deformity (including septal deviation without obstruction)	5	4
Rhinitis, allergic and nonallergic	11	10

minor anomalies, both of which occurred in slightly less than one fifth of the population. To make a definite diagnosis of the observed problems, additional testing would have been required by specialists in such areas as neurology, cardiology, or dysmorphology. Because this information is lacking, no attempt was made to compare the incidence of the physical findings in this population to the occurrence of such problems in children with normal hearing.

The otolaryngologic evaluation revealed a wide range of problems. The incidence of middle-ear disease appears to be comparable to that reported for children with normal hearing (U.S. Department of Health, Education, and Welfare, 1975).

The data from this and other studies (Osberger & Danaher, 1974; Porter, 1974) demonstrate that middle-ear disease frequently coexists with a severe or profound sensorineural hearing impairment. Additionally, previous research has shown that profoundly hearing-impaired individuals are susceptible to the build-up of cerumen, which can affect hearing sensitivity as well as clog the opening of an earmold (Erber & Alencewicz, 1976; Osberger & Danaher, 1974). Simple obstructions in the external ear canal, the presence of middle-ear disease, or both, can add as much as a 25-dB conductive component to an existing sensorineural hearing loss (Osberger & Danaher, 1974). The loss can occur in the mid and high frequencies where important speech information is carried. A finding of particular concern is that the middle-ear disease or obstructions in the external ear canal can go undetected for months or even years (Osberger & Danaher, 1974; Porter, 1974) in students with severe and profound sensorineural hearing losses. Although the relative frequency of occurrence is higher in younger students, the data show that medically treatable problems can occur in an older student as well. If they remain unrecognized, they can lead to more serious otologic problems as well as reduce the benefit which is received from amplification. These data indicate that regular otolaryngologic evaluations are warranted in hearing-impaired children, irrespective of type of hearing loss or age of the individual.

REFERENCES

ERBER, N. P., & ALENCEWICZ, C. M. (1976). Audiologic evalution of deaf children. *Journal of Speech and Hearing Disorders, 41,* 256-267.

OSBERGER, M. J., & DANAHER, E. M. (1974). Temporary conductive hearing loss in students with sensorineural deafness. *Volta Review, 76,* 52-56.

PORTER, T. A. (1974). Otoadmittance measurements in a residential deaf population. *American Annals of the Deaf, 119,* 47-52.

U.S. Department of Health, Education, and Welfare (1975). *Hearing sensitivity and related medical findings among youth 12-17 years* [DHEW Publication No. (HRA) 76-1636]. Washington, DC: U.S. Government Printing Office.

Chapter 3

Genetic Evaluation

Shelley Smith William J. Kimberling
Boys Town National Institute

EVALUATION METHOD

All of the students were screened for genetic disorders. A thorough physical examination was conducted by a pediatrician (see results in chapter 2), who looked particularly for any physical findings or dysmorphic features characteristic of a genetic syndrome. In addition, the following data were collected at the time of the examination by a member of the genetics staff: head circumference, eye measurements (inner and outer canthal distances; interpupilary distance), ear length, hand and palm length, dermatoglyphic patterns, height, and weight. A history was also obtained from the student with respect to childhood illnesses, injuries or hospitalizations, the suspected cause of deafness, and the presence of any affected relatives. Where possible, the parents were also interviewed by a member of the genetics staff for a more complete medical genetic history, including pregnancy history, medical and developmental history, and pedigree construction. Medical records were requested where relevant. Because of the residential status of the students, complete familial and medical histories often were difficult to obtain for many of the students.

Based on the available information, the etiology of the student's hearing loss was classified by consensus of a pediatrician and the genetics staff as genetic (autosomal dominant, autosomal recessive, sex-linked, multifactorial, or genetic with mode of inheritance unclear), nongenetic (congenital rubella, meningitis, ototoxic drug exposure, etc.), unknown syndromic (unknown etiology but with positive physical findings), or unknown nonsyndromic (no physical findings).

RESULTS

The data were analyzed and classified according to presumed etiology. This breakdown is shown in Table 8. Overall, 36 cases, or 24.3%, had a recognizable genetic etiology; 35, or 23.6%, had nongenetic hearing losses and 77, or 52%, were unknown.

Of the genetic cases, there were approximately equal numbers of students with recessive and dominant forms. Eight students, including two sib pairs, were diagnosed as having, or probably having, Waardenburg syndrome. One student had the Multiple Lentigenes, or LEOPARD, syndrome. Two students were diagnosed as having autosomal recessive syndromes; one had Pendred syndrome and the other had Hartnup syndrome.

TABLE 8. Etiologies of hearing loss.

Etiology	*n*	*(%)*
Genetic	36	24.3
Autosomal dominant	15	41.7
Autosomal recessive	17	47.2
Multifactorial	4	11.1
Nongenetic	35	23.6
Rubella	26	74.3
Meningitis	7	20.0
Other	2	5.7
Unknown	77	52.0
Nonsyndromic	67	87.0
Possible syndrome	10	13.0

The unknown cases included 67 students with nonsyndromic hearing loss for whom family and medical histories were either negative or unavailable. Ten students had associated physical findings, but no identifiable syndrome.

The hearing loss of 26 students was due to maternal rubella. As would be expected, 18 of these students were born in the epidemic years of 1964 and 1965. The 48 students born in these 2 years show a significantly different breakdown of etiologies when compared to the students born in the years 1960–63 and 1966–75 (contingency $\chi^2 = 10.00$, 2 *df*). For those 2 years, the unknown proportion is basically unchanged at 50%, but 30.6% show an acquired etiology and 19.4% are genetic. The 100 students born in the other years show 27% genetic, 16% nongenetic, and 57% unknown.

TABLE 9. Etiologies of hearing loss expressed in terms of age group.

Group	Age	*Genetic*		*Rubella*		*Nongenetic Meningitis*		*Other*		*Unknown*	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
1	4.5– 7.5	3	23.1	0	0.0	3	23.1	0	0.0	7	53.8
2	7.6– 9.5	4	28.6	3	21.4	0	0.0	0	0.0	7	50.0
3	9.6–11.5	4	33.3	0	0.0	0	0.0	0	0.0	8	66.7
4	11.6–13.5	6	27.3	2	9.1	1	4.5	1	4.5	12	54.5
5	13.6–14.5	5	26.3	5	26.3	0	0.0	0	0.0	9	47.4
6	14.6–15.5	4	12.1	12	36.4	1	3.0	0	0.0	16	48.5
7	15.6–16.5	4	36.4	3	27.2	0	0.0	0	0.0	4	36.4
8	16.6–20.0	6	25.0	1	4.2	2	8.3	1	4.2	14	58.3

Table 9 shows the etiologies of hearing loss by age group. The distribution of etiologies is relatively constant across age groups, with the exception of rubella, which occurs most frequently in Groups 5, 6, and 7. As noted above, this is not surprising in view of the rubella epidemic in the mid 1960s. Of interest is the relatively high incidence of hearing loss secondary to rubella in Group 2 and meningitis in Group 1. These two groups, however, contained fewer students than most of the others, and the findings may not be of clinical significance.

DISCUSSION

Several major studies have assessed the genetic influences on childhood deafness. Although exact percentages vary according to the population studied and the methods used, such studies generally indicate that about 50% of cases are attributable to genetic causes. Clinical populations may show somewhat lower proportions, whereas a population such as Gallaudet College shows a higher proportion with genetic etiology (Bergstrom, 1974; Brown, 1969; Chung, Robinson, & Morton, 1969; Fraser, 1964; Proctor & Proctor, 1967; Rose, 1975; Steele, 1981). These same studies indicate that 15–25% of cases can be shown to be due to nongenetic, acquired causes, but that approximately 25–35% of cases will have unknown etiologies even after careful evaluation. These include unrecognized environmental causes, but must also include a significant proportion of sporadic autosomal recessive cases, X-linked recessives, and new dominant cases. Sporadic instances of nonsyndromic genetic deafness, in which there are no obvious physical findings and a negative family history, will be particularly underdiagnosed. Thus, the tabulation of cases that can be shown to be due to genetic causes through family history or medical examination will represent a minimal estimate of the total number of cases with a genetic etiology. Moreover, as environmental causes of deafness are prevented through medical advances, the proportion of genetic cases can be expected to increase.

In comparing the above data to those of other studies, it would appear that genetic deafness is underrepresented and unknown cases are correspondingly overrepresented. This may be due to underascertainment rather than to an inherent difference in the population studied. Several of the autosomal recessive syndromes require special testing to diagnose, such as an EKG for the diagnosis of the Jervell and Lange–Nielsen syndrome, thyroid testing for Pendred syndrome, and ERG for early diagnosis of Usher syndrome. However, these syndromes are uncommon, and inclusion of these tests would only be expected to result in detection of 4 or 5 cases in this population. It may be that the unknown syndromic cases represent genetic syndromes that would be identifiable with more extensive medical or family information. As mentioned previously, complete medical and familial information was unavailable for many of the students. Some autosomal dominant syndromes may have been missed on the physical examination of a child with minimal expression and would only be detectable with a thorough family history.

The proportion of students with nongenetic hearing losses is comparable to the other studies noted above. For example, Bergstrom (1974) reported that 22.9% of their population had acquired hearing losses, primarily due to congenital rubella. Any comparison among studies, however, must be done cautiously because the relative proportions of the different etiologies will be susceptible to regional and temporal variations in addition to the more basic variations in methodology. Still, it is interesting to examine our data in light of the observation of Nance and McConnell (1973) that with minimal evaluations we should be able to detect about half of the genetic cases, because the proportion of students with genetically produced deafness is about half of the expected value of 50% and the unknown proportion is correspondingly increased.

Recognition of the etiology of hearing loss in a given individual can be important for several reasons. Once the diagnosis is known, optimal methods of treatment or remediation can be selected, and other diagnostic techniques may be discontinued. More accurate predictions about the nature and possible progression of the hearing loss may be made. The diagnosis may also reveal other related medical problems that require attention. Additionally, should any important breakthroughs be made in treatment of a given syndrome, those individuals who stand to benefit can be quickly identified.

Equally important, informed genetic counseling can be given to the individual and the family. It is interesting that in a study of 26 families with at least one child at a school for the deaf in New York, all 26 felt that their recurrence risk was 50%, as did most of their affected students. In fact, however, only 10 of the families could be shown to have a recurrence risk as high as 25%, and 4 had negligible risks. None of the families were aware that their deaf students had very low recurrence risk (Warren, Gallien, & Porter, 1982).

REFERENCES

BERGSTROM, L. (1974). *Handling the human communication sequelae.* Paper presented at International Symposium on Human Communication, Mexico City.

BROWN, K. S. (1969). Genetic and environmental factors in profound prelingual deafness. *Medical Clinics of North America, 53,* 741-772.

CHUNG, C. S., ROBINSON, O. W., & MORTON, N. E. (1969). A note on deaf mutism. *Annals of Human Genetics, 23,* 357-366.

FRASER, G. R. (1964). Profound childhood deafness. *Journal of Medical Genetics, 1,* 118-161.

NANCE, W. E., & MCCONNELL, F. E. (1973). Status and prospects of research in hereditary deafness. *Advances in Human Genetics, 4,* 175.

PROCTOR, C. A., & PROCTOR, B. (1967). Understanding hereditary nerve deafness. *Archives of Otolaryngology, 85,* 23-40.

ROSE, S. P. (1975). *Genetic studies of profound prelingual deafness.* Unpublished doctoral dissertation, Indiana University, Indianapolis.

STEELE, M. (1981). Genetics of congenital deafness. *Pediatric Clinics of North America, 28,* 973-980.

WARREN, N. S., GALLIEN, J. U., & PORTER, G. (1982). Genetic counseling in a school for the deaf: A pilot program. *American Annals of the Deaf, 127,* 401-404.

Chapter 4

Audiological Evaluation

Don W. Worthington   Patricia Stelmachowicz   Lori Larson

Boys Town National Institute

The purpose of audiological testing was to obtain a detailed description of each student's hearing sensitivity and their basic auditory function. The evaluation consisted of the following basic test battery:

Pure-tone audiogram. Typically, hearing sensitivity was assessed for the octave frequencies of 250–8000 Hz. When thresholds varied by 20 dB or greater between octave steps, midoctave frequencies also were tested. The type of hearing loss (conductive, mixed, or sensorineural) was determined by a comparison of the air and bone conduction thresholds. Pure-tone audiological results were used to determine the degree, configuration, and residual range of the hearing loss.

Speech reception threshold (SRT). The speech reception threshold (SRT) was defined as the lowest presentation level at which 50% of spondaic words could be identified correctly. In those cases where no items could be identified correctly from a closed set, a speech awareness threshold (SAT) was obtained.

Speech discrimination testing. The purpose of testing speech-discrimination ability was twofold. First, when possible, unaided discrimination testing was performed in order to determine how distinctly words could be perceived at suprathreshold levels. Second, aided scores were obtained (at a normal conversational level) to gain insight into the social communication handicap imposed by the hearing loss. A hierarchy of speech discrimination tests were used, ranging from open-set, adult vocabulary word lists to closed-set response tasks using pictures, objects, or both. The selection of test materials depended on the receptive vocabulary of the individual, as well as on their peripheral hearing loss. For individuals with extremely limited discrimination abilities, simple syllable recognition or nonspeech recognition materials were used. The tests included in the speech discrimination battery were

1. Northwestern University (NU-6) monosyllabic word lists (Tillman & Carhart, 1966);
2. Phonetically Balanced Kindergarten (PBK-50) word lists (Haskins, 1949);
3. Word Intelligibility by Picture Identification Test (WIPI) (Ross & Lerman, 1970);
4. Monosyllable, Trochee, Spondee (MTS) matrix (Erber & Alencewicz, 1976);
5. nonspeech, Sound Effects Recognition Test (SERT) (Hieber, Gerling, Matkin, & Skalka, 1980); and
6. prosodic feature recognition tasks, using MTS matrix.

All word discrimination and recognition tests first were performed with auditory input only. If scores were extremely poor, a combined auditory–visual presentation was used and an estimate of speechreading ability was also obtained; only the auditory data are reported here.

Electroacoustic impedance measures. Electroacoustic impedance measures were used to assess the integrity and function of the middle-ear system. Relative pressure-compliance functions were used to estimate middle-ear pressure and to rule out possible middle-ear effusions. Equivalent volume measures were used to identify potential tympanic membrane perforations and to evaluate patency of tympanostomy tubes where appropriate. When possible, contralateral acoustic-reflex thresholds were established. The information obtained from electroacoustic impedance measures was used to determine which students required otologic referral.

Hearing aid electroacoustic analysis. An electroacoustic analysis was completed for each student's personal hearing aid when applicable. Measures obtained included a high frequency gain curve (ANSI, 1976), a saturation sound pressure level (SSPL 90) curve, and harmonic distortion. In addition, a listening check was performed by the audiologist completing the evaluation. When available, response curves were compared with manufacturer specifications to determine if the hearing aid was functioning properly.

Aided performance. A measure of aided performance was obtained by completing the basic audiological test battery with each student's hearing aid(s) in place. These measures provided an estimate of functional gain as well as aided discrimination ability. Aided thresholds and speech-discrimination scores were used to determine if adequate gain was being achieved and if the hearing aid fitting was appropriate.

RESULTS AND DISCUSSION

Because the test procedures varied across students, only those measures that were administered to the majority of the students are reported here.

Hearing Loss as a Function of Age Group

All age group data are presented in accordance with the eight age groups shown in Table 10. This table presents the number of children in each age group. Also shown are the mean pure-tone averages (PTAs), standard deviation, and range. The number within parentheses denotes those individuals who demonstrated no response to auditory stimuli or for whom a 2- or 3-frequency PTA could not be established. Pure-tone average as presented here is defined in terms of the better ear average which was determined by averaging the pure-tone thresholds of 500, 1000, and 2000 Hz. In those cases where a 3-frequency average could not be calculated, a 2-frequency average was used.

TABLE 10. Distribution within each age group. Mean pure-tone average (MPTA), standard deviation *(SD)*, and range refer to each individual's better ear.

Group	*Age (yrs)*	*n*	*MPTA (dB HL)*	*SD*	*Range (dB HL)*
1	4.5– 7.5	9(2)	93.1	20.3	43–113
2	7.6– 9.5	14(0)	94.1	18.0	47–118
3	9.6–11.5	9(3)	91.8	17.1	55–107
4	11.6–13.5	18(3)	90.1	12.6	65–120
5	13.6–14.5	18(1)	90.7	16.4	63-113
6	14.6–15.5	27(5)	89.1	15.3	57–117
7	15.6–16.5	11(0)	91.7	8.2	78–103
8	16.6–20.0	22(2)	92.9	14.7	55–118

Note. Number within parentheses denotes those individuals who demonstrated responses at too few frequencies in order to calculate a 2- or 3-frequency PTA.

Note that the majority of students fall within the severe-to-profound hearing loss category. Furthermore, the mean PTA across all eight age groups does not vary by more than 5 dB. It is somewhat surprising to find such similarity in degree of hearing loss across these age groups. One might expect the younger children to exhibit higher mean PTAs due to successful integration of children with mild-to-moderate hearing loss into normal-hearing classrooms. It is possible that in a rural state, such as Nebraska, public school services to hearing-impaired children are still limited in many areas. As a result, children who may be potential candidates for successful integration are placed in residential programs out of necessity. A second possibility is that multiple handicaps (mental retardation, learning disabilities, etc.) may interact with the effects of hearing loss in determining school placement resulting in a wider range of PTAs. These findings with respect to distribution of degree of hearing loss across age groups are in agreement with those reported by other investigators (Jensema, 1974; Karchmer & Trybus, 1977). That is, individuals with profound hearing losses tend to be in residential schools rather than in other educational settings, and the percentage of students with profound hearing losses does not vary systematically with age.

Identification and Management of Hearing Loss

As part of the evaluation, each parent completed a questionnaire concerning his/her child's hearing loss. Questions included the age at which the parents first suspected their child had a hearing loss, the age at which the hearing loss was first confirmed, and the age at which the child first obtained a hearing aid. In Figure 1, age of suspicion, confirmation, and receipt of amplification is plotted as a function of age. In general, the trend with regard to the age of suspicion and confirmation of the hearing loss is rather discouraging. That is, the age of initial suspicion and subsequent confirmation appears similar for all students. Separate two-way analyses of variance (Age Group × Age of Suspicion and Age Group × Age of Confirmation) revealed nonsignificant differences for these two variables as a function of age group.

Across all ages, confirmation of the hearing loss appears to be delayed by approximately 8 months relative to the age of suspicion. Possible reasons for this delay are (a) parental delay in contacting professionals; (b) parents' apprehension in regard to wanting to know the truth; (c) parents not knowing whom to contact; (d) family physicians or pediatricians do not recognize the problem and therefore do not make the necessary referrals; and (e) parents, grandparents, and/or physicians simply "wait for the child to grow out of it."

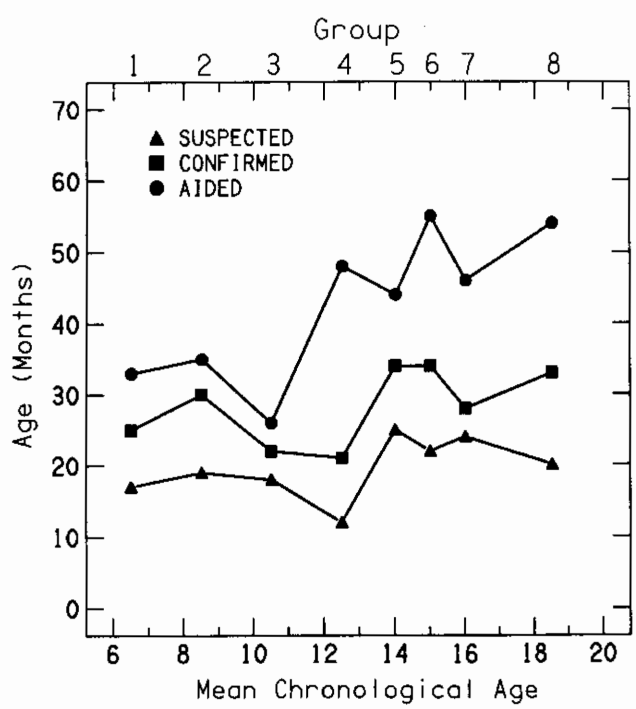

FIGURE 1. Age (in months) of suspicion, confirmation and receipt of amplification as a function of age. Data are plotted at the midpoint of each age group.

For the older students, the delay between age of confirmation and acquisition of a hearing aid was approximately 2 years. Thus, the average delay from suspected hearing loss to onset of rehabilitation, was approximately 3 years. Since the hearing loss was not suspected until approximately 2 years, these children were 4–5 years of age before any rehabilitation program was initiated. Many families reported that, although they were advised that they had a hearing-impaired child, they received no family support, guidance, education, or counseling until the child entered school. Hearing-impaired children living in remote areas frequently were served in programs that were not designed for the hearing impaired.

In contrast, the total delay in obtaining amplification is reduced by approximately 2 years for the younger children (4.5–11.5 years old). The analysis of variance revealed a significant effect of hearing aid acquisition as a function of age group ($F[1, 7] = 2.708$, $p < .05$). Although progress has been made, there is still a need for continued education of families and professionals concerning early awareness and identification of hearing loss. Furthermore, there is a need to convince professionals that no child is too young to be tested, and that any child suspected of having a hearing loss should be referred for evaluation at the youngest possible age (Gerber & Mencher, 1978). Audiological programs involved in early identification projects should have access to loaner hearing-aid programs, as should parent/infant programs, to assure that amplification and habilitation measures are implemented as soon as the hearing loss is identified.

Figure 2 presents the age of suspicion, confirmation, and acquisition of amplification as a function of the degree of hearing loss. Although the number of students within each PTA category varies, a number of trends are evident. The greater the hearing loss, the sooner the loss is suspected and confirmed. Although the confirmation of the hearing loss seems to be earlier with the severe-to-profound hearing loss group, the delay in the fitting of amplification remains constant. Difficulty in defining the precise degree of hearing loss for each ear in the very young child may contribute to this delay. In addition, many funding agencies typically have significant administrative delays before the purchase of a hearing aid can be completed.

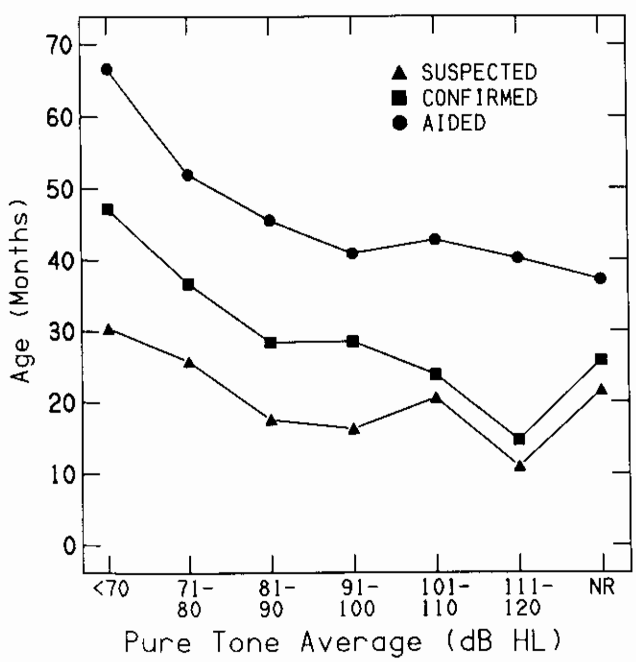

FIGURE 2. Age (in months) of suspicion, confirmation, and receipt of amplification as a function of better ear pure-tone average (dB HL).

As expected, students with moderate-to-severe hearing losses (50 dB HL to 80 dB HL) were identified as hearing impaired at a much later age. The average age of suspicion for this group was approximately 2½ years. It was then another 2½–3 years before these students were fitted with hearing aids. Delays of this magnitude may result in these children missing the critical period for development of speech and language skills. Early identification, early auditory management, and appropriate habilitative care involving parents are essential to building a base for language and academic development (Fry, 1978; Ling, 1981).

Incidence of Middle-Ear Pathology as a Function of Age

Electroacoustic impedance results for each student were divided into two categories: (a) normal middle-ear function and (b) probable middle-ear dysfunction requiring otologic referral. This latter category included suspected middle-ear effusion, ossicular anomalies, and eustachian-tube dysfunction (middle-ear air pressure in excess of -200 mm H_2O). Small changes in middle-ear pressure and slight tympanometric irregularities generally were not classified as requiring otologic follow up. The results of this analysis (Figure 3) clearly illustrate that the incidence of middle-ear pathology decreases as a function of age. The younger students show a much higher incidence (40–50%) of middle-ear pathology requiring otologic follow up than do the older students (5–10%). These results are in agreement with earlier studies (Eagles, Wishik, Doerfler, Melnick, & Levine, 1963; Erber & Alencewicz, 1976; Howie, Ploussard, & Sloyer, 1976; Shepard, Davis, Gorga, & Stelmachowicz, 1981) and illustrate that, for children 10 years of age and younger, impedance testing should be completed at frequent intervals, perhaps monthly, to screen for middle-ear pathology. Such testing is particularly important for children with severe-to-profound hearing losses, because bone-conduction testing (due to upper limits in output) may not provide information regarding a potential conductive component in these children (Erber & Alencewicz, 1976). Because of the profound nature of hearing loss that many of these children have experienced, even a slight decrement in hearing sensitivity can affect their performance and impede progress in educational situations. For the older children, testing could be performed less frequently or when they have colds or upper respiratory problems.

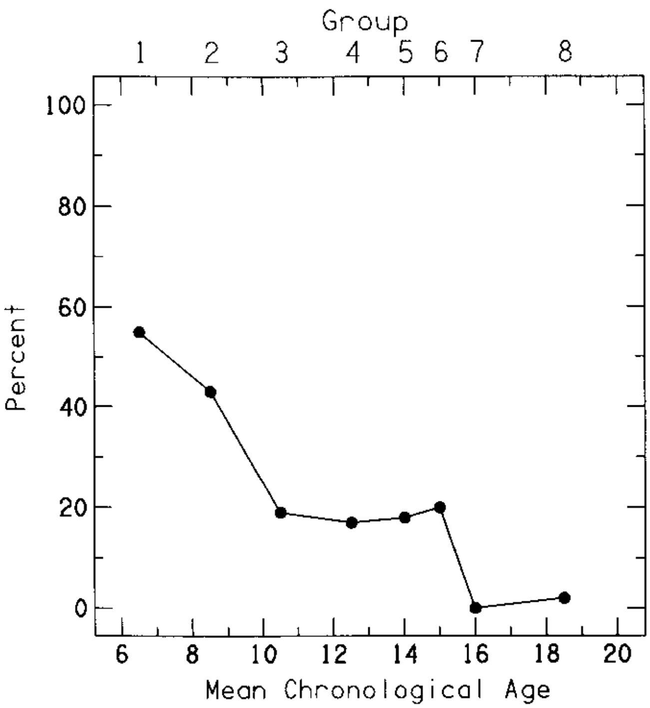

FIGURE 3. Percentage of individuals exhibiting middle-ear dysfunction requiring otologic referral as a function of age. Data are plotted at the midpoint of each age group.

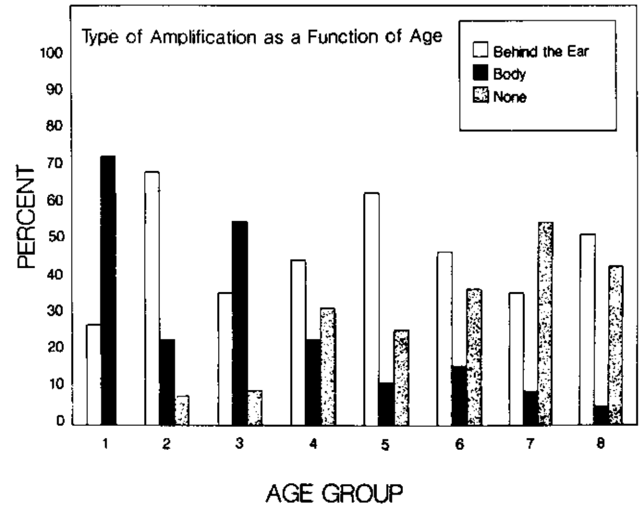

FIGURE 4. Percentage of individuals within each age group utilizing behind-the-ear, body-type, or no amplification.

Type of Amplification as a Function of Age

Figure 4 lists the type of amplification that each child is presently wearing as a function of age. With the exception of the 7.6–9.5 year olds, as age increases, the percentage of students who wear body aids shows a gradual decrease and the percentage of students who are unaided gradually increases. Thus, it appears that as the children grew older, they either opted for behind-the-ear instruments or chose to wear no hearing aid at all. Most of the students who are presently wearing behind-the-ear instruments initially wore a body aid. This high percentage of body aids recommended for any child with a newly identified severe-to-profound loss reflects the hearing aid fitting concept that was prevalent in the United States until approximately 3–4 years ago—that is, young children should be fitted with a body aid. The reasons involved included the following: (a) Behind-the-ear instruments did not have sufficient gain; (b) those behind-the-ear instruments that did have high gain were usually so large that they would not fit behind the ear of a small child; (c) body aids typically were more versatile with regard to frequency response, gain, and saturation sound pressure level; (d) there were fewer acoustic feedback problems with body aids than with behind-the-ear instruments; (e) because it was sometimes difficult to obtain thresholds under earphones, one could fit a body aid in a Y-cord arrangement to ensure that the "better ear" was being stimulated; (f) body aids are supposedly easier for parents to manipulate, and since they were larger, parents felt they were less subject to damage; and finally, (g) preschool teachers of the deaf were more conversant with the controls of body instruments and therefore felt more comfortable dealing with those instruments in the classroom.

The use of body-type hearing aids with all young, newly identified hearing-impaired children does not, however, represent our philosophy of fitting hearing aids. If one were to analyze the current results of amplification recommendations on newly identified hearing-impaired children, one would find that many more behind-the-ear instruments are being recommended regardless of age.

The rather steady increase in the number of students opting to wear no hearing aid at all with increasing age is interesting. By age 14 approximately 40–50% of all students are unaided (Karchmer & Kirwin, 1977). Recall (Table 10) that mean hearing sensitivity is the same for all eight age groups. This finding may be related to rejection of amplification for purely cosmetic reasons or may be based on unsatisfactory past experience with amplification.

Type of Amplification as a Function of Degree of Hearing Loss

The type of amplification as a function of degree of hearing loss is shown in Figure 5. As the severity of the hearing loss increases, the percentage of students wearing behind-the-ear instruments decreases and the percentage of individuals not wearing a hearing aid increases. That is, for PTAs greater than 101 dB HL, approximately 40% of the students are unaided. Data reported by the Office of Demographic Studies (Karchmer & Kirwin, 1977) also show that a large percentage of students with profound losses are nonwearers of amplification. In addition, the results reported by Karchmer and Kirwin show that more

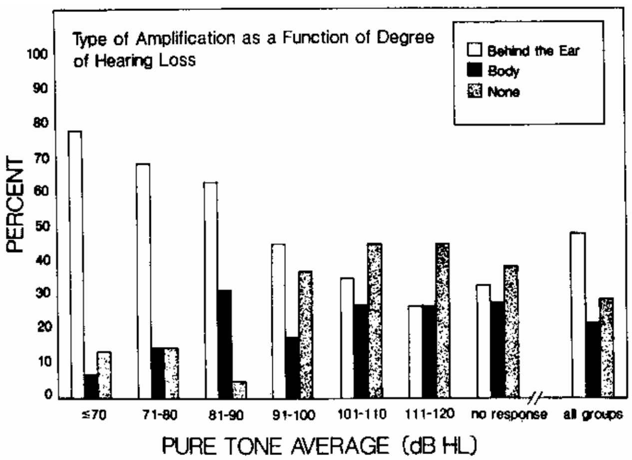

FIGURE 5. Percentage of individuals utilizing behind-the-ear, body-type, or no amplification as a function of better ear pure-tone average (dB HL).

students in residential settings are unaided than in any other educational setting. In fact, they found that the single best predictor of hearing aid use was the student's residential status: Not living in a residential school was associated with the greatest amounts of hearing aid usage.

The data in Figure 5 also show that the percentage of students wearing body aids remains relatively constant and is almost equal to the percentage wearing behind-the-ear aids. Note that the majority of students with profound hearing loss are wearing some type of amplification. Thus, even individuals who presumably are receiving minimal information with respect to speech discrimination may feel that amplification provides some benefit for them in their daily lives. Alternatively, this finding may be related to audiologist/parent/teacher insistence that the hearing aids be worn.

Functioning Versus Nonfunctioning Hearing Aids

Approximately one month prior to each student's evaluation, a team of audiologists from the Institute visited the school and inspected each child's earmold and hearing aid. The hearing aids were visually inspected for cracks, breaks, worn or frayed cords, broken receivers, or other easily discernible problems. A listening check with a hearing aid stethoscope was performed on each instrument to screen for clarity, distortion, or other obvious problems that might indicate the need for repair. If the hearing aid was malfunctioning, personnel were informed so that the hearing aid could be repaired prior to the evaluation at the Institute. In addition, each child's earmold was inspected visually to determine if there was an inadequate acoustic seal, broken tubing, cracks in the earmold, or any other abnormalities. Whenever inappropriate earmolds were found, a new impression was taken so that proper acoustic coupling could be available at the time of the evaluation. New earmolds were fabricated for over 50% of the students, and it was recommended that over 30% of the hearing aids be repaired.

When the students were evaluated, an electroacoustic analysis in accordance with ANSI standards (1976) was completed. Measures included full-on gain curves (SSPL 90) and harmonic distortion. In addition, frequency response curves (with both 60 and 90 dB SPL inputs) were obtained at each student's use-volume and tone-control settings. Based on the electroacoustic evaluation and the listening check, the hearing aids were classified as either functioning or nonfunctioning. Figure 6 shows these results as a function of age. For students less than 7.5 years, the majority of aids were nonfunctional. Some possible reasons for this high percentage are that (a) the children may not be capable of monitoring their own aids because of age, and (b) school personnel may not be monitoring the aids on a regular basis (these children are in a residential school). After age 7.5 years, between 30–40% of the aids were found to be nonfunctional. This appears to be relatively constant across all ages with a slight increase for the two older groups.

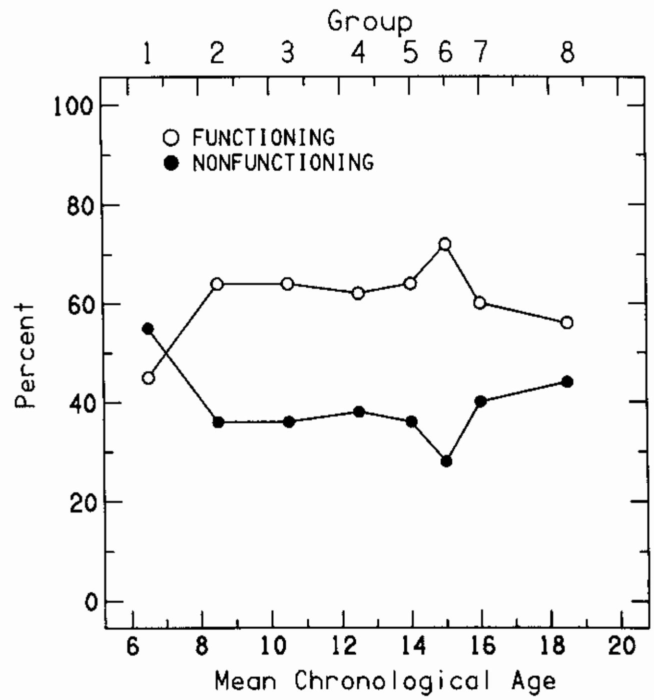

FIGURE 6. Percentage of individuals with functioning or nonfunctioning hearing aids as a function of age. Data are plotted at the midpoint of each age group.

These findings are consistent with those reported for other schools for the deaf (Porter, 1973), and they point out the need for constant monitoring of personal amplification systems. This monitoring is necessary not only to determine that the aids are functioning properly but that they meet the individual needs of each child. It was clear from the evaluation that a listening check alone is not sufficient because many more aids were found to be malfunctioning once electroacoustic analysis was completed. Although a listening check can be helpful to detect gross abnormalities, an electroacoustic analysis is needed to determine gain and SSPL 90 as a function of frequency and harmonic distortion levels.

The data from our evaluation show that the majority of the children at the school are consistent users of amplification. However, if those individuals who are not receiving maximum benefit from their amplification are eliminated, then clearly the majority of students are not effective users. Recent research (Davidsen, 1975) has shown that careful monitoring of amplification can result in a significant increase in the amount of time that the students receive optimum benefit from amplification. Inappropriate control settings may not only reduce the effectiveness of amplification, but in some cases may have an adverse effect on the child's hearing. That is, if the maximum output setting is too high, excessive sound pressure level may be delivered to the child's ear, which ultimately could result in a further reduction of hearing (Rintelmann & Bess, 1977; Ross & Lerman, 1967; Ross & Truex, 1965). If appropriate amplification and appropriate monitoring were both provided, the number of students properly using amplification might be increased greatly.

Monaural Versus Binaural Amplification

Figure 7 shows a comparison of those students wearing monaural and binaural amplification. In general, the majority of the students wear monaural amplification, a finding similar to that reported by the Office of Demographic Studies (Karchmer & Kirwin, 1977) for other populations of hearing-impaired students. Exceptions to this are individuals in the hearing loss category of less than 71 dB HL and in the category of showing a PTA of 101–110 dB HL.

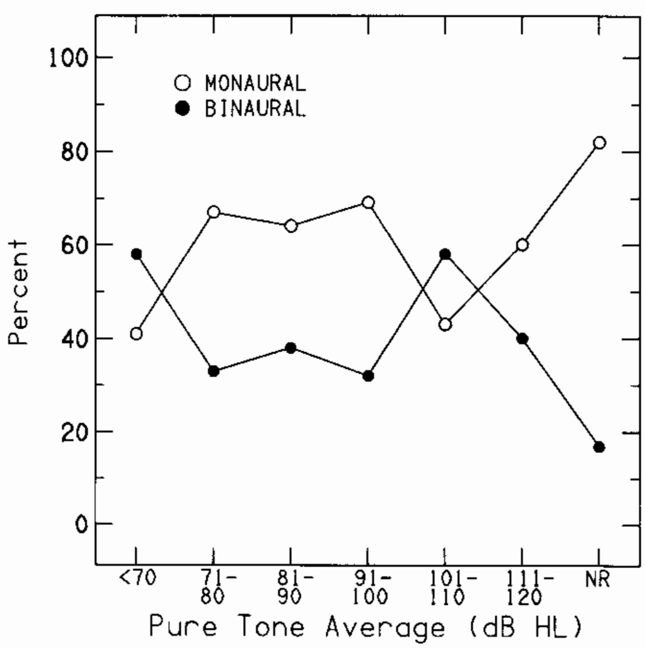

FIGURE 7. Percentage of individuals within each pure-tone average category utilizing monaural or binaural amplification.

It is difficult to account for this apparent reversal for these two hearing loss categories. Because the hearing aid recommendations were made at multiple audiological and hearing aid dealer facilities, we can only hypothesize about the reasons for the preponderance of monaural fittings. These include financial limitations, significant asymmetry in hearing loss (one ear unaidable), and the possibility that the students are utilizing the hearing aids primarily as an alerting device rather than for auditory discrimination, and therefore they receive as much information with one instrument as they would with two.

Auditory Discrimination Tasks

Recall that a hierarchy of speech-discrimination tests were utilized. The highest level discrimination task that each student was capable of performing is plotted in Figure 8. The open-set materials consisted of NU–6 and PBK–50 monosyllabic word lists. Closed-set picture-pointing tasks included both monosyllabic word identification (WIPI) and MTS matrix identification. The other two panels show the Sound Effects Recognition Test (SERT) and prosodic feature recognition using the MTS matrix. All cases represent aided conditions and presentation level never exceeded 70 dB HL. If a higher presentation level was necessary, the individual was grouped into the CNT/DNT category.

For the NU–6 and PBK–50 tests, a score of 30% was arbitrarily chosen as a minimally acceptable score before it was considered as an appropriate level task. For the MTS matrix, the SERT, and the prosodic tasks, a level of 33% was chosen as a minimally acceptable score. The CNT/DNT group includes those students that either could not successfully complete any of the above-mentioned tasks or those whose intellectual or behavioral functions precluded completion of the task.

Each panel represents the percentage of students within each PTA group that were able to perform the task in accordance with the criteria described previously. Across all panels the sum of the percentages shown in any single hearing loss category will total 100%. Consider, for example, individuals in the 91–100 dB category. With open-set materials, none (0%) of these individuals was able to achieve criterion performance. Performance gradually improved as the task became easier, until the majority of students (30%) reached criterion performance on the SERT. For hearing losses less than 80 dB HL, open- and closed-set monosyllabic word lists were successfully administered 85–90% of the time. In contrast, the MTS matrix appeared to be applicable over a wider range of hearing loss categories (81–110 dB HL).

The apparent reversal in the function for the no-response (NR) group may be due to the method by which PTAs were established. Further inspection revealed that the students in the NR group able to complete this task had relatively good thresholds at 250 and 500 Hz but no responses at 1000 and 2000 Hz (which placed them in the NR category). As with the MTS matrix, the SERT task appeared to be applicable over a wide range of hearing loss

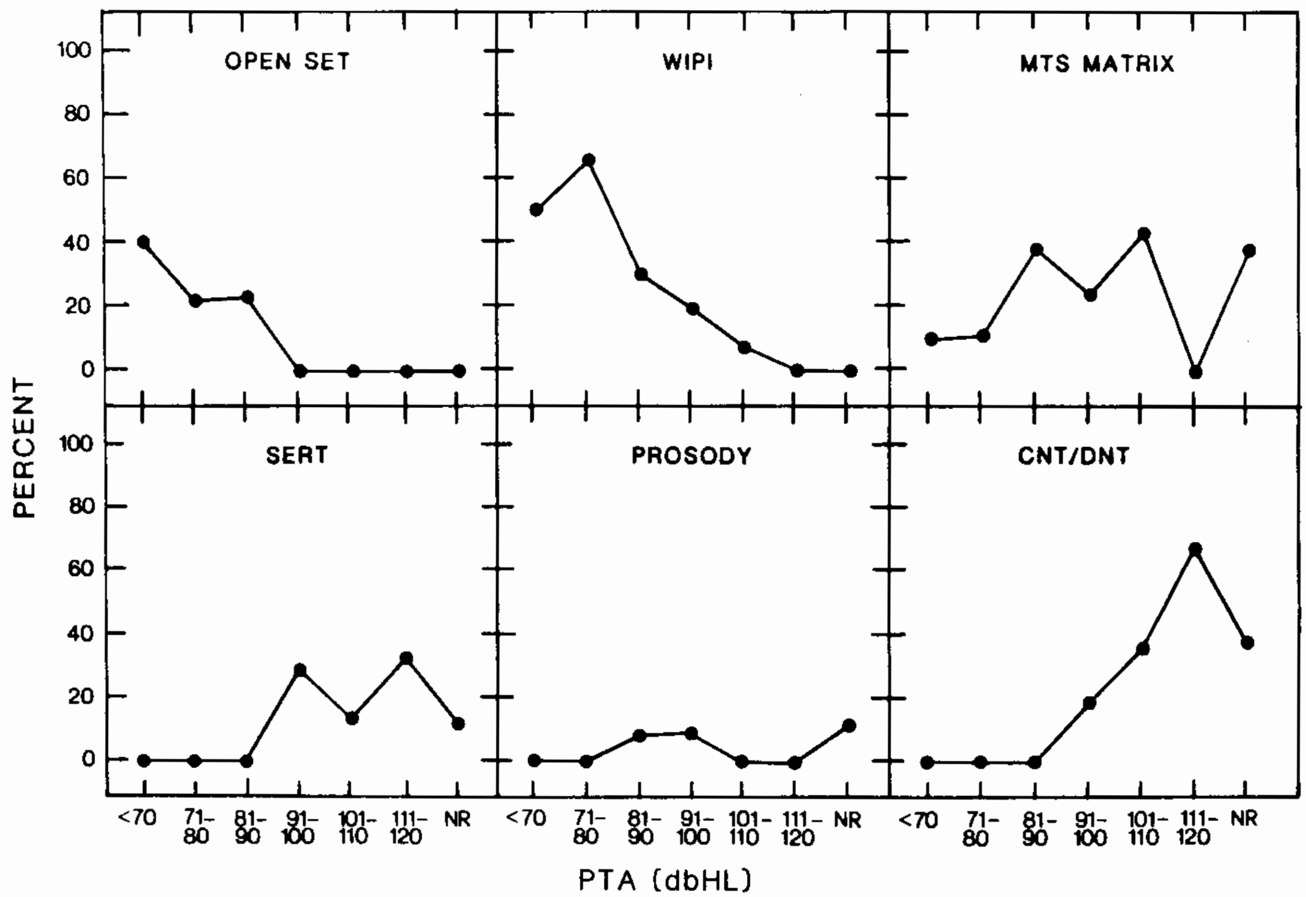

FIGURE 8. Percentage of individuals within each pure-tone average category able to reach criterion performance for the speech-discrimination tasks shown. WIPI = Word Intelligibility by Picture Identification test (Ross & Lerman, 1970); MTS = Monosyllable, Trochee, Spondee matrix (Erber & Alencewicz, 1976); SERT = Sound Effects Recognition Test (Hieber, Gerling, Matkin, & Skalka, 1980); CNT/DNT = included those who could not complete tasks or whose intellectual or behavioral functions precluded completion of the task.

(91–120 dB HL). For individuals with hearing loss greater than 91 dB HL, there does not appear to be any single discrimination task that is universally successful in assessing discrimination ability. Those students who could not complete successfully either the MTS matrix or the SERT tasks generally could not perform above chance on the prosodic feature task. These students are included in the CNT/DNT category.

It should be recognized, however, that the patterns seen in Figure 8 are dependent on our hierarchical ranking of these tests. We assumed that open-set materials would be more difficult than closed set, that monosyllabic words would be more difficult than spondees, and that identification of environmental sounds would be more difficult than the identification of prosodic features. It is possible, however, that the SERT and prosodic features task are equivalent in terms of difficulty. From available information, it is not possible to predict how our results would differ if the positions of these two tests had been reversed.

In summary, PTA does not appear to be predictive of the type of discrimination test that can be used. Thus, a battery of discrimination measures must be available to provide an estimate of residual speech-discrimination ability for hearing-impaired listeners.

Correlations Between Measures

Correlations were performed between a subset of audiologic variables judged by the staff to have the greatest potential influence on the educational achievement of the students. These consisted of (a) pure-tone average (PTA) in the better ear; (b) aided thresholds (PTAIDED); (c) the age when the hearing loss was first suspected (HLSUS); (d) the age when the hearing loss was confirmed (HLCONF); and (e) the age when a hearing aid was first acquired (HAACQ). Before the correlations were calculated, the students were classified into two groups, based on the better-ear PTA. Group I consisted of students with a PTA less than 105 dB HL, and Group II consisted of students with PTAs greater than 105 dB HL. Those students for whom a 2- or 3-frequency average could not be calculated (see Table 10) were placed in Group II (PTA > 105 dB). This classification scheme was used to separate those students who might have been responding to auditory stimuli on the basis of vibrotactile rather than auditory sensation (Boothroyd & Cawkwell, 1970). The 105-dB criterion is based on recent data by Boothroyd (1984), which show that students with losses greater than 105 dB HL perceive only the time-intensity patterns of speech, a performance pattern suggestive of vibrotactile rather than auditory perception of speech (Erber, 1972).

Independent sample t tests were used to compare the two groups on the variables of interest. Adjustment for unequal group variances was performed where appropriate. The results of this analysis appear in Table 11. Significant differences were found between Group I (PTA < 105 dB) and Group II (PTA > 105 dB) for all variables except the age when a hearing aid was first acquired (HAACQ). These data are consistent with those plotted in Figure 2. That is, the hearing loss was suspected and confirmed earlier in the students with the greater impairment (Group II), but the earlier identification of these losses did not result in earlier acquisition of amplification.

TABLE 11. Means, standard deviations, and t values for the audiologic variables.

Variable	*Group*	*n*	*M*	*SD*	*t*
PTAIDED	I	45	48	45	1.54**
	II	15	90	103	
HLSUS	I	21	16	2	−1.2*
	II	18	11	2	
HLCONF	I	92	32	18	−3.2*
	II	33	23	11	
HAACQ	I	90	48	25	−1.7
	II	30	40	22	

Note. PTAIDED = aided pure-tone thresholds; HLSUS = hearing loss first suspected; HLCONF = hearing loss first confirmed; HAACQ = hearing aid first acquired.
$*p < .05$. $**p < .01$.

Not shown in Table 11 is the age difference between Group I and Group II, which was found to be nonsignificant. Correlations between PTA and other variables were calculated only for the students in Group I because of the limited auditory capabilities of the students in Group II. These data appear in Table 12. Weak but significant correlations were found between PTA and all variables except aided pure-tone thresholds (PTAIDED). This finding might indicate that some of the students with more residual hearing were not wearing appropriate aids. Alternatively, it suggests that the losses of the students, even in Group I, were so severe that hearing aids could not provide sufficient gain to produce significant differences in aided sensitivity among them. Not shown in Table 12 is the correlation between PTA and age, which was found to be nonsignificant.

TABLE 12. Correlations between PTA and the audiologic variables.

	Audiologic variables			
	PTAIDED	*HLSUS*	*HLCONF*	*HAACQ*
PTA	.25	−.20*	−.26**	−.23*

Note. PTAIDED = aided pure-tone thresholds; HLSUS = hearing loss first suspected; HLCONF = hearing loss first confirmed; HAACQ = hearing aid first acquired.
$*p < .05$. $**p < .01$.

SUMMARY

The following conclusions are based on the data reported above.

1. These data illustrate the need for earlier identification and habilitation measures.
2. There is a need for continued education of family and professionals concerning early awareness and identification of hearing loss.
3. Professionals need to be convinced that no child is too young to be tested, and that any child suspected of a hearing loss should be referred for audiological testing at the earliest possible age.
4. Audiologists involved in early identification and evaluation should have access to loaner hearing aids as well as to parent/infant habilitation programs to ensure that amplification and habilitation measures are implemented as soon as the hearing loss is identified.
5. There is a need for appropriate habilitative care that will meet the needs of outside (rural) families.
6. There is a need for periodic audiologic monitoring of all students in schools for the deaf, including electroacoustic impedance measures. For children 10 years of age and younger, impedance testing should be completed at frequent intervals to screen for middle-ear pathology.
7. There is a need for electroacoustic measurement of hearing-aid performance characteristics and for in-service training programs on the care and maintenance of hearing aids for parents and teachers. The fact that 40% of the aids being worn by students were found to be nonfunctional highlights this need for constant monitoring of personal amplification systems. This monitoring is necessary not only to determine if the hearing aids are functioning properly, but to determine if the individual needs of each child are being met. A listening check alone is not sufficient, and electroacoustic analysis of each aid must be performed on a regular basis.
8. The data suggest that a hierarchy of discrimination tasks should be used with hearing-impaired children. Consideration needs to be given to age, degree of loss, and receptive vocabulary of the individuals being tested.
9. It is recommended that audiological evaluation of hearing-impaired children include (a) routine pure-tone audiometry, (b) measures of discrimination ability (taped speech materials should be utilized whenever possible), (c) electroacoustic impedance testing, (d) hearing-aid appraisal including electroacoustic analysis and listening checks, (e) functional gain estimates with the child's own hearing aid, (f) discrimination measures with the child's own aid,

and (g) evaluation with the classroom auditory training system (when appropriate). This type of evaluation should be completed on at least an annual basis and more frequently for younger children.

REFERENCES

American National Standard specification of hearing aid characteristics (ANSI S3.22-1976). (1976). New York, ANSI.

BOOTHROYD, A. (1984). Auditory perception of speech contrasts by subjects with sensorineural hearing loss. *Journal of Speech and Hearing Research, 27,* 134-144.

BOOTHROYD, A., & CAWKWELL, S. (1970). Vibrotactile thresholds in pure-tone audiometry. *Acta Oto-Laryngologica, 69,* 381-387.

DAVIDSEN, A. (1975). *Functional auditory speech training program* (Research Rep. No. 9). New York: City University of New York.

EAGLES, E., WISHIK, S., DOERFLER, L., MELNICK, W., & LEVINE, H. (1963). Hearing sensitivity and related factors in children. *Laryngoscope, 220*(Suppl.).

ERBER, N. P. (1972). Speech-envelope cues as an aid to lipreading for profoundly deaf children. *Journal of the Acoustical Society of America, 51,* 1225-1227.

ERBER, N. P., & ALENCEWICZ, C. M. (1976). Audiologic evaluation of deaf children. *Journal of Speech and Hearing Disorders, 41,* 256-267.

FRY, D. (1978). The role and primacy of the auditory channel in speech and language development. In M. Ross & T. Giolas (Eds.), *Auditory management of hearing-impaired children* (pp. 15-42). Baltimore: University Park Press.

GERBER, G. E., & MENCHER, G. T. (Eds.). (1978). *Early diagnosis of hearing loss* (pp. 1-32). New York: Grune & Stratton.

HASKINS, H. (1949). *A phonetically balanced test of speech discrimination for children.* Unpublished master's thesis, Northwestern University, Evanston, IL.

HIEBER, T. F., GERLING, I. J., MATKIN, N. D., & SKALKA, E. (1980). A sound effects recognition test for the pediatric audiological evaluation. *Ear and Hearing, 1,* 271-276.

HOWIE, V. M., PLOUSSARD, J. H., & SLOYER, J. L. (1976). Natural history of otitis media. *Annals of Otology, Rhinology, and Laryngology, 25*(Suppl.), 18-19.

JENSEMA, C. (1974). The distribution of hearing loss among students in special education programs for the hearing impaired. *Asha, 16,* 682-685.

KARCHMER, M., & KIRWIN, L. (1977). *The use of hearing aids by hearing-impaired students in the United States* (Series S, No. 2). Washington, DC: Gallaudet College, Office of Demographic Studies.

KARCHMER, M., & TRYBUS, R. (1977). *Who are the deaf children in "mainstream" programs?* (Series R, No. 4). Washington, DC: Gallaudet College, Office of Demographic Studies.

LING, D. (1981). Early speech development. In G. Mencher & S. Gerber (Eds.), *Early management of hearing loss* (pp. 319-333). New York: Grune & Stratton.

PORTER, T. (1973). Hearing aids in a residential school. *American Annals of the Deaf, 118,* 31-33.

RINTELMANN, W. F., & BESS, F. H. (1977). High-level amplification and potential hearing loss in children. In F. H. Bess (Ed.), *Childhood deafness* (pp. 267-293). New York: Grune & Stratton.

ROSS, M., & LERMAN, J. (1967). Hearing aid usage and its effect upon residual hearing. *Archives of Otolaryngology, 86,* 639-644.

ROSS, M., & LERMAN, J. (1970). A picture identification test for hearing-impaired children. *Journal of Speech and Hearing Research, 13,* 44-53.

ROSS, M., & TRUEX, E. (1965). Protecting residual hearing in hearing aid users. *Archives of Otolaryngology, 82,* 615-617.

SHEPARD, N. T., DAVIS, J. M., GORGA, M. P. & STELMACHOWICZ, P. G. (1981). Characteristics of hearing-impaired children in the public schools: Part I. Demographic data. *Journal of Speech and Hearing Disorders, 46,* 123-129.

TILLMAN, T. W., & CARHART, R. (1966). An expanded test for speech discrimination utilizing CNC monosyllabic words (*Northwestern University Auditory Test* No. 6) (Tech. Rep. SAM-TR-66-55). Brooks Air Force Base, TX: USAF School of Aerospace Medicine, Aerospace Medical Division (AFCS).

Chapter 5

Vestibular Evaluation

David G. Cyr   Patrick E. Brookhouser   Kathryn Beauchaine

Boys Town National Institute

A vestibular evaluation was performed because the same deformities and insults known to impair cochlear function also may affect vestibular function. Only the major vestibular findings are presented here because a detailed summary of the procedures and results have been reported in a previous publication (Brookhouser, Cyr, & Beauchaine, 1982). It should be noted, however, that data are reported for a larger number of students (166) than are included in the other chapters of this monograph. The additional students were preschoolers, and few appropriate measures were available for this young age group in the other areas of evaluation, particularly in language, academics, and processing. Results from the preschool students are included here because relatively little is known about vestibular function in children with severe and profound hearing impairments.

METHOD

Unlike most previous investigations of vestibular function in various hearing-impaired populations (Arnvig, 1955; Capute, Rimoin, Konigsmark, Esterly, & Richardson, 1969; Davis, Johnsson, & Kornfeld, 1981; Dohlman, 1973; Holderbaum, Ritz, Hassanein, & Goetzinger, 1979; Hyden, Odkvist, & Kylen, 1979; Rosenblut, Goldstein, & Landau, 1960; Sandberg & Terkildsen, 1965; Stool, Black, Craig, et al., 1981), the present evaluation included electronystagmography (ENG) as well as more traditional postural tests. ENG procedures, routinely used with adults, were employed with most students, although some modifications were necessary to evaluate the young or difficult-to-test ones. The modifications included the use of closed-loop caloric irrigation, an over-the-head optokinetic (OKN) drum, or a wall-projected OKN stimulus, and a pediatric calibration light bar. The reader is referred to Cyr (1980) for a more detailed discussion of these modifications.

An important part of the test protocol for the positional, caloric, and rotational tests was the use of mental alerting tasks. Because of the limited speech skills of many of the students, manual tasks, such as fingerspelling names with serial letters of the alphabet or telling a story with sign language, were used. An example of the effect of mental alerting tasks on the nystagmic response is shown in Figure 9. The effect of *tasking* on the response is shown in the left and right portions of the figure with the *no-tasking* condition in the middle. As the figure illustrates, the nystagmic response was essentially eliminated when the tasking was stopped.

Standard and tandem Romberg testing in the Jendrassik position (DeJong, 1979), with eyes open and closed, was performed on 127 students. The remainder of the students could not be tested with this procedure because they were either too young or had physical impairments that interfered with their performance on the Romberg maneuvers. Figure 10 illustrates the standard and tandem Romberg positions.

RESULTS

Vestibular Findings

The results of the caloric, positional, ocular tracking, and tandem Romberg tests are summarized in Table 13.

FIGURE 9. Response to caloric stimulation with and without mental alerting tasks. Left portion shows nystagmic response with tasking followed by no tasking; right tracing represents reinitiation of the tasking procedure.

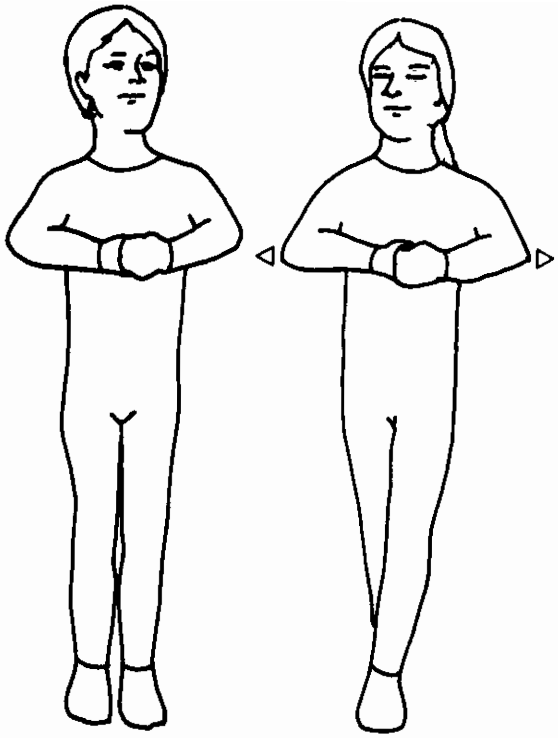

FIGURE 10. Standard and tandem Romberg testing used in Jendrassik position with eyes open and closed.

As the data show, abnormal caloric findings were present in 22% of the students, with slightly less than half of them demonstrating unilateral caloric right-left asymmetries exceeding 20%. Bilateral vestibular hypoactivity, with an average peak slow-phase velocity to bithermal caloric stimulation of less than 7.5°/s per ear (Coats, 1975), was present in the other half of the students.

TABLE 13. Summary of vestibular findings.

Abnormality	*n*	*Frequency (%)*
Caloric Test	37	22
Unilateral caloric hypoactivity	17	
Bilateral caloric hypoactivity	20	
Spontaneous/Positional nystagmus occurring with:	32	19
Unilateral caloric hypoactivity	10	
Bilateral caloric hypoactivity	7	
Ocular nystagmus	5	
No other abnormalities on ENG	10	
Ocular Tracking Abnormalities	18	11
Gaze nystagmus	7	
OKN asymmetry	9	
Poor visual pursuit	2	
Tandem Romberg Test occurring with:	41	32
Unilateral caloric hypoactivity	8	
Bilateral caloric hypoactivity	18	
Spontaneous or positional nystagmus only	4	
No other abnormalities	11	

Roughly one fifth (19%) of the students demonstrated spontaneous or positional nystagmus, or both, with the peak slow-phase velocity of greater than 7.5°/s. Twenty-two percent of the students with the bilateral hypoactivity demonstrated a direction-fixed spontaneous nystagmus, and 16% of the students had benign ocular nystagmus, as described by DeJong (1979).

A small number of the students (7) demonstrated gaze nystagmus on the ocular tracking test. Of these, 5 were considered to have benign congenital ocular nystagmus, whereas the origin of the gaze nystagmus in the other two students was suspected to be vestibular at the level of the brainstem. OKN asymmetry was found in 9 students, which in 7 cases was suspected to be secondary to peripheral spontaneous nystagmus. Two subjects were noted to have poor visual pursuit in the absence of ocular muscle pathology. Abnormal OKN and gaze tests were also found in these students, who were referred for neurological evaluations. Ocular dysmetria was not found in any of the students.

The data obtained from the standard Romberg procedure are not reported because this test condition proved to be of limited value in identifying bilateral or unilateral caloric weakness. In contrast, the results of the tandem Romberg (eyes opened and closed) were in general agreement with the caloric findings in most of the students. These data also appear in Table 13. The largest percentage of students with abnormal Romberg findings with eyes closed on this test also demonstrated bilateral caloric hypoactivity. Of the 20 subjects with bilateral hypoactivity, 18 had an abnormal tandem (eyes-closed) Romberg. In addition, 47% of the students with an abnormal tandem Romberg response demonstrated a unilateral caloric weakness (8 of 17). A relatively large percentage of the students (11%) demonstrated an abnormal tandem response in the absence of any other vestibular abnormalities (11 of 97).

DISCUSSION AND SUMMARY

The caloric test results revealed impaired vestibular function in roughly one fifth of the students. It is likely, however, that the incidence of vestibular abnormalities, especially bilateral hypoactivity, is underidentified in this sample because of the variables that can affect the caloric test results. An evaluation method preferable to caloric irrigation is the computerized rotary chair (harmonic accelerator) system that has been in use at the Institute since the time of this evaluation. The rotary chair system is an effective, noninvasive, and comfortable procedure that yields information as useful as the standard ENG procedure (Cyr & Beauchaine, 1984; Cyr, Brookhouser, Valente, & Grossman, 1985). Computerized harmonic acceleration has proven to be as reliable as caloric testing in adults as well (Wolfe, Engelken, Olson, & Kos, 1978) without the discomfort often associated with caloric stimulation. We have observed that children (particularly those with severe-to-profound hearing impairments) do not suppress nystagmic response to a rotational stimulation as they frequently do with caloric stimulation. As a result, mental alerting tasks are still important, although not as critical for the rotary chair test as for the caloric test. If a rotational stimulus cannot be used, closed-loop caloric irrigation in the simultaneous binaural bithermal condition seems to be more effective and less frightening than the standard alternate irrigation with water for use with children (Cyr, 1983).

The incidence of vestibular problems is of significance because vestibular evaluations are not performed routinely with profoundly hearing-impaired children. Thus, clinically significant vestibular dysfunction may be largely undiagnosed in this population. Upon careful questioning by an examiner proficient in sign language, approximately one half of the students demonstrating bilateral vestibular weakness indicated that they have experienced disorientation in the dark. The other students with bilateral vestibular weakness but without history of disorientation reaffirm the remarkable central compensation often seen in the handicapped child. The presence of a bilateral vestibular impairment may pose problems during certain activities such as bike riding, swimming, walking on a balance beam, or orienting in a dark room. These results indicate that severely and profoundly hearing-impaired children should receive a vestibular evaluation by adolescence, at least those who report symptoms characteristic of vestibular involvement. Identification of vestibular problems will assist recreational and occupational counseling regarding limitations posed by significant vestibular dysfunction. A critical part of the vestibular evaluation is the use of mental alerting tasks, using fingerspelling and sign language when appropriate. In addition, the results of the Romberg revealed that the tandem Romberg using the Jendrassik maneuver with the eyes opened and closed was more consistent with the caloric findings in students with bilateral hypoactivity than the results obtained with the standard Romberg procedure.

REFERENCES

Arnvig, J. (1955). Vestibular function in deafness and severe hardness of hearing. *Acta Otolaryngologica, 145,* 283-288.

Brookhouser, P. E., Cyr, D., & Beauchaine, K. (1982). Vestibular findings in the deaf and hard of hearing. *Otolaryngology—Head and Neck Surgery, 90,* 773-777.

Capute, A. F., Rimoin, D. L., Konigsmark, B. W., Esterly, N. B., & Richardson, F. (1969). Congenital deafness and multiple lentigines. *Archives of Dermatology, 100,* 207-213.

Coats, A. C. (1975). Electronystagmography. In L. J. Bradford (Ed.), *Physiological measures of the audio-vestibular system* (pp. 37-85). New York: Academic Press.

Cyr, D. G. (1980). Vestibular testing in children. *Annals of Otology, Rhinology, and Laryngology, 89*(Suppl.), 63-69.

Cyr, D. G. (1983). The vestibular system: Pediatric considerations. *Seminars in Hearing, 4,* 33-45.

Cyr, D. G., & Beauchaine, K. A. (1984). The role of vestibular function in the development of communication. In D. S. Beasley (Ed.), *Audition in childhood* (pp. 127-139). San Diego: College-Hill Press.

Cyr, D. G., Brookhouser, P. E., Valente, M. K., & Grossman, A. (1985). Vestibular evaluation of infants and preschool children. *Otolaryngology—Head and Neck Surgery, 93,* 463-468.

Davis, L., Johnsson, L., & Kornfeld, M. (1981). Cytomegalovirus labyrinthis in an infant: Morphological, virological, and immunofluorescent studies. *Journal of Neuropathology and Experimental Neurology, 40,* 9-19.

De Jong, R. N. (1979). *The neurologic examination.* K. Magee (Ed.). Hagerstown, MD: Harper & Row.

Dohlman, G. (1973). Cytochemical and cytofunctional studies of the vestibular system: Functional implications with regard to the concept of endoplymph circulation. *Advances in Otorhinolaryngology, 20,* 470-484.

Holderbaum, F., Ritz, S., Hassanein, K., & Goetzinger, C. P. (1979). A study of otoneurologic and balance tests with deaf students. *American Annals of the Deaf, 124,* 753-759.

Hyden, D., Odkvist, L. M., & Kylen, P. (1979). Vestibular syndromes in mumps deafness. *Acta Otolaryngologica, 360*(Suppl.), 182-183.

Rosenblut, B., Goldstein, R., & Landau, W. (1960). Vestibular responses of some deaf and aphasic students. *Annals of Otology, Rhinology, and Laryngology, 69,* 747-754.

Sandberg, L. E., & Terkildsen, K. (1965). Caloric tests in deaf children. *Archives of Otolaryngology, 81,* 350-354.

Stool, S. E., Black, F. O., Craig, H., et al. (1981). Otologic care in a school for the deaf. *Otolaryngology—Head and Neck Surgery, 89,* 651-657.

Wolfe, J. W., Engelken, E. J., Olson, J. W., & Kos, C. M. (1978). Vestibular responses to bithermal caloric and harmonic acceleration. *Annals of Otology, Rhinology, and Laryngology, 87,* 861-867.

Chapter 6

Speech Evaluation

Mary Joe Osberger   Amy McConkey Robbins   John Lybolt
Raymond D. Kent   Jo Peters

Boys Town National Institute

The literature on the speech of the hearing impaired is quite extensive, and throughout the years a variety of techniques has been employed to assess overall intelligibility as well as segmental and nonsegmental characteristics of speech (cf. Osberger & McGarr, 1981). Because the purpose of this evaluation was to quantify characteristics of the students' speech that later could be related to their language and learning skills, only the results of selected measures are reported. These consist of a measure of overall intelligibility and segmental (vowel and consonant) production skills. The method of evaluation consisted of listener judgments or phonetic transcriptions.

METHOD

Procedures

A variety of speech stimuli were employed to permit analysis of segmental production skills and speech intelligibility. The specific form of the perceptual analysis varied depending on the particular skill being assessed. A panel of judges (listeners) was used to evaluate the tape-recorded samples of those speech characteristics most likely to show the greatest interrater differences, based on previous research (McGarr, 1978; McGarr & Osberger, 1978; Smith, 1975). These characteristics consisted of vowel production and overall intelligibility. Data from these analyses are reported in terms of the mean value, averaged across judges. In contrast, the accuracy of consonant production was assessed during the evaluation itself by one speech-language pathologist who had extensive training and experience in phonetic transcription. Although it might have been preferable to use multiple judges to evaluate consonant production, it was not practical in view of the large number of subjects and the extensive data collection and analyses required in the other areas of interest. In addition, previous research indicates good interrater reliability of consonant transcription data for hearing-impaired talkers (Gold, 1978). Also, the data on segmental skills (consonants and vowels) are expressed in terms of percent correct production rather than in terms of error patterns. Analyses between speech production skills and audiologic variables are reported in this chapter because of the well-established relationship between these factors (cf. Smith, 1975).

Assessment of segmental skills: Vowel production. Only the three point vowels [i, a, u] were sampled from each student's speech in nine CVC monosyllabic words *(bead, beat, Pete, pop, Bob, bop, boot, toot, food).* The students' productions were recorded in a sound-treated room using a high-quality tape recorder and a lapel microphone placed approximately 12 in. (30.5 cm) from the speaker's mouth. To elicit the productions, the examiner showed the student a card with the word printed on it, and then simultaneously signed and spoke the word. The student was then asked to repeat the item.

Four speech-language pathologists who had no significant prior experience listening to the speech of the deaf judged the accuracy of the students' vowel productions. The judges heard each token two times and indicated whether the intended vowel was produced correctly. The data are presented in terms of the mean percentage of tokens judged correct for each vowel. This mean was derived by averaging the percentage of correctly produced vowels across words (three words for each vowel) and judges (four judges) for each vowel. To obtain a measure of intrajudge reliability, 20% of the tapes were reevaluated by each judge.

Assessment of segmental skills: Consonant production. Production of English consonants was analyzed using the Goldman–Fristoe Test of Articulation (Goldman & Fristoe, 1972). Although the test samples the target consonants in the initial, medial, and final position of words and consonant blends, only the data for the initial (prevocalic) and final (postvocalic) consonants are reported. In addition, the test was not administered to students whose speech consisted only of undifferentiated vocalizations, reducing the number of students tested to 113. Phonetic transcription of each student's productions was performed during the test situation by a speech-language pathologist who had both training and extensive experience in this area. The data are expressed in terms of percent correct production of the target prevocalic and postvocalic consonant.

Assessment of intelligibility skills. The intelligibility of a spontaneous speech sample was evaluated for each student. The sample was 3–6 min in length, elicited with a cartoon-story sequence. The same panel of four judges who evaluated vowel production also evaluated the intelligibility of each student's recorded speech sample on a scale of 0–100%, with 0% indicating that none of the speech could be understood and 100% indicating that all of the student's speech was understood. Intelligibility ratings were then averaged across judges for each student.

RESULTS

Vowel Production Skills

The percentage of vowel tokens that were produced correctly by the students is summarized in Table 14 and Figure 11. On the average, [a] and [u] were produced correctly most often; [i] was most often in error. The standard deviations in Table 14 and Figure 11 show that there was considerable variance in the students' ability to produce the target vowels within each age group. The data also show little improvement with age in the students' ability to produce the intended vowels. A nonsignificant correlation was found between age and production accuracy of all three vowels. Interjudge agreement on this task was 92% for [i] and 89% for both [a] and [u]. Intrajudge agreement also was high, with values of 83%, 95%, 95%, and 93% for Judges 1, 2, 3, and 4, respectively.

Consonant Production Skills

First, the data were analyzed in terms of percentage of consonants produced correctly as a function of age group for the different manners and places of production. If the constraints of English precluded the production of a phoneme in both the pre- and postvocalic position, data for these phonemes were not included. A three-way analysis of variance (Position × Manner × Age Group) revealed a significant position effect, $F(1, 7) = 37.83$, $p < .001$; a manner effect, $F(1, 7) = 58.98$, $p < .001$, and a two-way manner-by-position interaction, $F(1, 7) = 17.10$, $p < .001$. Age group differences were nonsignificant, as was the position-by-age group interaction. Production accuracy for prevocalic consonants, expressed in terms of manner of production, appear in Table 15 and Figure 12. Note that data for only four manners of production are reported. Data for semivowels, liquids, and glides have been omitted because the narrow transcriptions performed on these sounds indicated that they were seldom produced correctly. The data in Table 15 and Figure 12 show plosive consonants were most often produced correctly by the students, followed by the fricatives. Nasals ranked third in terms of accuracy of production for the majority of students, and affricates were the most difficult for all ages. The large standard deviations for these data, and all data reported subsequently in this section, indicate considerable variance among the students in speech production skills.

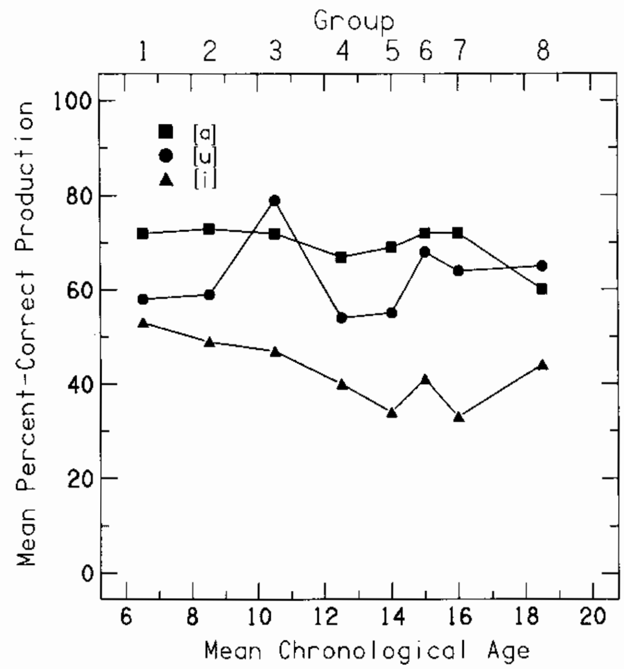

FIGURE 11. Production accuracy of the vowels as a function of age. Data are plotted at the midpoint of each age group.

TABLE 14. Percentage of vowels produced correctly in monosyllables.

Group	*Age*	*n*	*All vowels* *M*	*SD*	[i] *M*	*SD*	[a] *M*	*SD*	[u] *M*	*SD*
1	4.5– 7.5	5	61.0	46.4	53.4	49.6	71.8	42.4	58.4	53.4
2	7.6– 9.5	6	60.7	31.7	49.0	38.1	73.2	38.4	59.2	43.4
3	9.6–11.5	7	59.0	38.5	46.6	50.6	72.0	38.4	78.8	32.3
4	11.6–13.5	19	53.1	34.3	39.9	44.8	66.9	37.3	54.1	43.3
5	13.6–14.5	15	53.1	34.3	34.4	45.5	69.4	35.5	54.9	40.2
6	14.6–15.5	23	58.7	33.9	40.6	43.4	71.6	35.3	67.8	40.6
7	15.6–16.5	8	53.4	40.5	33.1	38.4	72.4	47.1	63.6	43.6
8	16.5–20.0	13	55.7	30.8	44.3	45.9	59.9	42.3	65.0	45.6
	Total	96	56.2	33.8	40.9	42.6	69.6	36.8	61.5	41.2

Table 15. % correct production of prevocalic consonants as a function of manner of production.

			Manner of production							
			Plosives [b,p,d,t,g,k]		*Fricatives* [z,s,ʃ,θ,v,f]		*Nasals* [m,n]		*Affricates* [d,t]	
Group	*Age*	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	4.5– 7.5	5	60.0	25.3	40.0	19.1	30.0	44.7	40.0	41.8
2	7.6– 9.5	12	66.6	24.8	45.8	18.9	37.5	43.3	12.5	22.6
3	9.6–11.5	8	68.4	21.8	45.9	24.8	50.0	46.3	12.5	23.1
4	11.6–13.5	19	70.6	26.5	54.4	15.7	39.5	42.7	18.4	34.2
5	13.6–14.5	17	62.9	25.4	61.7	20.2	47.4	48.1	38.2	48.5
6	14.6–15.5	22	53.7	31.2	51.5	24.5	56.8	47.0	31.8	45.1
7	15.6–16.5	9	70.5	16.3	40.8	16.9	22.2	26.4	11.1	33.3
8	16.6–20.0	21	66.6	27.4	46.1	15.8	42.9	45.5	26.2	40.7

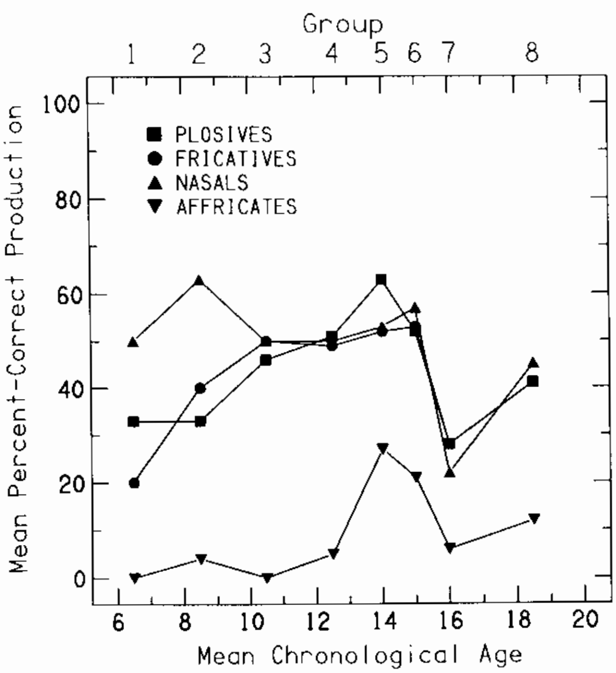

Figure 12. Production accuracy of the prevocalic consonants expressed in terms of manner of production. Data are plotted at the midpoint of each age group.

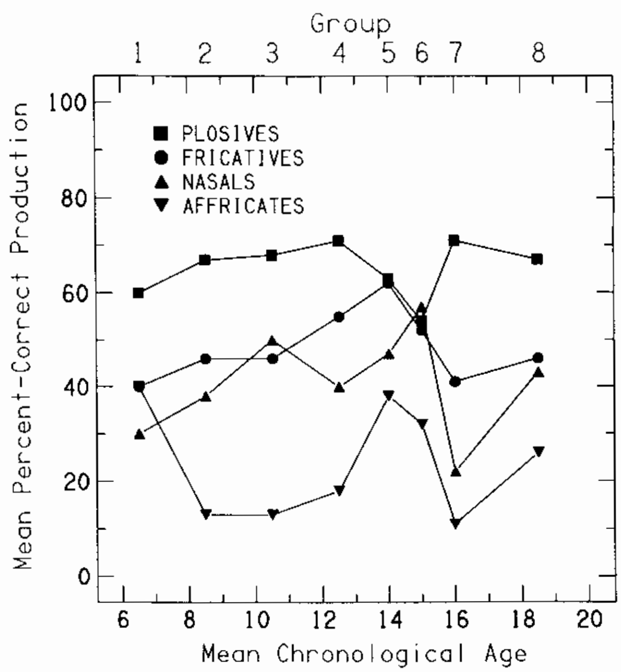

Figure 13. Production accuracy of postvocalic consonants expressed in terms of manner of production. Data are plotted at the midpoint of each age group.

Table 16. % correct production of postvocalic consonants as a function of manner of production.

			Manner of production							
			Plosives [b,p,d,t,g,k]		*Fricatives* [z,s,ʃ,θ,v,f]		*Nasals* [m,n]		*Affricates* [d,t]	
Group	*Age*	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	4.5– 7.5	5	33.2	23.7	20.2	7.2	50.0	50.0	0.0	0.0
2	7.6– 9.5	12	33.4	25.5	40.3	15.0	62.5	43.3	4.2	14.4
3	9.6–11.5	8	45.8	21.3	50.1	17.9	50.0	46.3	0.0	0.0
4	11.6–13.5	19	51.0	34.8	49.1	21.3	50.0	37.3	5.3	22.9
5	13.6–14.5	17	62.7	25.3	51.9	22.1	52.9	48.3	26.5	40.0
6	14.6–15.5	22	52.2	30.1	52.9	25.0	56.8	44.4	20.5	33.3
7	15.6–16.5	9	27.7	14.3	27.8	20.3	22.2	26.4	5.6	16.7
8	16.6–20.0	21	40.5	26.3	40.5	23.3	45.2	44.5	11.9	31.2

Table 16 and Figure 13 display production accuracy for the four manners of production in the postvocalic position for each age group. On the average, the rank order of the consonants in the postvocalic position is identical to that observed for the prevocalic data (Table 15). Production accuracy, however, is substantially lower for the phonemes in the postvocalic position than in the prevocalic position, particularly for plosives and fricatives.

The results of the three-way analysis of variance (Position × Place × Age Group) revealed a significant position effect, $F(1, 7) = 81.64$, $p < .001$, a significant place effect, $F(1, 7) = 90.12$, $p < .001$, and a significant position-by-place interaction, $F(1, 7) = 15.60$, $p < .001$. Age group was nonsignificant, as was the group-by-place interaction. In contrast, the group-by-position interaction was significant, $F(1, 7) = 2.12$, $p < .05$.

Table 17 and Figure 14 show consonant accuracy in the prevocalic position for the three places of production. Consonants produced in the front of the mouth were most often correct, followed by sounds produced in the back of the mouth. Sounds with a medial place of production were in error most often, although there was some variation in this pattern for Groups 7 and 8. The data also show that there is little change in performance with age.

The data for the three consonantal places of production in the postvocalic position are shown in Table 18 and Figure 15. Again, sounds produced in the front of the mouth were most often correct. In contrast to the prevocalic data, shown in Table 17 and Figure 14, the data in Figure 15 show that sounds produced in the middle of the mouth ranked second and back sounds ranked third in order of correct production, at least for Groups 1–4. For the older

TABLE 17. % correct production of prevocalic consonants as a function of place of production.

			Place of production					
			Front [b,m,v,f,θ]		*Middle* [d,t,n,z,s,ʃ]		*Back* [g,k]	
Group	*Age*	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	4.5– 7.5	5	68.0	17.9	20.2	18.2	50.0	50.0
2	7.6– 9.5	12	71.7	24.8	36.4	23.6	54.2	45.0
3	9.6–11.5	8	67.5	23.8	35.4	22.4	68.8	37.2
4	11.6–13.5	19	77.9	18.7	37.8	28.3	57.9	41.7
5	13.6–14.5	17	84.7	16.6	46.1	33.0	50.0	43.4
6	14.6–15.5	22	73.6	21.7	40.1	28.0	47.7	50.0
7	15.6–16.5	9	68.9	14.5	22.2	16.5	16.7	25.0
8	16.6–20.0	21	78.1	19.9	35.9	23.2	50.0	44.7

TABLE 18. % correct production of postvocalic consonants as a function of place of production.

			Place of production					
			Front [b,m,v,f,θ]		*Middle* [d,t,n,z,s,ʃ]		*Back* [g,k]	
Group	*Age*	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	4.5– 7.5	5	40.0	14.1	20.2	18.2	10.0	22.4
2	7.6– 9.5	12	53.3	24.6	33.3	20.1	12.5	22.6
3	9.6–11.5	8	55.0	27.8	41.6	15.5	37.5	44.3
4	11.6–13.5	19	60.0	27.5	40.4	25.1	36.8	40.3
5	13.6–14.5	17	68.2	26.5	45.1	27.4	47.1	44.9
6	14.6–15.5	22	71.8	26.7	37.9	34.5	31.8	39.5
7	15.6–16.5	9	31.8	27.7	14.8	19.4	11.1	22.0
8	16.6–20.0	21	60.0	32.9	29.4	22.9	21.4	29.0

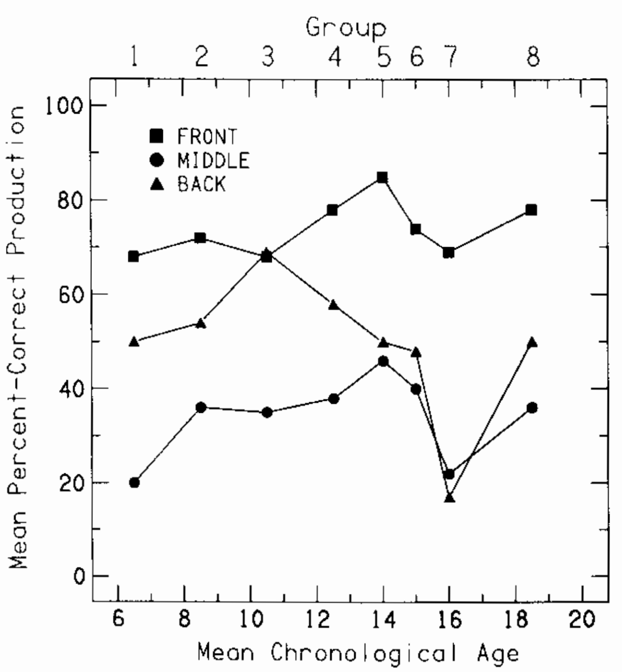

FIGURE 14. Production accuracy of the prevocalic consonants expressed in terms of place of production. Data are plotted at the midpoint of each age group.

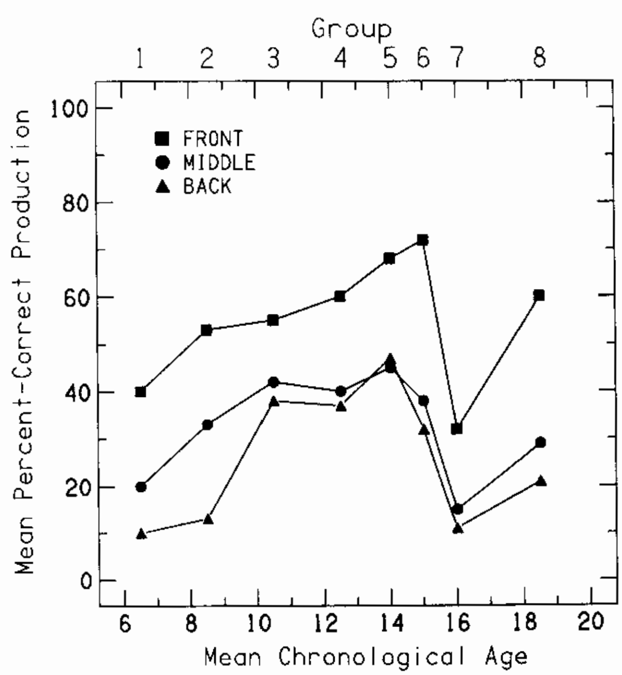

FIGURE 15. Production accuracy of the postvocalic consonants expressed in terms of place of production. Data are plotted at the midpoint of each age group.

age groups, the difference in production accuracy between the mid and back sounds is negligible.

The data were next averaged across age groups to illustrate more clearly the effect of consonant position (pre- or postvocalic) as a function of manner of production and place of production. The data for manner of production are illustrated in Figure 16. On the average, higher scores were achieved for plosives and affricates when these sounds were produced in the prevocalic position than in the postvocalic position. In contrast, the position of the consonant had little effect on the production of fricatives and nasals.

Figure 17 shows the effect of position on place of production. On the average, higher scores were achieved when the consonants comprising each of the three places of production were produced in the prevocalic rather than

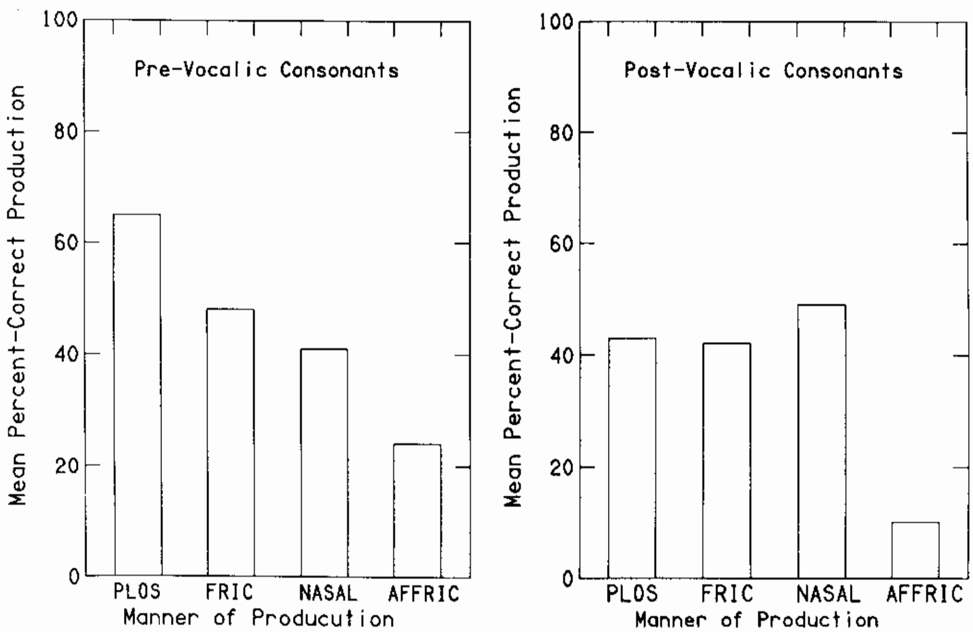

FIGURE 16. Production accuracy as a function of consonantal position for the four manners of production. Data are plotted at the midpoint of each age group.

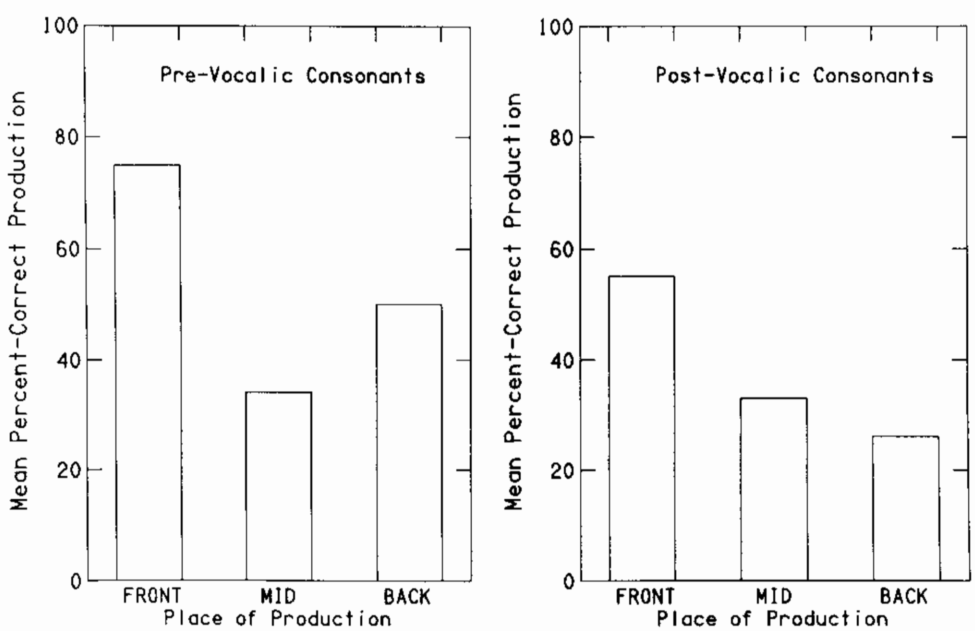

FIGURE 17. Production accuracy as a function of consonantal position for the three places of production.

in the postvocalic position. Position appears to have the greatest effect on sounds produced in the front of the mouth, which is evidenced by the large difference between the students' ability to produce these sounds accurately in the prevocalic position and the postvocalic position.

A measure of overall consonant production was derived by calculating the percentage of all consonants produced correctly by each student. The correlation between this measure and age was found to be nonsignificant.

Speech Intelligibility

Table 19 and Figure 18 summarize the intelligibility ratings assigned to the students' spontaneous speech samples. These data also show limited improvement in intelligibility with age, with the highest average rating of 38.8% achieved by Group 5. When the scores were averaged across all students, the data revealed that only about 18% of their speech was rated intelligible. The size of the standard deviations suggests considerable variance among the students within each age group. The correlation between age and performance on this measure did not reach statistical significance. Intrajudge agreement was 85%, 90%, 90%, and 92% for Judges 1, 2, 3, and 4, respectively. The data for interjudge agreement showed large differences: 68% of the judgments were within a 25% rating of one another, whereas 32% of the judgments differed from each other by a rating of 26% or more. The relatively large disagreement between judges on a task of this nature has been reported by other investigators (Levitt, McGarr, & Geffner, 1985), and it is not an unexpected finding. In fact, a major reason for using more than one judge was because of the known variability among listeners on this type of task.

TABLE 19. Mean intelligibility rating assigned the spontaneous speech sample.

Group	*Age*	*n*	*Rating (%)*	*SD*
1	4.5– 7.5	12	11.6	22.2
2	7.6– 9.5	12	15.8	31.2
3	9.6–11.5	11	15.7	27.7
4	11.6–13.5	22	21.0	36.1
5	13.6–14.5	18	38.8	43.8
6	14.6–15.5	30	29.6	39.7
7	15.6–16.5	11	13.2	27.9
8	16.6–20.0	19	20.4	33.6

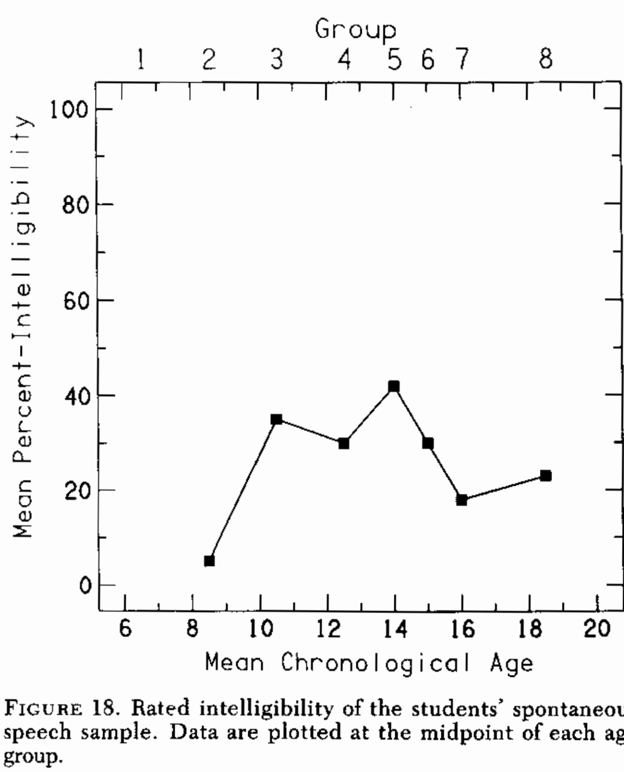

FIGURE 18. Rated intelligibility of the students' spontaneous speech sample. Data are plotted at the midpoint of each age group.

Correlations Between Measures

Partial correlations, adjusted for age and performance IQ, were calculated between the speech measures. The measure of consonant production consisted of the percentage of all consonants produced correctly by each student. The correlational data appear in Table 20. The rated intelligibility of the spontaneous sample is indicated by SPINT, and consonant production is indicated by CONS. As the data show, strong correlations were found between all variables. The correlations between segmentals (vowels and consonants) are similar to those reported by other investigators (Hudgins & Numbers, 1942; Smith, 1975).

TABLE 20. Correlations between the speech variables.

	Speech measures					
	SPINT	*CONS*	[i, a, u]	[u]	[a]	[i]
[i]	.60*	.67*	.85*	.60*	.50*	1.0
[a]	.44*	.42*	.79*	.64*	1.0	
[u]	.43*	.44*	.85*	1.0		
[i, a, u]	.60*	.64*	1.0			
CONS	.77*	1.0				
SPINT	1.0					

Note. SPINT = Speech intelligibility; CONS = consonants.
$^*p < .001$.

To examine the effect of degree of hearing loss on speech production characteristics, the students were divided into two groups using the classification scheme described in chapter 4 (i.e., Group I = PTA < 105 dB, Group II = PTA > 105 dB). The group differences were analyzed using independent sample t tests, with adjustment for unequal group variances where appropriate. Significant ($p < .01$) group differences were found for all variables analyzed. Because of the severely limited auditory capabilities of the Group II students, correlations between PTA and the other audiologic variables and speech production skills were calculated only for the students in Group I. These data appear in Table 21. Significant negative correlations were found between PTA and all the speech variables, with the strongest correlations observed between the better-ear pure-tone average and the intelligibility measure (SPINT). Vowel production did not show a significant relationship with the audiologic variables. In contrast, weak but significant correlations were found between consonant production, the two speech intelligibility measures, and the age when the hearing loss was first suspected and first confirmed. Most of the speech measures were not correlated significantly with the age of hearing aid acquisition, with the exception of SPINT. Consonant production was the only measure that showed a significant relationship with aided pure-tone thresholds.

TABLE 21. Correlations between the audiologic and speech variables.

Audiologic variables	*Speech measures* [i]	[a]	[u]	[i, a, u]	*CONS*	*SPINT*
PTA	−.38**	−.30**	−.25*	−.37**	−.48**	−.52**
PTAIDED	.10	−.03	.06	.07	−.33*	.01
HLSUS	.09	.01	.00	.05	.29*	.23*
HLCONF	.19	.07	.06	.14	.35**	.29**
HAACQ	−.07	.06	−.13	−.06	.15	.25*

Note. PTA = pure-tone average; PTAIDED = aided pure-tone thresholds; HLSUS = hearing loss first suspected; HLCONF = hearing loss confirmed; HAACQ = hearing aid first acquired; CONS = consonants; SPINT = speech intelligibility.

*$p < .01$.
**$p < .001$.

DISCUSSION

The speech production skills of these students appear to be highly similar to those of other populations of hearing-impaired children (Brannon, 1966; Geffner, 1980; Gold, 1980; Hudgins & Numbers, 1942; Markides, 1970; Smith, 1975). Production accuracy of the high-front vowel [i] was inferior to that of either the high-back vowel [u] or the low-back vowel [a], a finding previously reported by Smith (1975) and Gold (1980). The rank order of consonants in terms of manner and place of consonantal production also is consistent with the results of Smith (1975) and Gold (1980). That is, plosives and fricatives were produced correctly most often, followed by the nasals; affricates were prone to error most often.

Performance with respect to place of production showed that production accuracy was higher for back sounds [k, g, h] than sounds produced in the middle of the mouth (otherwise known as coronals [t, d, n]) and the sibilants [s, z, ʃ], at least in the prevocalic position. This pattern of performance supports the data of Smith (1975), Gold (1980), and Osberger (1983). It does not, however, support the clinical notion that the error rate of consonants increases in the speech of the hearing impaired as the place of production moves farther back in the mouth and visibility decreases. There appear to be several explanations for this observed performance pattern. First, it might be that only the most visible sounds (those produced in the front of the mouth) contain cues sufficient to be used by a hearing-impaired talker to facilitate his or her own speech production skills. Although some features of the middle sounds may be more visible than the back sounds, the visible characteristics may not be sufficient to assist the hearing-impaired observer in a speech-production task.

A second explanation may be that visibility in and of itself may not be a key factor in production. The lips, for example, although quite visible, are relatively more constrained in their range of movement than are the other articulators such as the tongue, thus permitting fewer possibilities for error (McGarr & Harris, 1980). Also, the mid-coronal group of sounds has roughly twice as many sounds as the back group. Because of this, precise positioning of the articulators is necessary in order to differentiate correctly all the sounds with a medial place of production. In contrast, there are only three velar sounds (k, g, h) included in the English repertoire. It is possible that greater variability in articulatory placement can be tolerated for velars than alveolars before they are misperceived by the listener.

Finally, the consonant data indicate that the majority of consonants were more prone to error when they occurred in the postvocalic than in the prevocalic position. This reaffirms the finding in the speech of the hearing impaired of omission of word-final consonants (Hudgins & Numbers, 1942; Markides, 1970; Smith, 1975). This finding might also reflect a listener's increased perceptual tolerance for less accurate production of consonants in the postvocalic than in the prevocalic position. That is, it often is more difficult to determine the presence of a sound when it is produced postvocalically, especially if it is an unreleased plosive.

The results of the speech intelligibility evaluation revealed that only a limited amount of what the students produced could be understood by the listeners. The speech intelligibility results with respect to overall performance level is similar to that reported by other investigators (Brannon, 1966; Gold, 1980; John & Howarth, 1965; Markides, 1970; Smith, 1975).

A finding of particular concern is the negligible improvement in all speech production skills with age. This finding is consistent with the data reported by Boothroyd (1985) and the Office of Demographic Studies (Jensema, Karchmer, & Trybus, 1978) for a large sample of hearing-impaired students in the United States, but is not in agreement with the results of a cross-sectional study by Smith (1975), which shows significant differences in speech production skills between younger and older students in the same school. Further, longitudinal data reported by Ling and Milne (1981) show significant improvement in the intelligibility of the speech of the students in their studies. The degree of hearing loss in the students in the Ling and Milne and the Smith studies was similar to that of the present sample, but, in contrast, students evaluated in the other studies attended schools that employed oral–aural teaching philosophies. This suggests that students in auditory–oral schools achieve significant gains in speech intelligibility, whereas students in total communication programs do not. Jensema et al. (1978) found that children with high intelligibility ratings used speech frequently, and as the use of signs and fingerspelling decreased, intelligibility increased. Additionally, the residential status of the students in the present study also might be a contributing factor to their reduced speech intelligibility, a finding also suggested by the data of Jensema et al.

The above findings, however, need to be interpreted with caution, because the relations cited are correlational in nature and causal effects should not be inferred from the data. In particular, there is insufficient evidence to suggest that use of total communication in and of itself is detrimental to the development of intelligible speech. Likewise, these data should not be interpreted to indicate that profoundly hearing-impaired children are incapable of improving their speech or that the development of speech is an unrealistic goal for them. In fact, significant changes have been observed to occur in the speech of the hearing impaired when they are provided with intense, systematic training (Calvert, 1981; Osberger, 1983; Osberger, Johnstone, Swarts, & Levitt, 1978). The amount of training provided the present students is unknown to us, although previous research suggests that the quality and quantity of speech services generally available to the hearing impaired are severely limited and inadequate (Hochberg, Levitt, & Osberger, 1980).

The correlational data show a significant relationship between residual hearing and speech production skills, a finding consistent with the results of other investigations (Boothroyd, 1969; Gold, 1978; Hudgins & Numbers, 1942; Smith, 1975). The data for the other audiologic variables indicate better speech skills in those students whose losses were suspected and confirmed earlier than the other students. A significant correlation between age of hearing aid acquisition and speech was not found for most of the measures probably because all students did not receive amplification for a relatively long period of time after their loss was identified. These data emphasize the need for early initiation of rehabilitation, including hearing aid fitting, as well as early identification of the hearing loss itself.

In summary, the results of the speech evaluation suggest that, on the average, the students in this sample demonstrated severely limited speech production skills, and there was negligible difference in these skills between the younger and older students. Residual hearing correlated strongly with speech intelligibility and to a moderate degree with the other speech measures. The findings with respect to vowel and consonant production and overall intelligibility are highly similar to other populations of hearing-impaired talkers in comparable educational settings.

REFERENCES

BOOTHROYD, A. (1969). *Distribution of hearing levels in the student population of the Clarke School for the Deaf.* Northampton, MA: Clarke School for the Deaf.

BOOTHROYD, A. (1985). Auditory capacity and carry-over in the speech of the deaf. In J. Lauter (Ed.), *Proceedings of the Conference on the Planning and Production of Speech in Normal and Hearing-Impaired Individuals: A Seminar in Honor of S. Richard Silverman. ASHA Reports, 15,* 8-14.

BRANNON, J. B. (1966). The speech production and spoken language of the deaf. *Language and Speech, 9,* 127-135.

CALVERT, D. R. (Ed.). (1981). Experimental project in instructional concention. *American Annals of the Deaf, 126,* 865-984.

GEFFNER, D. (1980). Closure characteristics of spontaneous speech production in young deaf children. *Journal of Communication Disorders, 13,* 443-454.

GOLD, T. (1978). *Speech and hearing skills: A comparison between hard-of-hearing and deaf children.* Unpublished doctoral dissertation, City University of New York, New York.

GOLD, T. (1980). Speech production in hearing-impaired children. *Journal of Communication Disorders, 13,* 397-418.

GOLDMAN, R., & FRISTOE, M. (1972). *Goldman–Fristoe Test of Articulation.* Circle Pines, MN: American Guidance Service.

HOCHBERG, I., LEVITT, H., & OSBERGER, M. J. (1980). Improving speech services to hearing-impaired children. *Asha, 22,* 480-486.

HUDGINS, C. V., & NUMBERS, F. C. (1942). An investigation of the intelligibility of the speech of the deaf. *Genetic Psychology Monographs, 25,* 289-392.

JENSEMA, C., KARCHMER, M., & TRYBUS, R. (1978). *The rated speech intelligibility of hearing-impaired children: Basic relationships and a detailed analysis* (Series R, No. 6). Washington, DC: Gallaudet College, Office of Demographic Studies.

JOHN, J. E. J., & HOWARTH, J. N. (1965). The effect of time distortions on the intelligibility of deaf children's speech. *Language and Speech, 8,* 127-134.

LEVITT, H., MCGARR, N., & GEFFNER, D. (1985). *Development of language and communication skills in hearing-impaired children.* Manuscript submitted for publication.

LING, D., & MILNE, M. (1981). The development of speech in hearing-impaired children. In F. Bess, B. A. Freeman, & J. S. Sinclair (Eds.), *Amplification in education* (pp. 98-108). Washington, DC: A. G. Bell Association for the Deaf.

MARKIDES, A. (1970). The speech of the deaf and partially hearing children, with special reference to factors affecting intelligibility. *British Journal of Disorders of Communication, 5,* 126-140.

MCGARR, N. S. (1978). *The difference between experienced and inexperienced listeners in understanding the speech of the deaf.* Unpublished doctoral dissertation, City University of New York, New York.

MCGARR, N. S., & HARRIS, K. S. (1980). Articulatory control in a deaf speaker. *Status Report on Speech Research SR-63/64* (pp. 309-332). New Haven: Haskins Laboratories.

MCGARR, N. S., & OSBERGER, M. J. (1978). Pitch deviancy and intelligibility of deaf speech. *Journal of Communication Disorders, 11,* 237-248.

OSBERGER, M. J. (1983). The development and evaluation of some systematic speech-training procedures for hearing-impaired children. In I. Hochberg, H. Levitt, & M. J. Osberger (Eds.), *Speech of the hearing impaired: Research, training, and personnel preparation* (pp. 333-348). Baltimore: University Park Press.

OSBERGER, M. J., JOHNSTONE, A., SWARTS, E., & LEVITT, H. (1978). The evaluation of a model speech training program for deaf children. *Journal of Communication Disorders, 11,* 293-313.

OSBERGER, M. J., & MCGARR, N. S. (1981). Speech production characteristics of the hearing impaired. In N. Lass (Ed.), *Speech and language: Advances in basic research and practice* (pp. 221-283). New York: Academic Press.

SMITH, A. (1975). Residual hearing and speech production in the deaf. *Journal of Speech and Hearing Research, 19,* 795-811.

Chapter 7

Intellectual Evaluation

Betty U. Watson Patricia Sullivan John Teare Ron Thompson

Boys Town National Institute

Each student received an intellectual assessment as a part of the multidisciplinary evaluation. Traditionally, IQ scores have been used in education as a reference point to determine whether a student is making adequate academic progress (Salvia & Ysseldyke, 1981). Significant differences between IQ and academic achievement or between IQ and language level may indicate the need for special services. Although IQ scores often are used as the reference point in making such decisions, it is important to remember that IQ by itself accounts for only 25–30% of the variance in achievement and language measures in hearing samples (Matarazzo, 1972; Zimmerman & Woo Sam, 1972) and for somewhat less in hearing-impaired samples (Watson, Goldgar, Kroese, & Lotz, in press; Watson, Sullivan, Moeller, & Jensen, 1982).

Intellectual evaluation of the hearing impaired is usually accomplished with nonverbal or performance tests because many individuals with congenital hearing losses are significantly delayed in language development. Verbal IQ results in this population often reflect the language handicap rather than the intellectual level (Vernon, 1976). The nonverbal or performance tasks used in assessing the deaf usually require minimal, if any, verbal instructions and allow for a nonverbal response. Examples of typical test items include puzzles, block designs, visual discrimination tasks, visual analogies, and visual memory. In this project, primarily nonverbal measures were used to assess intelligence; however, a verbal IQ scale was included as an experimental procedure.

There are numerous studies of nonverbal intelligence in the profoundly hearing impaired. Vernon (1976) reviewed 50 reports and concluded that the evidence strongly supported the presence of average nonverbal intelligence in the hearing impaired. Anderson and Sisco (1977) have reported nonverbal IQ data on a relatively large (N = 1,228) and demographically representative sample of hearing-impaired children drawn primarily from residential schools. The mean IQ was within the average range but significantly below the mean of the normal-hearing standardization sample. The standard deviation also was significantly greater. This finding of a lower mean IQ score may reflect the greater incidence of mental retardation in the hearing-impaired population due to the overlapping etiologies of some deafness and mental retardation.

Although the intellectual testing reported here was done for clinical/educational purposes, several hypotheses were generated about the group results. First, it was anticipated that the mean nonverbal intelligence of this sample would fall within the Average range and possibly slightly below the mean of normal-hearing samples. Second, it was anticipated that the mean IQ of age groups 5, 6, and 7 would be lower because these groups would contain some youngsters with etiologies of maternal rubella contracted during the epidemic of 1964–1965. Third, it was expected that verbal IQ would fall below the Average range. Finally, data on teachers' estimates of the intellectual ability of their students were analyzed. It was hypothesized that teachers may be inaccurate in perceiving the ability of hearing-impaired students.

METHOD

Measures

Two nonverbal IQ measures were administered to each student. These were the Hiskey–Nebraska Test of Learning Aptitude (H–NTLA) (Hiskey, 1966) and the performance scale from one of the three Wechsler scales: Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Wechsler, 1967); Wechsler Intelligence Scale for Children–Revised (WISC–R) (Wechsler, 1974); and Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1955). The WPPSI was given to students ages 4–6½ years, the WISC–R to students 6–16 years 11 months, and the WAIS to students 16 years and older. The verbal scale of the Wechsler tests also was given to some of the students.

The Wechsler scales contain a minimum of five verbal and five nonverbal subtests. Scores are calculated for the individual subtests, Verbal IQ, Performance IQ, and Full Scale. These Wechsler tests have been recognized as adequately standardized (Salvia & Ysseldyke, 1981). Although these scales were developed for use with normal-hearing subjects, the performance scales are frequently used in the evaluation of hearing-impaired individuals and are recommended for this purpose (Vernon, 1976). Hirshoren, Hurley, and Kavale (1979) analyzed the psychometric properties of the WISC–R Performance Scale with a hearing-impaired sample and found that the internal consistency and intercorrelations among the subtests were similar to those in hearing samples. Evidence of concurrent validity of the WISC–R Performance Scale in hearing-impaired samples has been reported for other IQ measures (Hirshoren et al., 1979) and language measures (Watson et al., 1982). This scale appears to have a weak, albeit significant, relationship to academic achievement in hearing-impaired samples (Hirshoren et al., 1979; Hurley, Hirshoren, Kavale, & Hunt, 1979; Watson et al., in press).

The H–NTLA consists of two forms. The first contains eight subtests and is administered to children 3–11 years of age; the second has seven subtests and is given to individuals 11 years and older. The H–NTLA yields scores for the individual subtests as well as an overall score, the learning quotient (LQ). Hiskey (1966) has urged the use of the term *learning quotient* with the hearing impaired rather than IQ. When hearing norms are used, the results are expressed as *IQ*. In contrast, the term *LQ* is applied when the hearing-impaired norms are used. Unlike the Wechsler scales, the H–NTLA was developed specifically for use with the hearing impaired and includes separate norms and directions for this population. This test has been described by some reviewers as one of the best instruments for assessing the learning ability of the hearing impaired (Newland, 1972; Salvia & Ysseldyke, 1981). However, a relative weakness of the test has been the standardization sample, which was not adequately stratified and which also included small numbers at the youngest ages. Other psychometric characteristics of this test with the hearing impaired are more adequate. Hiskey (1966) has reported satisfactory internal consistency, and Watson (1983) found adequate test–retest stability. There is evidence of concurrent validity with other nonverbal IQ measures (Hurley et al., 1979), language measures (Watson et al., 1982), and academic achievement (Giangreco, 1966; Watson et al., in press).

Procedures

Each child was tested individually by one of four psychologists. Three of the psychologists worked with an interpreter during the administration of the Wechsler scales. The directions and questions were given in total communication. The H–NTLA was administered by these psychologists through pantomime directions for the hearing impaired. The fourth psychologist was fluent in sign and administered the Wechsler in total communication. The H–NTLA was also given in sign by this psychologist, using the directions for hearing subjects as well as the hearing norms. Subjects were assigned randomly so that approximately half were tested by the psychologist who used total communication, and the other half were tested with the assistance of an interpreter.

The order in which the two tests were given was alternated from subject to subject. The standardized directions for test administration were followed. However, when the Wechsler Verbal Scales were given, it was necessary to rephrase some questions by changing unfamiliar vocabulary and some syntax that was particularly difficult for the hearing-impaired students. The obvious questions raised by such modifications are addressed in subsequent sections.

RESULTS

The results were first analyzed for sex differences and examiner/mode of administration effects to see if data could be combined for male and female students and across the two modes of examination (*no interpreter* and *interpreter*). These findings are discussed first, and then the findings of primary interest, the IQ results, are presented.

Examiner/Mode of Administration and Sex Effects

The mean Wechsler and H–NTLA scores were compared for differences between the two modes of examination. Significant differences were found for Wechsler Performance IQ. The mean of the group tested with an interpreter was 99.6 and without an interpreter, 110.1 ($t = 3.64$, $p < .01$). Significant differences were also found for Wechsler Verbal IQ. The mean of the group tested with an interpreter was 63.4 and without an interpreter, 73.7 ($t = 3.44$, $p < .01$).

No significant differences were found for the two conditions for the H–NTLA. Approximately half of the students were tested in pantomime, and the hearing-impaired norms were used in scoring. The others were given the hearing directions in total communication, and the hearing norms were used. The use of the two different sets of norms has probably obscured a significant difference. The hearing-impaired norms are set approximately one-half year lower for most subtests than the hearing norms. Thus, had the hearing-impaired norms been used for both groups, the group tested with the hearing directions would have had an even higher mean score.

No significant differences were found between boys and girls on Wechsler Performance or Verbal IQ or on the H–NTLA. Thus, the findings suggest that the data for boys and girls could be combined, but that separate analyses are necessary for the different examination conditions.

Nonverbal Intelligence

The means and standard deviations for the Wechsler Performance IQ and H–NTLA LQ or IQ are shown in Table 22. The mean Wechsler Performance IQ is close to the standardization group mean of 100 for the subjects receiving the test through an interpreter. The mean of the group receiving the test through total communication without an interpreter is significantly higher ($p < .001$) than the standardization group mean. The standard devia-

Table 22. Means and standard deviations for Wechsler Performance IQ and Hiskey–Nebraska Test of Learning Aptitude (H–NTLA) (Hiskey, 1966) learning quotient/IQ.

Test/Mode of examination	*n*	*M*	*SD*
Wechsler Performance Scale			
Interpreter	70	99.6	18.4
Total communication	69	110.1	15.3
H–NTLA			
Pantomime	70	99.5	22.6
Total communication	70	103.6	16.2

tion of the group receiving the test through an interpreter also is significantly greater ($p < .01$) than the standard deviation of 15 for the standardization sample.

The mean H–NTLA score for the group receiving the test with pantomimed directions and hearing-impaired norms does not differ from the standardization group mean of 100. However, the mean IQ score of the group receiving the test with the hearing directions and norms is significantly higher ($p < .05$) than that of the standardization group. Since the H–NTLA test manual does not provide information about the standard deviation of LQ in the hearing-impaired standardization group, no comparison can be made with the one obtained for this sample. The standard deviation for the hearing standardization group was 15 and does not differ significantly from that obtained for this sample.

Table 23 shows the distribution of Wechsler and H–NTLA scores for the subjects in the interpreter/pantomime test conditions. The table shows the frequencies for several broad IQ categories and provides expected frequencies based on the findings from the WISC–R standardization sample. Chi squares were significant between the obtained and expected frequencies for both H–NTLA LQ [$\chi^2(3) = 57.16$, $p < .001$], and Performance IQ [$\chi^2(3) = 13.64$, $p < .01$].

The differences between these distributions reflect in part the greater number of mentally retarded individuals

Table 23. Frequency of LQ and Performance IQ scores.

IQ/LQ category	*Obtained frequencies* *H–NTLA LQ*	*Wechsler Performance IQ*	*Expected frequencies* *WISC–R Standardization IQ*[a]
69 and below	10	6	1.56
70–89	10	13	15.76
90–119	37	47	46.79
120 and above	14	5	6.89

Note. IQ/LQ = intelligence/learning quotient; H–NTLA = Hiskey–Nebraska Test of Learning Aptitude (Hiskey, 1966); WISC–R = Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974).

[a]Expected frequencies are the product of the percentages in the standardization sample (Wechsler, 1974) times the number of subjects in this sample.

in the hearing-impaired sample versus the standardization sample. When chi squares were repeated without the mentally retarded subjects, the obtained distribution of Wechsler Performance IQ does not differ from the expected distribution. However, the comparison between the obtained and expected proportions was still significant for the H–NTLA [$\chi^2(2) = 12.52$, $p < .01$]. In a further analysis of this finding, Watson and Goldgar (1985) noted the tendency of the H–NTLA to yield an unexpected number of subjects with extreme scores, which is apparently due to a problem in test standardization.

Age Trends

Tables 24 and 25 give the means and standard deviations of the IQ/LQ performance of the eight age groups. None of the age groups had means outside the Average range. There is a slight decrement in performance for age groups 4–7 across both modes of administration. However, there were no statistically significant differences among age group means.

Table 24. Mean Wechsler Performance scores as a function of age.

Group	*Age*	*n*	*M*	*SD*
1	4.5– 7.5	13	106.8	14.6
2	7.6– 9.5	14	106.6	15.7
3	9.6–11.5	12	113.7	16.0
4	11.6–13.5	21	105.3	21.1
5	13.6–14.5	19	101.9	17.6
6	14.6–15.5	31	100.6	18.1
7	15.6–16.5	11	101.9	20.1
8	16.6–20.0	24	105.3	14.7

Table 25. Mean Hiskey–Nebraska Test of Learning Aptitude (Hiskey, 1966) learning/intelligence quotient (LQ/IQ) as a function of age.

		IQ (hearing norms)			*LQ (deaf norms)*		
Group	*Age*	*n*	*M*	*SD*	*n*	*M*	*SD*
1	4.5– 7.5	3	78.3	11.1	5	65.6	8.9
2	7.6– 9.5	8	78.0	14.3	4	75.8	7.6
3	9.6–11.5	7	86.7	13.2	3	55.0	6.1
4	11.6–13.5	9	82.9	13.9	8	62.5	16.9
5	13.6–14.5	7	83.3	15.1	10	62.9	14.1
6	14.6–15.5	17	78.9	10.2	9	59.6	14.0
7	15.6–16.5	5	75.2	9.0	4	60.8	16.8
8	16.6–20.0	12	82.0	10.7	2	74.0	17.0

Verbal Intelligence

Sixty-eight students were given the Wechsler Verbal Scale in total communication without an interpreter. Forty-five received the Verbal Scale through an interpreter. The mean of the group tested without an interpreter was 73.7 with a standard deviation of 15.4, and the mean of the group tested with an interpreter was 63.4 with a standard deviation of 13.7. The mean of the first group falls within the Borderline range and the mean of the second, within the range of Mental Retardation. Both scores are significantly different ($p < .001$) from the mean of 100 for the standardization group.

Two caveats must be noted in regard to the Verbal IQ results. First, some departures from standardized testing procedures occurred. These modifications were generally of the sort to simplify syntax or to shorten the length of the questions. Second, not all students received the Verbal Scale. Of the subjects tested through an interpreter, 25 did not take the Verbal Scale. The decision not to administer was strictly at random, and in some cases, the scale was not given to a particular student because the examiner suspected a severe language handicap. Thus, these Verbal IQ data do not provide normative information about hearing-impaired students. Rather, these results document the extreme difficulty of the Wechsler Verbal Scales for many hearing-impaired youngsters, even when some accommodations have been made in the testing procedures.[1]

Teachers' Perception of Intelligence

Teachers of 41 students were asked to complete a 5-point rating scale of students' intelligence. The anchor adjectives were as follows: Below Average, Low Average, Average, Above Average, and Superior. Teacher ratings were compared to the psychometric classifications for the H–NTLA scores and the WISC–R Verbal and Performance scores. An agreement between teacher ratings and psychometric classification was counted when the discrepancy was no greater than the adjacent category (i.e., Average and Low Average would be counted as an agreement, whereas Average and Below Average would be counted as a disagreement).

Agreement between the teacher ratings and the three measures were WISC–R Verbal IQ—63%, WISC–R Performance IQ—68%, and H–NTLA LQ or IQ—76%. The agreement between WISC–R Performance IQ and H–NTLA scores was 100%.

These results suggest that teachers perceived the majority of the hearing-impaired students' intellectual ability accurately. However, in approximately one quarter of the cases, the teachers' perceptions were markedly inaccurate when compared to actual test scores. The direction of the discrepancy was often that the teacher rating was lower. This was true for all but one discrepancy for the WISC–R Performance IQ and true for all the H–NTLA discrepancies. It should be noted that the tendency of the H–NTLA to yield extreme scores may account for some of the discrepancies between ratings and LQ scores.

[1]Because administration of the verbal scale was considered an experimental procedure, this measure was not included in the chi-square analysis to determine if the sample who received the test differed significantly from the total sample.

DISCUSSION

The finding of an examiner effect warrants some review before the results of primary interest are discussed. The scores obtained for the Wechsler scales by the examiner working without an interpreter were significantly higher than those obtained by the other examiners who used interpreters. It is likely that a similar difference would have been observed for the H–NTLA if both sets of examiners had used the same norms in scoring. No interpreters were used in administering the H–NTLA, but one examiner gave the test using the directions for hearing subjects through total communication. The other examiners used the directions for hearing-impaired subjects, which are pantomimed. The results of the first examiner were higher than those obtained by the other examiners.

There are three possible explanations for these differences: nonrandom assignment of subjects to testing conditions, an examiner effect, or a testing condition (mode of administration) effect. The first explanation can be fairly well ruled out because assignment of subjects to examiners was generally done randomly. The other two possibilities can neither be ruled in nor out due to a confounding of the "experimental design." That is, the lack of an experimental design in which all examiners and all methods were combined makes it impossible to differentiate between an examiner versus mode of administration effect. Only one of the psychologists tested in total communication, whereas the other three tested exclusively through an interpreter or by pantomime in the case of the H–NTLA. Without ruling out an examiner effect, a conditions or mode of administration effect cannot be confirmed. Although the idea that total communication yields a better performance on nonverbal intelligence tests by hearing-impaired children is intriguing at first glance, it may seem less likely when the nature of these nonverbal tests is examined. Directions on many of the nonverbal subtests are brief, many include visual demonstrations as part of the directions, and some of the task requirements are obvious such as the puzzles and block designs. Thus, these tasks do not require complex directions that might be difficult to communicate through an interpreter. It is possible the presence of an interpreter affects testing in more subtle ways, such as "diluting" rapport with the examiner, but the cognitive rather than the personal nature of the tasks does not make this too likely.

The primary finding from the intelligence testing was that the Performance, or nonverbal, IQ of this sample was within the Average range and did not differ significantly from that of the normal-hearing standardization samples. The one exception was the mean Wechsler score obtained without an interpreter, which fell within the High Average range.

The mean Wechsler Performance IQ scores for both examination conditions were higher than those obtained by Anderson and Sisco (1977) in their large sample of residential deaf students. They obtained a mean of 95.7 versus means of 99.6 (interpreter) and 110 (no interpreter) in this sample. It is possible that these higher scores in part reflect the generally higher levels of intellectual ability which have been reported for children residing in the geographic region from which the present sample was drawn.

Although the means obtained in this hearing-impaired sample are similar to those of the hearing standardization samples for the Wechsler Performance Scales, the distribution of IQ is significantly different. A greater number of subjects fell within the range of mental retardation in this sample. This difference in distribution is also reflected in the standard deviation of 18.2 obtained for this sample versus the standard deviation of 15 obtained for the normal-hearing standardization sample. These differences in distribution and variability are most likely due to the overlapping etiologies of some deafness and mental retardation.

Performance IQs and H–NTLA IQs and LQs were within the Average range or higher across all eight age groups. The means of the age groups 4–7 were low relative to the other groups. However, there were no statistically significant differences among the age group means.

The Wechsler Verbal Scales also had been administered as an experimental procedure. In the course of administering these scales, occasional departures were made from standardized testing conditions. The modifications were of the nature to shorten sentence length and simplify syntax. In addition, the Verbal Scale was administered to a subset of the sample which was probably slightly biased toward inclusion of students with better language ability. Thus, these data do not provide normative information about the performance of hearing-impaired students on the Wechsler Verbal Scales. However, they do document the extreme difficulty that many hearing-impaired students have with this task. In contrast to the Average and above mean nonverbal IQ scores of the sample, the mean Verbal IQ score fell significantly below the Average range. The mean of the group tested without an interpreter fell within the Borderline range; the mean of the group tested with an interpreter fell within the range of Mental Retardation. The difficulty of this task, of course, reflects the heavy weighting that the Wechsler Scales give to verbal comprehension (Kaufman, 1979). Further, the Wechsler scales may present even greater difficulty than some other language tasks due to the nature of some of the subtests which contain low probability vocabulary, long sentences with minimal redundancy, and complex syntax.

Finally, teachers were asked to rate the intelligence of their students because it was suspected that this might be difficult since nonverbal IQ is less observable. It was found that teachers estimated the intelligence of most students accurately. However, estimates were discrepant from the actual, obtained scores for approximately one quarter of the sample, and the usual direction of the discrepancy was that the teacher estimate was lower.

Whether teachers' perceptions of ability affect their management of the child is debatable. The literature on the "Pygmalion Effect" (Rosenthal & Jacobsen, 1968), in which teacher expectations possibly influence actual gains in IQ, has failed to confirm consistently this effect. However, there is some support (Sutherland & Goldschmid, 1974) that negative expectations may affect later IQ performance of Superior children. Because a number of the discrepancies in the present sample involved children who were Superior by psychometric standards, it may be of some use to apprise teachers of the outstanding ability of such youngsters.

To summarize the intellectual findings, the main result was of average nonverbal intelligence. The actual means were quite consistent with those reported for the normal-hearing samples on which the IQ measures were standardized. Despite the similar means, the distribution of nonverbal IQ scores differed significantly from the distribution of the normal-hearing standardization sample. The present sample included a larger number of subjects within the range of mental retardation. Average nonverbal IQ was observed across all age groups. In contrast to the Average nonverbal IQ that was found, verbal IQ scores were significantly below those of the normal-hearing groups on which the tests are standardized. This, of course, reflects the English-language problems of the prelingually hearing-impaired student. Finally, it was found that teachers were relatively accurate in estimating their hearing-impaired students' intellectual level in spite of the less observable nature of nonverbal intelligence.

REFERENCES

Anderson, R. J., & Sisco, F. H. (1977). *Standardization of the WISC–R Performance Scale for deaf children.* Washington, DC: Gallaudet College, Office of Demographic Studies.

Giangreco, C. J. (1966). The Hiskey–Nebraska Test of Learning Aptitude (Revised) compared to several achievement tests. *American Annals of the Deaf, 8,* 566-577.

Hirshoren, A., Hurley, O. L., & Kavale, K. (1979). Psychometric characteristics of the WISC–R Performance Scale with deaf children. *Journal of Speech and Hearing Disorders, 44,* 73-79.

Hiskey, M. S. (1966). *Hiskey–Nebraska Test of Learning Aptitude.* Lincoln: Union College Press.

Hurley, O. L., Hirshoren, A., Kavale, K., & Hunt, J. T. (1979). Predictive validity of two mental ability tests with black deaf children. *Journal of Negro Education, 48,* 14-19.

Kaufman, A. S. (1979). *Intelligent testing with the WISC–R.* New York: Wiley.

Matarazzo, J. D. (1972). *Wechsler's measurement and appraisal of adult intelligence.* Baltimore: Williams & Wilkins.

Newland, T. E. (1972). Hiskey–Nebraska Test of Learning Aptitude. In O. K. Buros (Ed.), *The seventh mental measurements yearbook* (Vol. 1). Highland Park, NJ: Gryphon Press.

Rosenthal, R., & Jacobson, L. (1968). *Pygmalion in the classroom.* New York: Holt, Rinehart & Winston.

Salvia, J., & Ysseldyke, J. E. (1981). *Assessment in special and remedial education* (2nd ed.). Boston: Houghton-Mifflin.

Sutherland, A., & Goldschmid, M. L. (1974). Negative teacher expectation and IQ change in children with superior intellectual potential. *Child Development, 45,* 852-856.

Vernon, M. (1976). Psychologic evaluation of hearing-impaired children. In L. Lloyd (Ed.), *Communication intervention and assessment strategies.* Baltimore: University Park Press.

Watson, B. U. (1983). Test–retest stability of the Hiskey–Nebraska Test of Learning Aptitude in a hearing-impaired sample. *Journal of Speech and Hearing Disorders, 48,* 51-55.

Watson, B. U., & Goldgar, D. E. (1985). A note on the use of the Hiskey–Nebraska Test of Learning Aptitude with deaf children. *Language, Speech, and Hearing Services in Schools, 16,* 53-57.

WATSON, B. U., GOLDGAR, D. E., KROESE, J. M., & LOTZ, W. K. (in press). Nonverbal intelligence and academic achievement in hearing-impaired students. *Volta Review.*

WATSON, B. U., SULLIVAN, P. M., MOELLER, M. P., & JENSEN, J. K. (1982). Nonverbal intelligence and English language ability in deaf children. *Journal of Speech and Hearing Disorders, 47,* 199-204.

WECHSLER, D. (1955). *Wechsler Adult Intelligence Scale–Revised.* New York: Psychological Corporation.

WECHSLER, D. (1967). *Wechsler Preschool and Primary Scale of Intelligence.* New York: Psychological Corporation.

WECHSLER, D. (1974). *Wechsler Intelligence Scale for Children.* New York: Psychological Corporation.

ZIMMERMAN, I. L., & WOO SAM, J. M. (1972). Research with the Wechsler Intelligence Scale for Children: 1960–1970. *Psychology in the Schools, 9,* 232-271.

Part II

LANGUAGE AND LEARNING SKILLS

Chapter 8

Receptive Language Skills

Mary Pat Moeller Mary Joe Osberger Malinda Eccarius

Boys Town National Institute

Three major aspects of language were evaluated: (a) lexical/semantic skills, (b) syntactic/morphological skills, and (c) functional communicative skills. Both receptive (comprehension of language) and expressive (production of language) skills were assessed, although complete separation of these was not always possible. As Geers, Kuehn, and Moog (1981) noted, tests labeled *expressive* require the student to comprehend the language necessary to produce an appropriate expressive response, and likewise, some tests that purport to assess comprehension of language require a verbal (sign) response. For organizational purposes, the measures have been classified as receptive or expressive, based on the primary focus of the test. The results of the receptive language evaluation are presented in this chapter. The expressive language results are presented in chapter 9 with the correlations between the receptive and expressive measures. Correlations between the measures in each area as well as between other relevant variables (speech intelligibility, nonverbal IQ, and PTA) are presented at the end of each chapter.

METHOD

Procedure

The receptive language measures administered to the students were designed to tap lexical/semantic or syntactic/morphological skills. Although it would have been desirable to include measures that assessed functional communicative skills, no practical procedures of this nature were available. Also, our intent was not to assess the students' knowledge of American Sign Language or any manually coded system of English. Even though the tests were administered via total communication, our goal was to assess comprehension and use of the English language. The data are interpreted with this goal in mind.

The receptive language tests were administered individually to the students by an aural rehabilitation specialist using total communication. An exception to this was the administration of the Test of Syntactic Abilities (TSA) (Quigley, Steinkamp, Power, & Jones, 1978), which was completed by the students in small groups. The tests used to assess receptive language skills are summarized in Table 26 and described in more detail in Appendix A. Table 27 contains a list of the tests and the acronyms used to refer to them throughout this monograph. Some tests purport to measure the same skills but differ in terms of test format and/or the age range of the standardization sample.

Because the Peabody Picture Vocabulary Test (PPVT) (Dunn, 1959) was appropriate for every age group, this test was administered first to each student. The results of the PPVT were then used to identify the tests most appropriate for each child. In general, the two youngest age groups (1 and 2) were given one test battery—Vocabulary Comprehension Scale (VCS) (Bangs, 1975), Miller–Yoder Test of Grammatical Comprehension (TGC) (Miller & Yoder, 1975), Reynell Verbal Comprehension Scale (R–VCS) (Reynell, 1975)—whereas the older students were given the remaining measures. However, if a student's language skills were superior or inferior to those of the peers in his/her age group, some or all of the measures were given from the other battery. Thus, students in Group 2 who achieved relatively high scores on the PPVT received some or all of the tests administered to the older students. In this case, they would receive the BOHM (Boehm Test of Basic Concepts) (Boehm, 1971) rather than the VCS, and the TO–GU (Grammatic Understanding subtest of the Test of Language Development) (Newcomer & Hammill, 1977) rather than the TGC and the R–VCS. In contrast, some of the other tests given the older students, such as the TSA, were considered inappropriate for even those younger students with above-average language abilities. An older student who had severely reduced language skills might have received the test battery designed for the younger students. If, however, only a few students in a particular age group received a test that their peers did not, these data are not reported. This situation occurred infrequently.

A common situation that occurred with the older students (Groups 3–8) was that only selected measures within the test battery were determined inappropriate for individual students, based on their performance on the PPVT. Most often, a particular measure was considered too diffi-

TABLE 26. Summary of the Receptive Language Test Battery.

Test	*Area assessed*	*Standardization population*	*Range of norms*	*Response format*
Peabody Picture Vocabulary Test (Dunn, 1959)	Vocabulary	Hearing students	2.5–18 years	Picture selection
Test of Language Development (Newcomer & Hammill, 1977) Picture Vocabulary subtest	Vocabulary	Hearing students	4.0–9.11 years	Picture selection
Vocabulary Comprehension Scale (Bangs, 1975)	Selected concepts	Hearing students	2–6 years	Object manipulation
Boehm Test of Basic Concepts (Boehm, 1971)	Selected concepts	Hearing students	Kindergarten to 2nd grade	Picture selection
Test of Grammatical Comprehension (Miller & Yoder, 1975)	Syntax	Hearing students	3–6 years	Picture selection
Test of Language Development Grammatic Understanding subtest	Syntax	Hearing students	4.0–9.11 years	Picture selection
Child Language Ability Measures (Mehrabian & Moynihan, 1979) Grammar Comprehension subtest	Syntax	Hearing students	4–8 years	Picture selection
Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978)	Syntax	Hearing-impaired students	10–19 years	Multiple choice: written format
Verbal Comprehension Scale (Reynell Developmental Language Scales, Reynell, 1977)	Vocabulary concepts, connected language	Hearing students	18 months–7 years	Object and toy manipulation
Inventory of Language Assessment Tasks (Kellman, Flood, & Yoder, 1977)	Conjunctions and comparative relations	Hearing students	9–14 years	Cloze task and "yes–no" response

cult for a given student because of its format. For example, the CLAM (Child Language Abilities Measure) (Mehrabian & Moynihan, 1979) and the TO–GU both purport to measure receptive syntactic/morphological skills of children in roughly the same age range, but our previous experience with these two measures has shown that deaf students achieve lower scores (in terms of equivalent-language age) on the CLAM than on the TO–GU. Whenever possible, both tests were administered to the students; those students whose language skills appeared to be somewhat inferior to those of their peers received the "easier" of the two measures (i.e., the TO–GU). This also was true for the TO–GC (Grammatic Completion subtest of the TOLD) and the TSA, with the TSA being the more difficult of the two measures. Those tests where the sample size for a particular age group is smaller than that reported in Table 1 generally reflect the performance of the students with slightly "better" language abilities. The exception to this is the BOHM test which was considered to be too easy for many of the older students. Keep in mind, however, that the results of the chi-square analysis, reported in chapter 1, showed that the sample of students tested on each language measure did not differ significantly from the sample of 150 students in terms of hearing loss or performance IQ.

The students' mean equivalent language age was derived by converting each student's raw score to a language age and then averaging across students in each age group. If a student achieved either the lowest or highest possible score on a test, this basal (or ceiling) score was taken as the measure of the student's performance and was included in the average with the scores of the other students. For organizational purposes, the test results are discussed according to the skills assessed: lexical/semantic skills or syntactic/morphologic skills. The results of those tests which assessed several different skills [Reynell Verbal Comprehension Scale (R–VCS) and the Inventory of Language Assessment Tasks (LAT–R) (Kellman, Flood, & Yoder, 1977)] are presented in a separate section to permit comparison of performance across subtests.

TABLE 27. Receptive language tests and acronyms.

Test	Acronym
Lexicon/Semantics	
Peabody Picture Vocabulary Test (Dunn, 1959)	PPVT
Test of Language Development (Newcomer & Hammill, 1977) Picture Vocabulary	TO–PV
Boehm (1971) Test of Basic Concepts	BOHM
Vocabulary Comprehension Scale (Bangs, 1975)	VCS
Syntax/Morphology	
Test of Grammatical Comprehension (Miller & Yoder, 1975)	TGC
Test of Language Development Grammatic Understanding	TO–GU
Child Language Ability Measures (Mehrabian & Moynihan, 1979)	CLAM
Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978)	TSA
Other Measures	
Reynell (1977) Developmental Language Scales Verbal Comprehension Scale	R–VCS
Inventory of Language Assessment Tasks (Kellman, Flood, & Yoder, 1977) Receptive items	LAT–R

RESULTS

Lexical/Semantic Skills

The results of the two tests designed to assess word knowledge, the Peabody Picture Vocabulary Test (PPVT) and the Picture Vocabulary subtest (TO–PV) of the Test of Language Development (TOLD), are summarized in Tables 28 and 29, and Figure 19. There are two forms of the PPVT (Form A and Form B); half of the students were randomly assigned Form A, and half were randomly assigned Form B. The structure and age norms of the PPVT permitted it to be used with students spanning a wider age range than was possible with the TO–PV. For this reason, vocabulary skills were assessed with the majority of younger students with the PPVT only.

TABLE 28. Performance on the Peabody Picture Vocabulary Test (Dunn, 1959).

Group	Age	n	M	SD	Age equivalent (years)
1	4.5– 7.5	13	39.6	16.0	4.4
2	7.6– 9.5	13	55.5	9.3	6.2
3	9.6–11.5	12	59.4	11.0	6.8
4	11.6–13.5	22	63.0	9.5	7.6
5	13.6–14.5	19	66.0	9.7	9.1
6	14.6–15.5	32	66.9	12.1	9.3
7	15.6–16.5	11	71.7	11.4	9.3
8	16.6–20.0	23	69.4	11.6	9.8

The data in Tables 28 and 29 and in Figure 19 reveal several major findings. First, on the average, the students are severely delayed in their receptive lexical skills relative to their hearing peers. Second, the students achieved a higher performance level on the TO–PV than on the PPVT, but the TO–PV appears to be less discriminating among age groups than the PPVT. That is, there is a larger difference between groups as a function of age on the PPVT than on the TO–PV. Performance on both tests was correlated significantly with age ($p < .001$), but a higher correlation between performance and age was observed for the PPVT ($r = .60$) than for the TO–PV ($r = .41$). Third, the gap between the students' chronological age and lan-

TABLE 29. Performance on the Picture Vocabulary subtest of the Test of Language Development (Newcomer & Hammill, 1977).

Group	Age	n	M	SD	Age equivalent (years)
2	7.6– 9.5	9	14.7	3.7	6.7
3	9.6–11.5	10	16.7	4.5	7.2
4	11.6–13.5	18	19.5	4.5	9.2
5	13.6–14.5	19	19.3	4.2	9.2
6	14.6–15.5	32	20.4	3.6	9.5
7	15.6–16.5	11	21.1	2.8	9.7
8	16.6–20.0	23	20.7	2.9	9.6

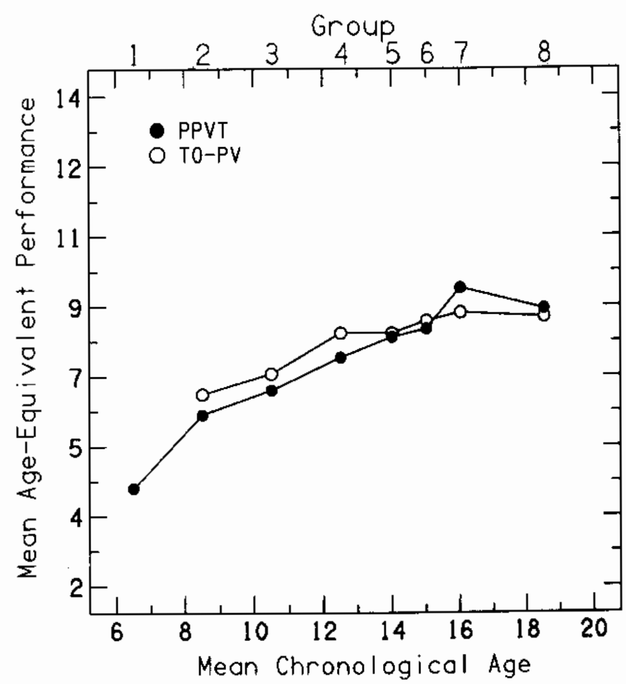

FIGURE 19. Performance of the students on the Peabody Picture Vocabulary Test (PPVT) (Dunn, 1959) and Picture Vocabulary subtest of the Test of Language Development (TO–PV) (Newcomer & Hammill, 1977), receptive vocabulary tests, as a function of age. Raw scores have been converted to an equivalent language age. Data are plotted at the midpoint of each age group.

guage age increases from Group 1 to Group 8. It should be noted, however, that the performance of Groups 6 and 7 could not be accurately measured on the TO–PV because many of the students' scores reached the test ceiling of 8 years 11 months.

Assessment of lexical/semantic skills also included evaluation of key concepts. Two different tests were used, depending on the age and suspected performance level of the student. The majority of students in Groups 1 and 2 received the Vocabulary Comprehension Scale (VCS), whereas the older students received the Boehm Test of Basic Concepts (BOHM). Some of the more advanced students in Group 2 were administered the BOHM rather than the VCS.

The students' comprehension of the concepts on the VCS is summarized in Table 30. The data were averaged across the students in Groups 1 and 2 because of the small sample size in each group. Table 30 shows that, on the average, a nearly perfect score was achieved on items assessing comprehension of size and quality. The small standard deviations on those items suggest that there is little variance in the students' performance. In contrast, only about half of the items assessing quantity, position, or pronouns were correctly comprehended by the students. Large standard deviations were obtained, indicating a wide range in abilities among students on these items. Statistical analysis revealed no significant correlation between age and performance on the VCS. This finding, however, may reflect the limited age range of the students who received the measure.

TABLE 30. Performance (% correct) of Groups 1 and 2 ($n = 12$) on the Vocabulary Comprehension Scale (Bangs, 1975).

Concept	*M*	*SD*
Size	96.4	7.4
Quality	90.6	9.9
Quantity	63.0	29.9
Position	57.9	14.7
Pronouns	54.5	20.4

Items on the VCS are also specified by an age level at which 80% of the normal-hearing standardization sample passed each item. For example, a 2.0 age level means that 80% of the 2-year-old children in the standardization sample correctly comprehended that item. The age levels span a range of 2.0–5.6 years in 6-month intervals. The hearing-impaired students' scores, calculated as a function of age level of the test item, appear in Table 31 and Figure 20. The data do not always show the expected relationship between performance and developmental age level. For example, the 3:0 to 3:6 (years:months) items were easier than the 2:6 to 3:0 items, and more students correctly identified the 4:0–4:6 items than the 3:6–4:0 items.

The performance of the students on the BOHM is summarized in Table 32 and Figure 21, which show the raw scores, averaged across all items for each of the age

TABLE 31. Performance (% correct) of Groups 1 and 2 ($n = 12$) on the Vocabulary Comprehension Scale (Bangs, 1975) as a function of age level of the test item.

Item–Age level (yr:mo)	*M*	*SD*
2:0–2:6	89.6	20.7
2:6–3:0	66.0	19.3
3:0–3:6	75.1	16.4
3:6–4:0	55.0	17.8
4:0–4:6	60.8	17.3
4:6–5:0	52.5	26.0
5:0–5:6	53.0	15.5

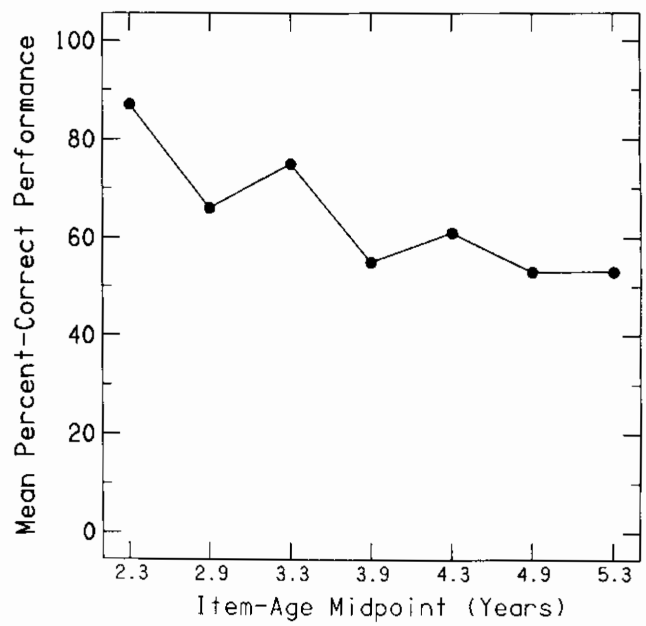

FIGURE 20. Performance of the students on the Vocabulary Comprehension Scale (Bangs, 1975) expressed in terms of item age level. Data are plotted at the midpoint of each age group.

groups. On this measure, raw scores are not converted to age equivalents. Rather, the test comprises items that normal-hearing students master between kindergarten and second grade. The highest score achieved was equivalent to a performance level of a 6-year-old child with normal hearing. Table 33 and Figure 22 summarize the results in terms of percent correct for the four item categories. The highest scores were achieved for the space concepts, followed by quality concepts and miscellaneous items; time concepts were the most difficult. The data show some growth in the four conceptual-skill areas with age, with the largest differences between groups observed for the items involving time concepts. A low but statistically significant correlation was observed between age and performance on this test ($r = .27$, $p < .01$). The majority of students who received this measure, however, even by 16–18 years of age, were not comprehending some of the basic linguistic concepts mastered by 6–8-year-old children with normal hearing. It should be kept in mind, however, that this test

Part II

LANGUAGE AND LEARNING SKILLS

guage age increases from Group 1 to Group 8. It should be noted, however, that the performance of Groups 6 and 7 could not be accurately measured on the TO–PV because many of the students' scores reached the test ceiling of 8 years 11 months.

Assessment of lexical/semantic skills also included evaluation of key concepts. Two different tests were used, depending on the age and suspected performance level of the student. The majority of students in Groups 1 and 2 received the Vocabulary Comprehension Scale (VCS), whereas the older students received the Boehm Test of Basic Concepts (BOHM). Some of the more advanced students in Group 2 were administered the BOHM rather than the VCS.

The students' comprehension of the concepts on the VCS is summarized in Table 30. The data were averaged across the students in Groups 1 and 2 because of the small sample size in each group. Table 30 shows that, on the average, a nearly perfect score was achieved on items assessing comprehension of size and quality. The small standard deviations on those items suggest that there is little variance in the students' performance. In contrast, only about half of the items assessing quantity, position, or pronouns were correctly comprehended by the students. Large standard deviations were obtained, indicating a wide range in abilities among students on these items. Statistical analysis revealed no significant correlation between age and performance on the VCS. This finding, however, may reflect the limited age range of the students who received the measure.

Table 30. Performance (% correct) of Groups 1 and 2 ($n = 12$) on the Vocabulary Comprehension Scale (Bangs, 1975).

Concept	*M*	*SD*
Size	96.4	7.4
Quality	90.6	9.9
Quantity	63.0	29.9
Position	57.9	14.7
Pronouns	54.5	20.4

Items on the VCS are also specified by an age level at which 80% of the normal-hearing standardization sample passed each item. For example, a 2.0 age level means that 80% of the 2-year-old children in the standardization sample correctly comprehended that item. The age levels span a range of 2.0–5.6 years in 6-month intervals. The hearing-impaired students' scores, calculated as a function of age level of the test item, appear in Table 31 and Figure 20. The data do not always show the expected relationship between performance and developmental age level. For example, the 3:0 to 3:6 (years:months) items were easier than the 2:6 to 3:0 items, and more students correctly identified the 4:0–4:6 items than the 3:6–4:0 items.

The performance of the students on the BOHM is summarized in Table 32 and Figure 21, which show the raw scores, averaged across all items for each of the age

Table 31. Performance (% correct) of Groups 1 and 2 ($n = 12$) on the Vocabulary Comprehension Scale (Bangs, 1975) as a function of age level of the test item.

Item–Age level (yr:mo)	*M*	*SD*
2:0–2:6	89.6	20.7
2:6–3:0	66.0	19.3
3:0–3:6	75.1	16.4
3:6–4:0	55.0	17.8
4:0–4:6	60.8	17.3
4:6–5:0	52.5	26.0
5:0–5:6	53.0	15.5

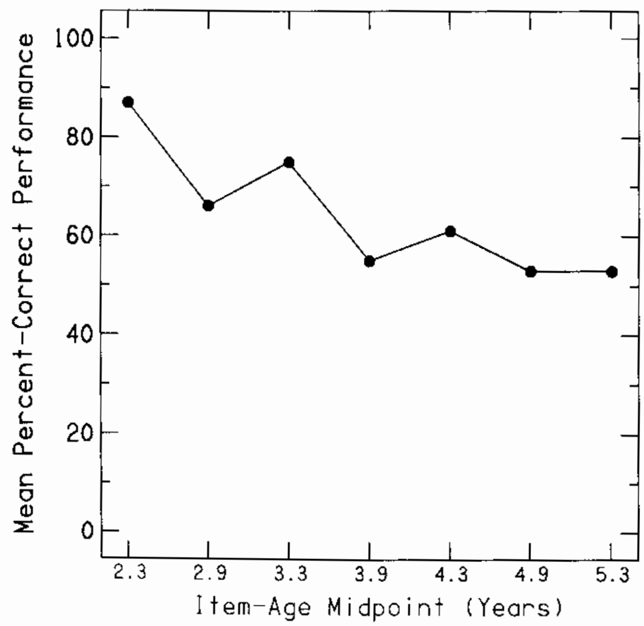

Figure 20. Performance of the students on the Vocabulary Comprehension Scale (Bangs, 1975) expressed in terms of item age level. Data are plotted at the midpoint of each age group.

groups. On this measure, raw scores are not converted to age equivalents. Rather, the test comprises items that normal-hearing students master between kindergarten and second grade. The highest score achieved was equivalent to a performance level of a 6-year-old child with normal hearing. Table 33 and Figure 22 summarize the results in terms of percent correct for the four item categories. The highest scores were achieved for the space concepts, followed by quality concepts and miscellaneous items; time concepts were the most difficult. The data show some growth in the four conceptual-skill areas with age, with the largest differences between groups observed for the items involving time concepts. A low but statistically significant correlation was observed between age and performance on this test ($r = .27$, $p < .01$). The majority of students who received this measure, however, even by 16–18 years of age, were not comprehending some of the basic linguistic concepts mastered by 6–8-year-old children with normal hearing. It should be kept in mind, however, that this test

TABLE 32. Performance (% correct) on the Boehm Test of Basic Concepts (Boehm, 1971).

Group	Age	n	M	SD
2	7.6– 9.5	6	36.8	6.4
3	9.6–11.5	8	37.8	7.6
4	11.6–13.5	15	39.1	9.7
5	13.6–14.5	11	40.3	9.5
6	14.6–15.5	24	41.9	7.9
7	15.6–16.5	8	43.6	7.2
8	16.6–20.0	18	44.9	6.5

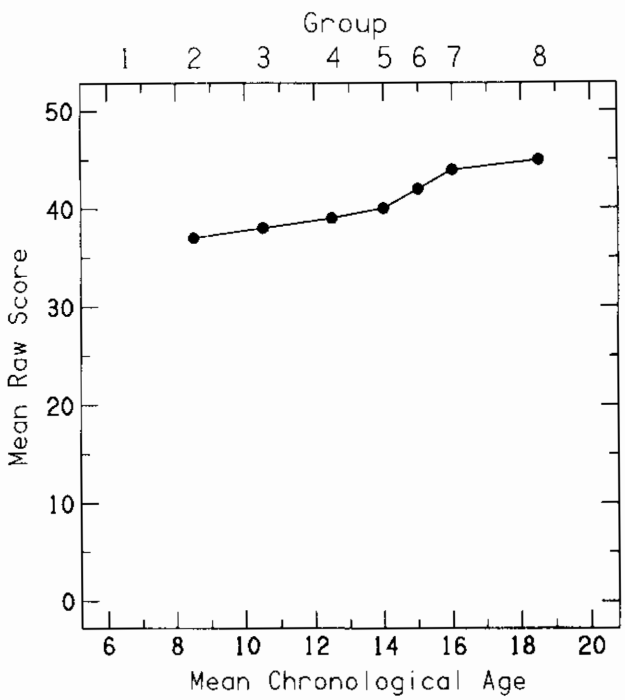

FIGURE 21. Raw scores of the students on the Boehm Test of Basic Concepts (Boehm, 1971) as a function of age. Data are plotted at the midpoint of each age group.

was not administered to many of the older students because their performance on the PPVT indicated that the test would not be sufficiently difficult for them.

Syntactic/Morphological Skills

The Test of Grammatic Comprehension (TGC) was administered to the students in Groups 1 and 2. Scores, averaged across the two age groups, appear in Table 34 and are expressed as the rank order of correct reception of the 12 syntactic forms. The highest score was achieved on the modification structures, followed by negative/affirmative statements and prepositions. Progressively lower scores were obtained for the other structures. The size of the standard deviations indicates substantial variance among students in their knowledge of these various syntactic structures. The correlation between age and performance on this test did not reach statistical significance.

TABLE 33. Performance (% correct) on the concepts of the Boehm Test of Basic Concepts (Boehm, 1971).

Age group		Space	Quantity	Miscellaneous	Time
		Concepts			
Group 2	M	75.4	65.8	62.2	33.3
	SD	12.2	20.3	25.4	25.0
	n	9			
Group 3	M	79.6	70.5	77.5	62.5
	SD	17.8	19.8	16.7	23.1
	n	8			
Group 4	M	79.9	72.3	73.3	63.3
	SD	16.7	19.5	26.9	35.2
	n	15			
Group 5	M	84.6	76.8	76.4	79.5
	SD	15.7	23.2	26.6	21.8
	n	11			
Group 6	M	89.3	81.3	80.0	84.8
	SD	12.9	19.7	22.6	22.3
	n	23			
Group 7	M	89.9	79.9	75.0	87.5
	SD	10.3	20.6	23.3	19.9
	n	8			
Group 8	M	85.6	84.2	85.0	79.2
	SD	20.2	22.4	26.9	25.6
	n	17			

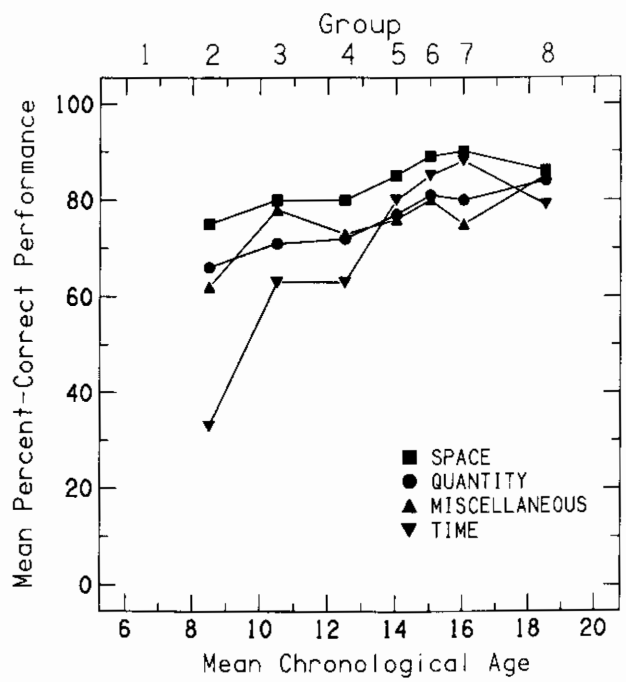

FIGURE 22. Raw scores of the students on the four item categories of the Boehm (1971) Test of Basic Concepts. Data are plotted at the midpoint of each age group.

The TGC also specifies items by four age levels (4-year, 5-year, 6-year, and 6+-year items) at which 90% of the normative population met passing criteria. The age levels of the items are based on normative data obtained

TABLE 34. Performance (% correct) of Groups 1 and 2 (n = 12) on the Test of Grammatical Comprehension (Miller & Yoder, 1975).

Syntactic form	*M*	*SD*
Modification	73.7	22.4
Negative/Affirmative	69.1	27.6
Prepositions	57.1	30.1
Active: Subject/Object	46.4	41.4
Reflexivization	39.3	35.0
Possession	37.5	40.1
Pronouns: Subject	37.1	37.9
Singular/Plural	6.8	33.2
Pronouns: Object	26.1	32.5
Verb Inflection	20.5	23.5
Passive	14.3	23.4
Pronouns: Subject/Object	2.4	9.9

(Owings, 1972) from 30 normal-hearing children in each of the following age groups: 3 years, 4 years, 5 years, and 6 years. Table 35 shows the mean and standard deviation for the different items by age level, averaged across students. On the average, performance decreases as the age level of the item increases. Only about 68% of the 4-year items were identified by the 4.6–9.5-year-old hearing-impaired students; much lower scores were achieved on the items at the higher age levels. There are, however, substantial individual differences among the students on the different age items as evidenced by the large standard deviations.

Three tests were used to measure comprehension of syntax and morphology in the older students. These consisted of the Test of Syntactic Abilities (TSA), the Grammatic Understanding subtest (TO–GU) of the TOLD, and the Grammar Comprehension subtest of the Child Language Abilities Measure (CLAM).

The TSA was administered only to students in Groups 4–8. The students' knowledge of the various syntactic structures is summarized in Table 36 and Figures 23 and 24. On the average, the highest scores were achieved for

TABLE 35. Performance (% correct) of Groups 1 and 2 (n = 12) on the Test of Grammatic Comprehension (Miller & Yoder, 1975) as a function of age level of the test item.

	Item age level			
	4 years	*5 years*	*6 years*	*6+ years*
M	67.6	46.9	36.9	20.6
SD	20.3	24.3	22.7	10.6

TABLE 36. Performance (% correct) on the Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978) by group (with age range in years and group size given).

Syntactic form	*Group 4 (11.6–13.5; n = 13)*	*Group 5 (13.6–14.5; n = 8)*	*Group 6 (14.6–15.5; n = 23)*	*Group 7 (15.6–16.5; n = 10)*	*Group 8 (16.6–20.0; n = 16)*
Negation					
M	69.2	77.5	79.2	85.6	86.0
SD	29.8	17.9	25.4	14.9	16.2
Question Formation					
M	53.7	50.9	69.9	63.2	71.1
SD	33.6	25.4	27.1	32.7	26.9
Determiners					
M	55.5	51.6	64.9	64.2	69.1
SD	27.7	29.2	29.6	35.0	27.3
Conjunctions					
M	55.0	47.5	56.4	51.8	73.7
SD	32.2	29.9	29.6	35.7	22.1
Pronominalization					
M	50.0	61.3	55.7	59.0	62.5
SD	29.6	19.1	25.0	30.1	19.1
Complementation					
M	44.2	44.3	54.7	46.6	62.1
SD	26.5	26.5	21.4	25.1	26.3
Nominalization					
M	43.4	43.3	50.5	59.2	56.5
SD	24.9	22.7	19.9	22.5	24.1
Verbal Processing					
M	40.8	47.5	51.7	47.0	63.8
SD	29.4	21.2	30.6	32.7	25.3
Relativization					
M	43.6	43.6	49.6	49.2	52.1
SD	22.8	21.1	23.1	25.5	25.0

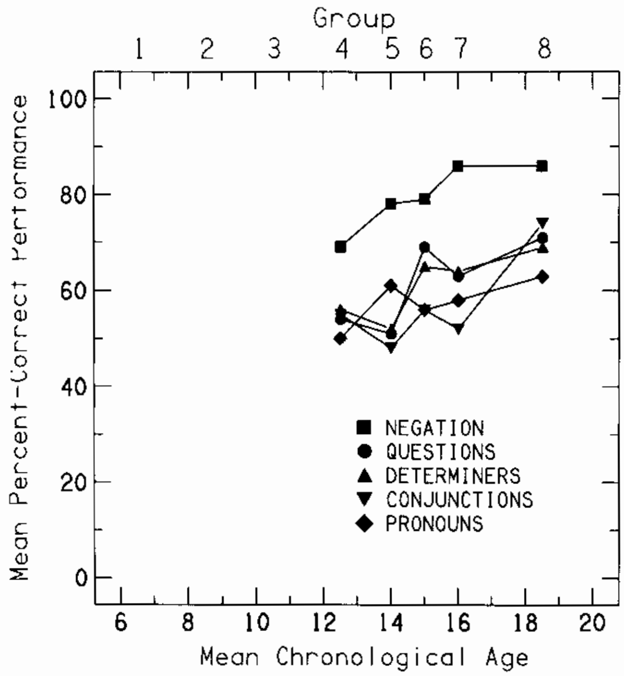

FIGURE 23. Raw scores of the students on the Negative, Question, Determiner, Conjunction, and Pronominalization forms on the Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978). Data are plotted at the midpoint of each age group.

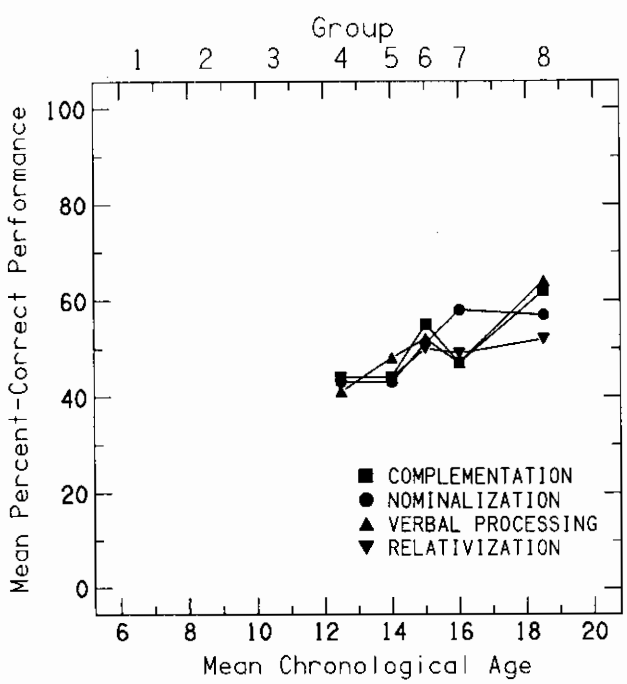

FIGURE 24. Raw scores of the students on the Complementation, Nominalization, Verbal Processing, and Relativization forms of the Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978). Data are plotted at the midpoint of each age group.

the negation forms. As shown in the figures, the students' performance on this structure was far superior to that on any other form. The next highest scores were obtained on question, determiners, conjunction, and pronominalization forms. The lowest scores were obtained on the complementation, nominalization, verb processes, and relativization forms. Large standard deviations are present on all structures, indicating substantial variability in performance. Although none of the forms is mastered by any age group, there is evidence of growth in the comprehension of many of the structures with age. A significant correlation ($r = .28$, $p < .01$) was found between performance on this measure and age.

The data for the subtests of the CLAM and TO–GU are summarized in Tables 37 and 38 and Figure 25. These two tests reportedly assess similar syntactic and grammatic structures, although there are major differences in test format, described in Appendix A. Norms for the CLAM are expressed in percentile rankings using five cutoff points: 95, 75, 50, 25, and 5th. A score can be converted to an equivalent language age in 6-month intervals (e.g., 3–3½ years, 3½–4 years, etc.) by locating the raw score corresponding to the 50th percentile in the test manual. On the average, the students obtained a higher language age on the TO–GU than on the CLAM. The difference in performance among age groups is minimal. Performance on neither test was correlated significantly with age. These data show that the majority of hearing-impaired students in this sample comprehend English syntax on the level of a 5–7 year-old child with normal hearing.

TABLE 37. Performance on the Child Language Abilities Measure (Mehrabian & Moynihan, 1975).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (yr:mo)*
2	7.6– 9.5	8	39.0	5.6	5:0–5:6
3	9.6–11.5	11	39.4	5.0	5:0–5:6
4	11.6–13.5	16	36.6	7.7	4:6–5:0
5	13.6–14.5	12	39.1	6.8	5:0–5:6
6	14.6–15.5	27	37.8	5.9	5:0–5:6
7	15.6–16.5	9	36.3	6.5	4:6–5:0
8	16.6–20.0	19	39.9	7.2	5:0–5:6

TABLE 38. Performance on the Grammatic Understanding subtest of the Test of Language Development (Newcomer & Hammill, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
1	4.5– 7.5	2	13.5	2.1	–
2	7.6– 9.5	8	15.4	1.5	6.0
3	9.6–11.5	10	16.4	4.3	6.7
4	11.6–13.5	17	16.2	5.0	6.7
5	13.6–14.5	19	16.7	4.4	6.7
6	14.6–15.5	31	16.6	3.3	6.7
7	15.6–16.5	11	15.6	3.1	6.2
8	16.6–20.0	23	16.8	4.5	6.6

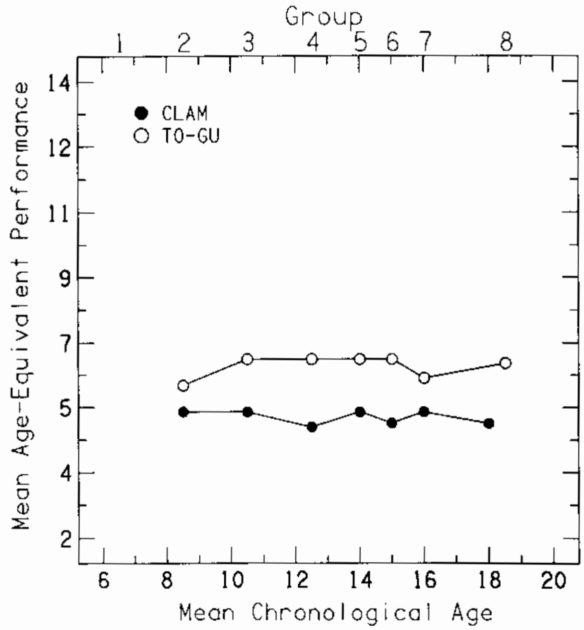

FIGURE 25. Performance of the students on the Test of Language Development–Grammatic Understanding (TO–GU) (Newcomer & Hammill, 1977) and Child Language Ability Measures (CLAM) (Mehrabian & Moynihan, 1979), receptive syntax tests, as a function of age. Raw scores have been converted to an equivalent language age. Data for the CLAM are plotted at the midpoint of the 6-month interval of the equivalent language age. Data are plotted at the midpoint of each age group.

Additional Measures

The Verbal Comprehension Scale of the Reynell Developmental Language Scales (R–VCS) was administered to the students in Groups 1 and 2. The test consists of a range of developmentally ordered tasks that require the student to comprehend linguistic information ranging from isolated words to connected language. For purposes of analysis, the test was subdivided into six categories, based on item type. The categories and item numbers are (a) Category 1 (items 1–21): object identification; (b) Category 2 (items 22–25): relational directions; (c) Category 3 (items 26–35): object identification by functional descriptor; (d) Category 4 (items 36–45): following directions with 2–5 critical elements; (e) Category 5 (items 46–59): following directions with 4–7 critical elements; and (f) Category 6 (items 60–67): conceptual reasoning.

The performance of the students in the two youngest age groups is summarized in Tables 39 and 40 and Figure 26. The data in Table 39 show performance expressed in terms of the raw score and equivalent language age for the entire test, indicating that the average performance of the students on this measure approaches that of a 4-year-old hearing child. There was no significant correlation between performance of this measure with age. Table 40 summarizes performance in terms of item category. On the average, a nearly perfect score was obtained on the items in Category 1 (object identification). For the other categories, the data show that the scores of the hearing-impaired students do not reflect the expected relation between performance and item difficulty. The score for the items in Category 3 (identification of object by functional descriptor) was higher than the scores for the items in Cat-

TABLE 39. Performance of Groups 1 and 2 on the Verbal Comprehension Scale of the Reynell (1977) Developmental Language Scales.

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (yr:mo)*
1	4.5–7.5	12	42.3	10.7	3:3
2	7.6–9.5	5	50.4	5.4	3:11

TABLE 40. Performance (% correct) of Groups 1 and 2 on the Verbal Comprehension Scale of the Reynell (1977) Developmental Language Scales as a function of item category.

Category	*Description*	*M*	*SD*
A	Object identification	99.5	3.4
B	Relational directions	70.6	29.6
C	Object identification by functional descriptor	89.2	19.0
D	Following directions with 2–5 critical elements	69.4	26.3
E	Following directions with 4–7 critical elements	27.8	19.1
F	Conceptual reasoning	39.2	22.1

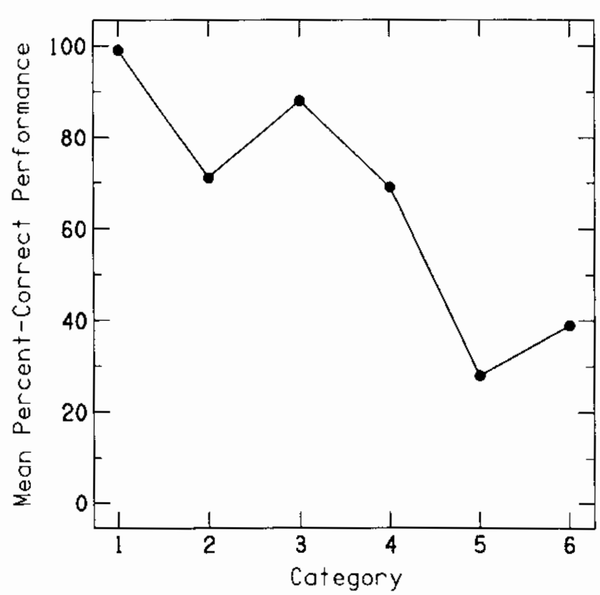

FIGURE 26. Performance of the students on the six category items of the Verbal Comprehension Scale of the Reynell (1977) Developmental Language Scales, where Category 1 is object identification, Category 2 is relational directions, Category 3 is object identification by functional descriptor, Category 4 is following directions with 2–5 critical elements, Category 5 is following directions with 4–7 critical elements, and Category 6 involves conceptual reasoning.

egory 2 (relational directions). Performance on the items in Category 4 (following directions with 2–5 critical elements) was similar to that for Category 2 (relational directions). The most difficult category of items was 5 (following directions with 4–7 critical elements and, therefore, increased length). Approximately 40% of the items involving conceptual reasoning (Category 6) were answered correctly by the students.

Comprehension of several different linguistic aspects was evaluated in the older students with the Inventory of Language Assessment Tasks (LAT). The receptive portions of the test (LAT–R), which were in this study, consisted of two categories of items. Ten items involved use of conjunctions, which required the student to place the missing conjunction *(but, because, and)* in a short sentence (e.g., *Everyone came* ______ *Peter*). The students' scores, expressed in terms of percent correct, appear in the first row of Table 41. The highest level on these items was achieved by the students in Group 7, whose performance was only slightly better (i.e., 13%) than that demonstrated by the students in Group 3.

The second row of Table 41 summarizes performance in terms of percent correct for the group of 10 items designed to assess comparative relations. A "yes" or "no" response to a question was required of the student for this task (e.g., "Are watermelons bigger than apples?"). High scores were achieved by almost all age groups on this test. The exception to this pattern was Group 7. The size of the standard deviation indicates that there was considerable variance among the students on this measure. Age and performance on the LAT–R were not correlated significantly.

Correlations Between Measures

Partial correlations, adjusted for age and performance IQ, were calculated between the receptive language measures. Raw scores were used to compute the correlations. Of the three tests administered to the younger students, a significant correlation ($r = .73$, $p < .001$) was found between the VCS, which assessed basic concepts, and the R–VCS, which assessed comprehension of structures varying in length, syntactic complexity, and semantic content. The TGC, a syntax measure, did not correlate significantly with either the VCS or R–VCS.

The correlational data for the remaining tests, primarily administered to the older students, appear in Table 42. Most of the tests were significantly correlated, although there is some variability in the strength of the correlations. The highest correlation was observed between the BOHM, a concept test, and the CLAM ($r = .75$), a syntax/morphology test. The next highest correlation was found between the two syntax/morphology measures (CLAM and TO–GU) ($r = .70$), and between the TSA and

TABLE 41. Performance (% correct) on the Inventory of Language Assessment Tasks–receptive portion (Kellman, Flood, & Yoder, 1977) by group (with age range given in years).

Items	*Group 3 (9.6–11.5)*	*Group 4 (11.6–13.5)*	*Group 5 (13.6–14.5)*	*Group 6 (14.6–15.5)*	*Group 7 (15.6–16.5)*	*Group 8 (16.6–20.0)*
Conjunctions						
M	66.8	73.6	76.8	79.4	79.5	93.3
SD	19.9	25.5	17.3	16.8	16.4	14.5
Comparative relations						
M	83.3	86.9	92.1	90.8	80.9	93.3
SD	24.0	19.9	14.2	16.7	32.4	14.5

TABLE 42. Partial correlations, adjusted for age and performance IQ, between receptive language tests.

Test	*LAT–R*	*TSA*	*CLAM*	*TO–GU*	*BOHM*	*TO–PV*	*PPVT*
PPVT	.55*	.60*	.63*	.61*	.20	.46*	1.0
TO–PV	.42*	.46*	.54*	.49*	.57*	1.0	
BOHM	.49*	.44*	.75*	.59*	1.0		
TO–GU	.52*	.57*	.70*	1.0			
CLAM	.54*	.63*	1.0				
TSA	.70*	1.0					
LAT–R	1.0						

Note. LAT–R = Inventory of Language Assessment Tasks–receptive items (Kellman, Flood, & Yoder, 1977); TSA = Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978); CLAM = Child Language Ability Measures (Mehrabian & Moynihan, 1979); TO–GU = Test of Language Development–Picture Vocabulary subtest (Newcomer & Hammill, 1977); BOHM = Boehm Test of Basic Concepts (Boehm, 1971); TO–PV = TOLD–Picture Vocabulary subtest; PPVT = Peabody Picture Vocabulary Test (Dunn, 1959).
*$p < .001$.

the LAT–R ($r = .70$). Note also the relatively high correlations between the three syntax tests (TSA, CLAM, and TO–GU). An interesting finding is that a higher correlation was found between the syntax subtest of the TOLD (TO–GU) and the PPVT than between the vocabulary subtest of the TOLD (TO–PV) and the syntax test of the TOLD (TO–GU).

Significant correlations were found between performance IQ (PIQ), as measured by the WISC–R, and 7 of the 10 receptive language tests: PPVT ($r = .28$, $p < .001$), TO–PV ($r = .31$, $p < .001$), BOHM ($r = .25$, $p < .05$), TO–GU ($r = .25$, $p < .01$), CLAM ($r = .26$, $p < .01$), TSA ($r = .33$, $p < .01$) and LAT–R ($r = .27$, $p < .01$). Speech intelligibility (SPINT) correlated significantly with performance on four of the measures: PPVT ($r = .24$, $p < .01$), TO–GU ($r = .51$, $p < .001$), CLAM ($r = .41$, $p < .001$), and R–VCS ($r = -.42$, $p < .001$). The significant negative correlation between the R–VCS and intelligibility indicates that those students who had poor speech production skills achieved higher scores on the R–VCS than the other students. Recall that the R–VCS was administered to only the students in Groups 1 and 2. The negative correlation might reflect an interaction with degree of hearing loss and language skills in that those students with the most profound losses were identified early and, thus, received more language training than those students with less severe hearing impairments (see Results in chapter 4). The students with the most profound losses would be expected to have the poorest speech skills (see Results in chapter 6). The interaction between residual hearing, speech production skills, language skills, and the effect of early training are apparent for the younger students only.

To examine the relation between residual hearing and receptive language skills, the students again were divided into two groups, based on their better ear pure-tone average (Group I = PTA < 105 dB HL; Group II = PTA > 105 dB HL). Independent sample t tests, adjusted for unequal group variances where appropriate, revealed significant group differences ($p < .01$) on the PPVT only. Correlations between PTA and the receptive language measures for the students in Group I revealed a significant relationship between PTA and two of the syntax measures: CLAM ($r = -.31$, $p < .01$) and TO–GU ($r = .32$, $p < .001$).

DISCUSSION

Lexical/Semantic Skills

The results in this area revealed that, on the average, the students were severely delayed in lexical/semantic skills. Their performance on the measures in this area approached that of a 5–7-year-old child with normal hearing. The limited word knowledge of the hearing impaired has been observed by other investigators (Geers et al., 1981; Rosenstein & MacGinitie, 1969) as well. One reason for the limited vocabulary skills of the hearing impaired appears to be due to their dependence on direct teaching of the meaning of the words they learn, a situation in marked contrast to that of the child with normal hearing, who acquires the majority of word meanings vicariously.

Of the two vocabulary measures, the PPVT appears to provide the most accurate estimate of skills in this area. Also, an advantage of this test is that it contains more items than the TO–PV and thus allows for more scatter in the student's response prior to achieving a test ceiling. This pattern of scattered errors was demonstrated by many of the students in that they incorrectly identified items throughout the test before the criterion for test termination was achieved (i.e., n consecutive incorrect responses). In addition, the PPVT correlated more highly with the other receptive language measures than the TO–PV, with the exception of the BOHM.

Verbal-conceptual skills also were delayed relative to the performance of normal-hearing children. The order of difficulty of the concepts on the VCS was similar to that reported for a group of 6–8-year-old, profoundly hearing-impaired students educated in an oral communication program (Geers et al., 1981). The average performance level on the concepts involving size and quality also were similar to that reported by Geers et al.; however, the students in the present study achieved substantially lower scores on the other item types (quantity, position, pronouns) than reported in the Geers et al. study. The order of difficulty of the various concepts on the Boehm Test of Basic Concepts was consistent with that reported by Davis (1974) for a group of hard-of-hearing students educated in various types of mainstream programs. Unfortunately, performance on this test did not change much with age. Davis also reported no significant difference between the younger and older students in her study. These results suggest that either the deaf students reach a plateau in their development of specific language concepts at a fairly early age, or the Boehm test is not sufficiently sensitive to detect the developmental changes which are taking place. At this time, we do not have adequate data to address this issue.

The high correlation between the Reynell (R–VCS) and the VCS suggests that these tests measure some of the same skills. Our previous clinical experience with the R–VCS has shown that this test provides useful diagnostic information about young hearing-impaired children's language performance. The tasks are designed to reflect conceptual maturation as well as integration of semantic and syntactic information. In addition, the graded increases in abstraction between categories (subtests) appear to be consistent with the increasing demands language learning places on a child as s/he matures.

Syntactic/Morphologic Skills

In general, the data revealed that English syntactic/morphological skills were more delayed than content (lexical) skills. Few students achieved greater than a 5–7-year language age in receptive syntax. On the average, performance was higher on the TO–GU than the CLAM, probably due to differences in test format. The CLAM uses a format of minimally contrastive pairs (i.e., *horse's white truck* vs. *white horse's truck*), which forces the student to process the linguistic rule to respond accurately. The TO–GU also uses a multiple choice of pictures, but the alternatives have many dissimilarities, and on many items a student can select the correct answer by merely attending to key words. Thus, the CLAM appears to be a more sensitive measure in that its format dictates that the student attend to word-order relationships and syntactic rules rather than to key-word clues. However, a relatively high correlation ($r = .70$) was obtained between the two tests. Thus, the TO–GU is an acceptable procedure to measure syntactic/morphological skills if clinical priorities dictate this test be administered to a given student.

The ordering of rule mastery on the TSA was similar to that reported by Quigley, Wilbur, Power, Montanelli and Steinkamp (1976) and Geers et al. (1981). However, the average performance level of the students in this study was poorer than that reported by Quigley et al. and Geers et al. Even though the TSA is a time-consuming test to administer, it appears to yield useful information about a student's ability to comprehend structures that s/he encounters frequently in print. Another advantage is the availability of norms on hearing-impaired students, and it is a test that can be administered by the classroom teacher to a group of students. A disadvantage of the test is the written format, which makes the test impractical to administer to students with severe reading problems or visual processing deficits. The correlations between this measure and the two syntax tests that use an oral/sign presentation mode, the CLAM and the TO–GU, were high, suggesting these two tests are reasonable alternatives to the TSA.

The performance of the students on the syntax/morphology tests suggests that they have acquired the structures necessary to comprehend and generate only the simplest sentences of English, an observation also made by other investigators (Kretschmer & Kretschmer, 1978; Quigley et al., 1978). The forms that were the most difficult for the students were those that did not adhere to simple subject-verb-object sentence order. The inability of hearing-impaired students to comprehend complex syntactic structures poses serious problems for reading. In fact, data obtained by Quigley, Power, and Steinkamp (1977) indicate that beginning reading materials, designed for hearing students, contain complex syntactic structures that are beyond the linguistic competence of many hearing-impaired students. These authors suggest that reading materials should be modified to conform more closely to the language performance of hearing-impaired students. The superficial knowledge of the organization and function of English also has been shown to have a dramatic effect on hearing-impaired students' ability to use language to aid memory (Fremer, 1971; Odom & Blanton, 1967) and to understand the implications of discourse organization (Kretschmer & Kretschmer, 1978).

Plateau in Learning

A striking feature of the data is the very restricted improvement in language skills with age. On the average, the students achieved language ages of 5–7 years on syntactic/morphological skills and 6–8 years of age on lexical/semantic skills, with little growth occurring after 12–13 years of age. It is possible that the reduced rate of learning reflects the situation that not all of the students were administered the same measures (for reasons explained in the first part of this chapter). That is, had more of the children who would have scored low been tested on some of the measures, then a stronger age effect might have been observed. This may account, in part, for the low correlations between age and performance. However, our clinical experience has shown that a gap between chronological age and language age is frequently observed in the performance of hearing-impaired children, with a widening in the gap as age increases. Further, the observed plateau in learning in profoundly hearing-impaired students has been reported by other investigators (Clarke & Rogers, 1981; Meadow, 1976).

The significance of the above finding should be interpreted in light of the following considerations. First, the language skills assessed in this project do not necessarily reflect the communicative competence of the students. The majority of receptive measures employed were those designed to assess the literal meaning of words and sentences. As Rees and Shulman (1978) have pointed out, these measures do not tap the broad range of operations that the listener performs to obtain information from the spoken/signed utterance. There are few, if any, standardized procedures, however, that permit quantification of comprehension of the types of utterances that occur in colloquial discourse.

A related aspect is that the tests did not assess the use of comprehension strategies. In many conversational situations, the normal-hearing child may employ sophisticated comprehension strategies in the absence of complete linguistic knowledge to understand a message (Chapman, 1978). Thus, in a functional communicative situation, these hearing-impaired students may be more adept at comprehending a message than the data indicate, even though their linguistic and syntactic skills may not be fully developed.

The above discussion is not meant to imply that the very reduced form and content skills of the students tested is not of significance. Clearly, acquisition of lexical/semantic and syntactic/morphological skills is critical to the educational and vocational development of these students. Even with the above considerations, the receptive language skills of these students is severely delayed relative to their hearing peers, and the gap between chronological age and language skills widens with age. It is important to keep in mind, however, that the language ages derived from the various measures may not be representative of the performance level of these students in functional communication situations.

Deviations in Developmental Patterns

The younger students' performance on the VCS and the Reynell Verbal Comprehension Scale (R–VCS) revealed patterns inconsistent with expected developmental progression which appear to be a result of several variables. First, instructional priorities for preschool deaf students may not coincide with developmental sequences. For example, the VCS results suggested much earlier mastery of quality and size concepts than quantity and position concepts and pronouns. Quality and size concepts, which are somewhat easy to illustrate visually, are often introduced earlier in a student's program than other concepts and pronouns. Clinical observation suggests that position concepts, although introduced early, require a long time to master because generalization beyond specific activities requires more time and training for these concepts than for those involving quality and size. Quantity concepts, considered "preacademic," are often introduced after achievement of other language skill areas.

Personal pronoun concepts were limited, which is not surprising in view of the fact that most hearing-impaired students are taught noun referents (at a delayed age relative to hearing peers) before pronoun referents. In addition, we learned that the students in our study had not been systematically exposed to pronoun signs within their program; rather, pronouns were introduced by the school at a later stage in fingerspelled forms.

Concept strength and weaknesses may influence the student's ability to process connected information. On the R–VCS, for example, deficits in position concepts influenced the student's ability to follow relational directions. That is, when asked to "put the knife on the plate," the students often failed to attend to the spatial relational concept and instead focused on the key words, handing the examiner the knife and plate. Yet, object identification by functional descriptor (which is reported to be much more difficult conceptually than relational directions for hearing students) elicited responses with greater precision than the preceding category by the hearing-impaired students. This category required the student to relate an internalized concept (an attribute) to a perceived object (e.g., "Which one do we sleep in?"). In this case, linguistic features (such as prepositions) do not need to be comprehended by the hearing-impaired student because the key words (such as *sleep*) cue the relationship. Divergence from developmentally expected performance may be due to the nature of the task which allows the student to draw upon "inner language" or conceptual understanding rather than specific syntactic comprehension. The perplexing finding is that the relational directions should be implicit (i.e., spoons usually go into cups), yet the hearing-impaired youngsters attended to the content words of the subtest sentences rather than to the contextual cues.

This same point was illustrated by the last two sets of items on the R–VCS. The one that required assimilation of several semantic and syntactic details (following directions with 4–7 critical element-categories) was extremely difficult, yet on the following task (Category 6, conceptual reasoning), in which the ideational content goes far beyond the concrete evidence available, the students' performance improved. The task required for the Category 6 items is highly abstract and requires verbal reasoning, but the linguistic demands are reduced enough to allow the student to draw upon her/his conceptual base to choose the correct answers.

Third, especially for the younger students, the length of input of signed instructions may have affected performance. This may also explain some of the deviation in developmental pattern on the R–VCS because most of the students relied on a "key word" comprehension strategy. For example, given an examiner directive, some students appeared to respond on the basis of the key ideas s/he could store in short-term memory, often to the sacrifice of less salient grammatical or semantic cues (e.g., "Put the three short pencils in the box" resulted in three pencils of any size in the box). Diagnostic teaching revealed that chunking of the information ("See three short pencils? Put them in the box.") and selective emphasis were effective in obtaining the correct response. (If this approach was employed, the student was not given credit for the item.) Performance on items such as these was apparently influenced by the inability to handle utterance length within short-term memory.

Nonlinguistic Effects on Performance

The majority of tests administered to the students were developed for oral rather than sign presentation. It is unclear how this modification in administration mode affected test performance. Clinical observation suggests that scores may be reduced or inflated by a sign presentation mode, particularly when vocabulary skills are assessed. For example, many of the advanced items on the PPVT had to be presented via fingerspelling because there was no sign for the item in the system used by the school. Thus, the vocabulary scores of the older students might have been influenced by their receptive fingerspelling abilities. On the other hand, spurious results may have been obtained on some multiple-choice tests because the pictured alternatives on such tests permit the student to use iconic or sign association cues to make an "educated guess" at the meaning of a word. That is, the student may guess the right answer by matching the sign with the associated picture, a perceptual matching task rather than a linguistic one. Although signs are not often "guessable" (Wilbur, 1979) with an open-set format, this is not always the case when a multiple-choice task is used. In fact, preliminary data collected in our laboratory have shown that when the items of PPVT are administered using only sign, roughly 70% of the items are correctly identified by normal-hearing adults with no prior exposure to sign.

Finally, a comment needs to be made regarding the gap between the students' cognitive and linguistic skills. Because of the severe language delays of the students, they were administered tests that comprised both linguistic and nonlinguistic tasks appropriate for children much younger than themselves. In this situation, the hearing-impaired student approaches the nonlinguistic aspects of the test with more sophisticated nonverbal cognitive strategies (or "real world knowledge") than the population for whom the test was developed. As a consequence, nonlinguistic factors may have a spurious effect on linguistic results.

Correlational Data

The correlational data revealed essentially no significant relationship between receptive language and degree of hearing loss, a finding consistent with the data reported by Levitt, McGarr, and Geffner (1985). It should be kept in mind, however, that the majority of students had profound hearing losses (see Table 10). Had there been more students with severe losses, a significant correlation between receptive language and hearing level might have been found.

Slightly less than half of the tests correlated significantly with speech intelligibility, indicating that speech production skills and receptive language skills do not have a strong relationship in these students. Nonverbal IQ bore a significant relationship with 7 of the 10 receptive measures. This finding is in general agreement with the results of Watson, Sullivan, Moeller, and Jensen (1982). These data suggest that nonverbal intelligence may account, in part, for the language problems of some profoundly hearing-impaired children. The strength of the correlations, however, indicates that other factors also bear a significant relationship with the language performance of the deaf.

SUMMARY

The students are delayed relative to their hearing peers in all areas of receptive language assessed, with slightly greater delays evidenced in syntax/morphology than in lexicon/semantics. There was negligible improvement in performance after approximately 12–13 years of age, and most of the measures did not correlate significantly with age. Receptive language skills also did not correlate significantly with hearing level, and the correlations between the majority of measures and speech intelligibility were not statistically significant. On the other hand, low but significant correlations were obtained between nonverbal intelligence and 70% of the receptive language tests. In general, the pattern and performance level of these students is similar to that reported for other populations of hearing-impaired students. Comparison data, however, were not available for the majority of receptive language measures used in this study. Analyses of test performance revealed deviations in developmental pattern in the young students which appears to be due, in part, to instructional priorities in their educational programs. Anecdotal information suggests that a sign rather than an oral only presentation mode may affect test performance, but it is unclear to what extent this occurs.

REFERENCES

BANGS, T. E. (1975). *Vocabulary Comprehension Scale.* Boston: Teaching Resources.

BOEHM, A. (1971). *Boehm Test of Basic Concepts.* New York: Psychological Corporation.

CHAPMAN, R. (1978). Comprehension strategies in children. In J. Kavanaugh & W. Strange (Eds.), *Speech and language in the laboratory, school, and clinic* (pp. 308-327). Cambridge: MIT Press.

CLARKE, B. R., & ROGERS, W. T. (1981). Correlates of syntactic abilities in hearing-impaired students. *Journal of Speech and Hearing Research, 24,* 48-54.

DAVIS, J. (1974). Performance of young hearing-impaired children on a test of basic concepts. *Journal of Speech and Hearing Research, 17,* 342-351.

DUNN, L. (1959). *Peabody Picture Vocabulary Test.* Circle Pines, MN: American Guidance Service.

FREMER, J. (1971). *Recognition memory for approximations to English in deaf and hearing subjects at three age levels.* Unpublished doctoral dissertation, Columbia University, New York.

GEERS, A. E., KUEHN, G., & MOOG, J. S. (1981). Experimental project in instructional concentration: Evaluation and results. *American Annals of the Deaf, 126,* 929-964.

KELLMAN, M., FLOOD, C., & YODER, D. (1977). *Inventory of Language Assessment Tasks.* Madison, WI: Madison Public Schools.

KRETSCHMER, R., & KRETSCHMER, L. (1978). *Language development and intervention with the hearing impaired.* Baltimore: University Park Press.

LEVITT, H., MCGARR, N. S., & GEFFNER, D. (1985). *Development of language and communication skills in hearing-impaired children.* Manuscript submitted for publication.

MEADOW, K. P. (1976). The development of deaf children. In M. E. Hetherington (Ed.), *Review of child development research* (Vol. 5). Chicago: University of Chicago Press.

MEHRABIAN, A., & MOYNIHAN, C. (1979). *Child Language Abilities Measure.* Los Angeles: University of California Press.

MILLER, J., & YODER, D. (1975). *Miller–Yoder Test of Grammatical Comprehension.* Unpublished experimental edition, Madison, WI.

NEWCOMER, P., & HAMMILL, D. (1977). *Test of Language Development.* Los Angeles: Western Psychological Services.

ODOM, P., & BLANTON, R. (1967). Phrase-learning in deaf and hearing subjects. *Journal of Speech and Hearing Research, 10,* 600-605.

OWINGS, N. O. (1972). *Internal reliability and item analysis of the Miller-Yoder Test of Grammatical Comprehension.* Unpublished master's thesis, University of Wisconsin–Madison.

QUIGLEY, S., POWER, D., & STEINKAMP, M. (1977). The language structures of deaf children. *Volta Review, 79,* 73-84.

QUIGLEY, S., STEINKAMP, M., POWER, D., & JONES, B. (1978). *Test of Syntactic Abilities.* Beaverton, OR: Dormac.

QUIGLEY, S., WILBUR, R., POWER, D., MONTANELLI, D., & STEINKAMP, M. (1976). *Syntactic structures in the language of deaf children.* Urbana, IL: Institute for Child Behavior and Development.

REES, N., & SHULMAN, M. (1978). I don't understand what you mean by comprehension. *Journal of Speech and Hearing Disorders, 43,* 208-219.

REYNELL, J. K. (1977). *Reynell Developmental Language Scales.* Windsor, England: NFER Publishing Company.

ROSENSTEIN, J., & MACGINITIE, W. (1969). *Verbal behavior of the deaf child: Studies of word meanings and associations.* New York: Teachers College Press.

WATSON, B. U., SULLIVAN, P., MOELLER, M. P., & JENSEN, J. (1982). Nonverbal intelligence and English language ability in deaf children. *Journal of Speech and Hearing Disorders, 47,* 199-203.

WILBUR, R. (1979). *American Sign Language and sign systems: Research and applications.* Baltimore: University Park Press.

Chapter 9

Expressive Language Skills

Mary Joe Osberger   Mary Pat Moeller   Malinda Eccarius
Amy McConkey Robbins   Deborah Johnson

Boys Town National Institute

PROCEDURES

Test administration and scoring procedures were the same as those employed for evaluation of receptive language skills. It should be noted that, in general, students both signed and spoke their responses. However, some of the students with more intelligible speech (approximately 12) preferred to use a spoken rather than a signed response, which also was acceptable. The measures included in the expressive language test battery appear in Table 43 and Appendix B. Table 44 contains a list of the tests and their acronyms. Again, most of the measures assessed lexical/semantic or syntactic/morphological skills. Several tests were developed to evaluate expressive functional communicative skills. These procedures, however, are nonstandardized, and the results should be interpreted

TABLE 43. Summary of expressive language test battery.

Test	*Area assessed*	*Standardization population*	*Range of norms*	*Response format*
Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977)				
Picture Vocabulary	Vocabulary	Hearing students	1st–12th grade	Picture labeling
Antonyms/Synonyms	Vocabulary: opposites and similarities	Hearing students	1st–12th grade	Oral (Signed) in response to printed-word query
Analogies	Verbal analogous relationships	Hearing students	1st–12th grade	Provide final word in analogy presented in print
Quantitative Concepts	Math concepts	Hearing students	1st–12th grade	Respond to numeral supported examiner questions
Test of Language Development (Newcomer & Hammill, 1977)				
Oral Vocabulary	Ability to define words	Hearing students	4.0–8.3 yrs.	Oral (signed) descriptions
Grammatic Completion	Ability to use grammatical endings	Hearing students	4.0–8.11 yrs.	Fill-in-the-blanks
Reynell (1977) Developmental Language Scales	Expressive content, vocabulary, and grammar	Hearing students	18 mos./7 yrs.	Object, picture labeling, and description
Inventory of Language Assessment Tasks (Kellman, Flood, & Yoder, 1977)	Range of verbal-conceptual skills	Hearing students	9–14 yrs.	Oral (sign) and written

TABLE 44. Expressive language tests and acronyms.

Test	Acronym
Lexicon/Semantics	
Woodcock–Johnson (1977) Psycho-Educational Test Battery	
Picture Vocabulary	WJ–PV
Antonyms/Synonyms	WJ–A/S
Analogies	WJ–AN
Quantitative Concepts	WJ–QC
Test of Language Development (Newcomer & Hammill, 1977)	
Oral Vocabulary	TO–OV
Syntax/Morphology	
Test of Language Development	
Grammatic Completion	TO–GC
Other Measures	
Reynell (1977) Developmental Language Scales	
Expressive scale	R–ES
Inventory of Language Assessment Tasks (Kellman, Flood, & Yoder, 1977)	
Expressive items	LAT–E

with this in mind. The organizational structure for presentation of the expressive language data is the same as that used in the preceding chapter.

RESULTS

Lexical/Semantic Skills

Two tests were employed to assess specific aspects of oral/sign vocabulary. These consisted of the Oral Vocabulary subtest of the Test of Language Development (TO–OV) (Newcomer & Hammill, 1977) and the Picture Vocabulary subtest of the Woodcock–Johnson Psycho-Educational Test Battery (WJ–PV) (Woodcock & Johnson, 1977). The WJ–PV required the student to assign a specific label to the pictured item, whereas the TO–OV subtest required the child to define familiar words. That is, the purpose of the TO–OV subtest was not merely to ascertain whether the student knew a specific stimulus word, but whether s/he could isolate attributes to provide an adequate definition of the word. The students' performance on these two measures is summarized in Tables 45 and 46, and Figure 27. On the average, the data show that the students are severely delayed in their expressive vocabulary skills on both measures. Slightly higher scores were achieved on the TO–OV subtest than on the WJ–PV for Groups 2, 3, and 4; Groups 5, 6, 7, and 8 achieved similar scores on the two tests. Performance on the TO–OV subtest should be interpreted with caution because almost half of the students in the older age groups reached the test ceiling of 8 years 3 months. The method for averaging basal and ceiling scores was the same as that described in

TABLE 45. Performance on the Picture Vocabulary subtest of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6– 9.5	7	8.9	1.1	5.4
3	9.6–11.5	11	10.3	4.5	6.2
4	11.6–13.5	18	10.9	3.6	6.3
5	13.6–14.5	18	12.3	4.6	7.1
6	14.6–15.5	28	13.8	4.3	7.8
7	15.6–16.5	11	14.3	4.3	8.4
8	16.6–20.0	23	13.0	4.3	7.4

TABLE 46. Performance on the Oral Vocabulary subtest of the Test of Language Development (Newcomer & Hammill, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6– 9.5	9	9.6	3.2	6.3
3	9.6–11.5	10	11.7	4.9	6.8
4	11.6–13.5	18	12.5	4.7	7.2
5	13.6–14.5	19	13.3	5.9	7.0
6	14.6–15.5	32	13.7	4.8	7.5
7	15.6–16.5	11	14.5	3.2	8.0
8	16.6–20.0	23	12.7	4.1	7.4

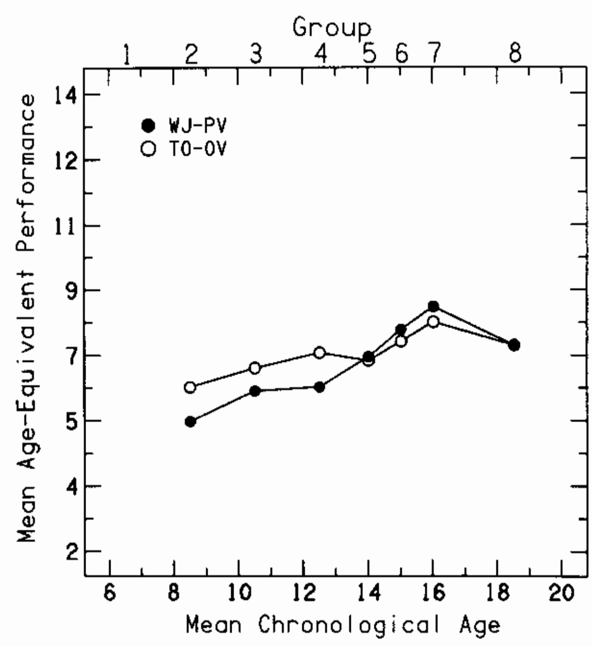

FIGURE 27. Performance on the Oral Vocabulary subtest of the Test of Language Development (TO–OV) (Newcomer & Hammill, 1977) and the Picture Vocabulary subtest of the Woodcock–Johnson Psycho-Educational Test Battery (WJ–PV) (Woodcock & Johnson, 1977) as a function of age. Data are plotted at the midpoint of each age group.

chapter 8. The data also show restricted growth on the two vocabulary tests as a function of age, although both tests showed a low but statistically significant correlation with age (TO–OV: $r = .23$, $p < .01$; WJ–PV: $r = .32$, $p < .001$). Large standard deviations are present for all age groups, again suggesting substantial variance among the performance of the students.

Different aspects of lexical knowledge were assessed with two other subtests of the Woodcock–Johnson Psycho-Educational Test Battery, the Quantitative Concepts (WJ–QC) subtest, and the Antonyms/Synonyms (WJ–A/S) subtest. The WJ–QC requires the student to use selected vocabulary to solve math problems. This test emphasizes the application of lexical knowledge rather than assessment of the ability to "name" or label specific words or pictures. The test also provides a visual referent to accompany the information given by the examiner.

The students' performance on the WJ–QC subtest is summarized in Table 47. Although there are delays on this measure, the hearing-impaired students' overall level of performance is superior to that observed on the other vocabulary-related tests (the TO–OV and WJ–PV). There also is evidence of improvement in performance from Groups 2 to 8 (with the exception of Group 6), and there was a significant correlation between this measure and age ($r = .44$; $p < .001$).

The results of the WJ–A/S are summarized in Table 48. Average performance on this measure was also superior to that observed on the other vocabulary measures, with the exception of the WJ–QC. A comparison of the students' performance on the WJ–QC and WJ–A/S appears in Figure 28. Difference in performance on the two tests increases with age, with the highest scores achieved on the WJ–QC, except for the students in Group 6, who achieved similar scores on both tests. Performance on the WJ–A/S shows little improvement in performance after 13.6–15.5 years. A low, but statistically significant correlation between age and performance on the WJ–A/S was found ($r = .31$, $p < .001$).

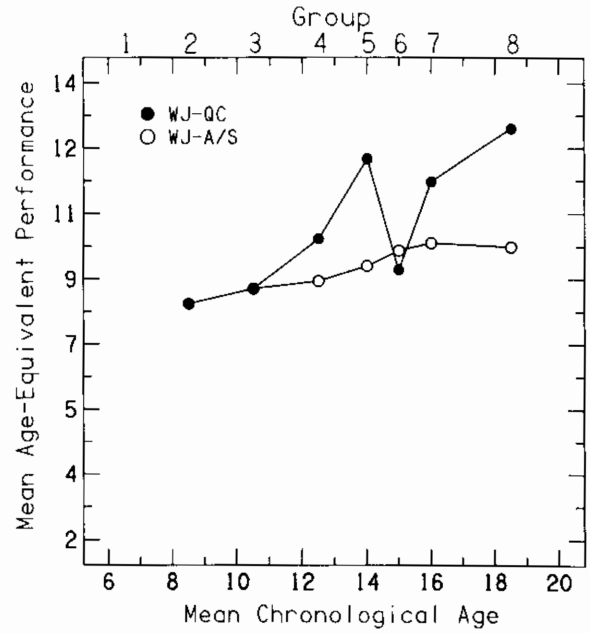

FIGURE 28. Performance on the Quantitative Concepts (WJ–QC) and Antonyms/Synonyms (WJ–A/S) subtests of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977) as a function of age. Data are plotted at the midpoint of each age group.

Expressive conceptual skills were assessed with the Analogies (WJ–AN) subtest of the Woodcock–Johnson Psycho-Educational Test Battery. The results of the WJ–AN subtest, in Table 49, indicate that the students are delayed in this area relative to their hearing peers. There is, however, some improvement in performance with age. A small but statistically significant correlation was observed between performance on the WJ–AN and age ($r = .27$, $p < .01$).

TABLE 47. Performance on the Quantitative Concepts subtest of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6– 9.5	6	18.2	1.6	8.2
3	9.6–11.5	11	18.7	4.7	8.6
4	11.6–13.5	18	21.5	5.8	9.9
5	13.6–14.5	18	25.1	5.6	12.0
6	14.6–15.5	28	24.0	5.6	9.1
7	15.6–16.5	11	24.6	4.2	11.4
8	16.6–20.0	23	26.6	4.6	12.8

TABLE 48. Performance on the Antonyms/Synonyms subtest of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6– 9.5	7	15.3	4.0	8.2
3	9.6–11.5	11	16.5	2.8	8.6
4	11.6–13.5	17	17.2	3.2	8.8
5	13.6–14.5	18	17.8	4.4	9.2
6	14.6–15.5	28	19.1	3.8	9.6
7	15.6–16.5	11	19.3	4.5	9.8
8	16.6–20.0	22	19.1	3.7	9.7

TABLE 49. Performance on the Analogies subtest of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6– 9.5	7	11.6	3.4	7.2
3	9.6–11.5	10	15.2	4.6	8.2
4	11.6–13.5	15	15.4	4.2	9.2
5	13.6–14.5	18	15.8	5.5	9.8
6	14.6–15.5	27	16.4	4.6	9.6
7	15.6–16.5	11	16.0	4.6	10.6
8	16.6–20.0	22	17.5	3.8	10.3

Syntactic/Morphologic Skills

Only one measure, the Grammatic Completion subtest of the TOLD (TO–GC) (Newcomer & Hammill, 1977), was used to assess expressive syntax/morphology. The test was administered to the students in Groups 2–8. The results of the TO–GC appear in Table 50. The average data for Group 2 should be interpreted with caution because many of the students scored below the basal norms on this measure (i.e., below 4 years of age). The performance of the older age groups is extremely poor, with evidence of expressive syntax approaching only that of a 5–6-year-old hearing child. There is very little change in performance with age, a finding reflected in the nonsignificant correlation between performance and age on this measure.

Additional Measures

Three groups of items were assessed on the Expressive scale of the Reynell Developmental Language Scales (R–ES) (Reynell, 1977). These consisted of structure (syntax), vocabulary (lexicon), and content (expression of meaning). The performance of the students in the two youngest age groups is summarized in Table 51. These data show performance expressed in terms of raw scores and an equivalent language age for the entire test, and they indicate that the average performance of the students on this measure is below that of a 3½-year-old-child with normal hearing. When the data were analyzed in terms of item category, Structure items were the easiest (M = 72.8, SD = 5.4), followed by the Vocabulary (M = 61.0, SD = 10.8) and the content items (M = 51.8, SD = 15.9).

A summary of the Expressive items, which were taken from the Language Assessment Tasks (LAT–E) (Kellman, Flood, & Yoder, 1977), appear in Table 52 and Figures 29 and 30. Performance on conjunctions is low and changes little with age. The Vocabulary items required the stu-

TABLE 50. Performance on the Grammatic Completion subtest of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
2	7.6–9.5	6	8.7	9.5	4.9
3	9.6–11.5	5	17.8	10.3	6.9
4	11.6–13.5	15	13.9	9.2	5.8
5	13.6–14.5	17	16.9	9.7	6.3
6	14.6–15.5	25	15.0	9.8	6.1
7	15.6–16.5	11	12.8	9.6	5.5
8	16.6–20.0	24	15.3	9.9	6.0

TABLE 51. Performance on the Expressive scale of the Reynell Developmental Language Scales (Reynell, 1977).

Group	*Age*	*n*	*M*	*SD*	*Age equivalent (years)*
1	4.5–7.5	12	39.5	9.5	3.1
2	7.6–9.5	5	42.2	3.7	3.4

TABLE 52. % correct performance on the Expressive items of the Language Assessment Tasks (Kellman, Flood, & Yoder, 1977) by group (with age range in years and group size given).

Expressive items	*Group 3 (9.6–11.5; n = 6)*	*Group 4 (11.6–13.5; n = 13)*	*Group 5 (13.6–14.5; n = 14)*	*Group 6 (14.6–15.5; n = 26)*	*Group 7 (15.6–16.5; n = 11)*	*Group 8 (16.6–20.0; n = 15)*
Conjunctions						
M	53.2	53.9	65.9	55.2	51.5	56.3
SD	21.6	18.3	24.7	21.5	23.6	21.8
Vocabulary						
M	10.4	22.7	35.4	26.4	22.7	31.7
SD	22.1	23.6	32.8	30.5	30.5	27.5
Idioms						
M	22.3	3.8	22.6	13.8	5.7	12.8
SD	20.8	7.5	32.6	24.4	8.5	16.8
Temporal Tasks						
M	84.2	89.2	93.9	92.5	96.6	93.2
SD	17.7	14.4	11.2	16.3	5.5	13.7
Classification						
M	86.5	78.1	80.1	79.7	72.5	83.6
SD	12.2	17.8	23.1	19.3	17.8	13.5
Class Inclusion						
M	60.0	53.1	63.8	58.8	45.0	60.0
SD	30.8	30.7	29.3	27.4	25.1	25.7

dents to define double function words (*sweet, bright, cold, crooked*). Scores on these items were very low, even for the older age groups. The test included six idioms which the children were required to define: *feeling blue, cool,*

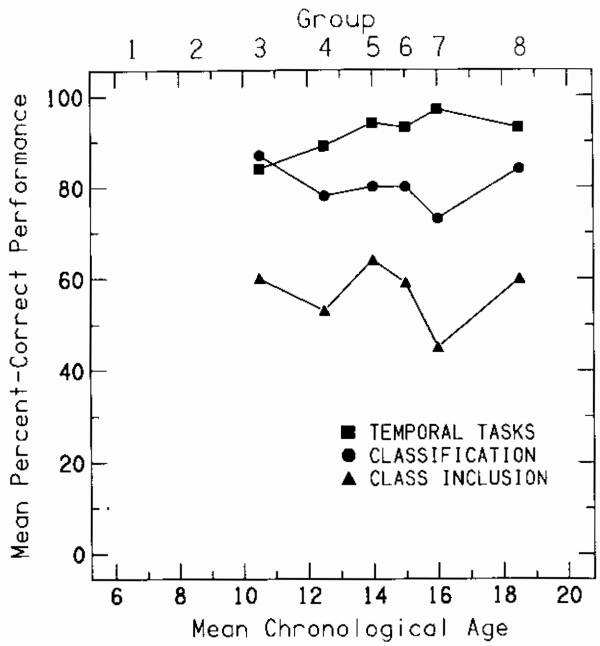

FIGURE 29. Performance on the Temporal tasks, Classification, and Class Inclusion items on the Expressive portion of the Language Assessment Tasks (Kellman, Flood, & Yoder, 1977). Data are plotted at the midpoint of each age group.

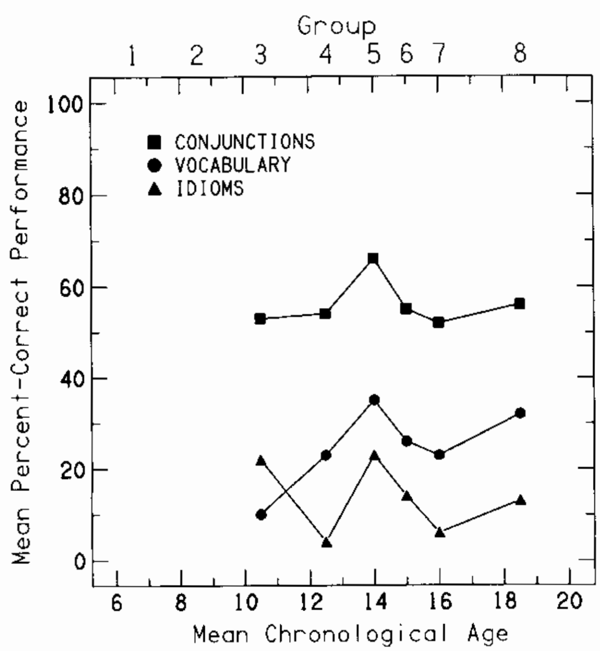

FIGURE 30. Performance on the Conjunctions, Vocabulary, and Idiom items on the Expressive portion of the Language Assessment Tasks (Kellman, Flood, & Yoder, 1977). Data are plotted at the midpoint of each age group.

spaced out, raining cats and dogs, hit the sack, and *it's a drag.* Performance was very poor for all age groups, with slightly better scores achieved by the youngest age group than the oldest age group.

Temporal tasks required the student to (a) express various types of temporal series (e.g., "Say the days of the week. How many are there?" "When is Christmas?"), (b) answer questions about temporal order (e.g., "What day was yesterday?" "What about the day after tomorrow?"), and (c) answer questions about temporal duration (e.g., "How long do you sleep at night?" "How long is summer vacation?"). High scores were achieved on these items by even the youngest group tested (Group 3), with near perfect scores obtained by the older age groups.

The Classification tasks required the student to select and state why one of four words was inappropriately placed in the classification scheme (e.g., "*radish, lemon, beets, carrots:* Which one doesn't belong?" "Why?"). The students in Group 3 performed reasonably well on this measure, but there was a substantial decrement in performance from Group 4 to Group 7, with the average score of Group 8 approaching that of Group 3.

The Class Inclusion tasks required the students to solve moderately abstract classification problems (e.g., "If all the flowers died, would there be any roses left?") and employ hierarchies to problem solve (e.g., "If this is a *second*, and this is a *minute*, and this is an *hour*, then this would be _____ and this would be _____," etc.). The students' performance on this type of task was poor, with only about 60% of the items correctly answered by even the oldest age group.

Performance on the expressive portion of the LAT did not correlate significantly with age.

Functional Communicative Skills

Evaluation of written language. Written language was assessed using a story retell procedure. A series of cartoons,[2] shown in Figure 31, provided visual support to a story sequence that was first told/signed by an examiner, with many syntactic structures and a large amount of story detail. (An example of an examiner's story narrative appears in Appendix C.) The student was then required to retell the story in written form. The samples were analyzed in two ways. First, each child's written sample was examined for the percentage of 26 possible story events included. This condition is referred to as Written Story Retell (WSRT). The results of this analysis appear in Table 53. The data show gradual improvement with age. Approximately 30% of the story events were included in the written samples of the youngest age group whereas the oldest age group included 50% of the story events. For Groups 5–8, scores of 50% to 60% were obtained. A low but significant correlation was found between performance on the WSRT and age ($r = .33$; $p < .001$). It is important to point out that this procedure has not been standardized

[2]The cartoon sequence was developed by Malinda Eccarius, Boys Town National Institute.

with normal-hearing or deaf students. It is not known, for example, at what age, if at any, a normal-hearing child would have included the complete number of story events.

Secondly, the content of the sample was evaluated with the rating scale in Table 54. This condition is referred to as Written Content (WC). The scale was adapted from one employed by Levitt, McGarr, and Geffner (1985) to rate the written language of deaf children. These ratings were performed independently by two clinicians familiar with the language of the profoundly hearing impaired. An average of the two ratings was then assigned to each sample. The students' performance is expressed in terms of the values on the rating scale (i.e., 0–100%), in Table 55. These data show that, on the average, only the gist of the story can be understood from the youngest students' writ-

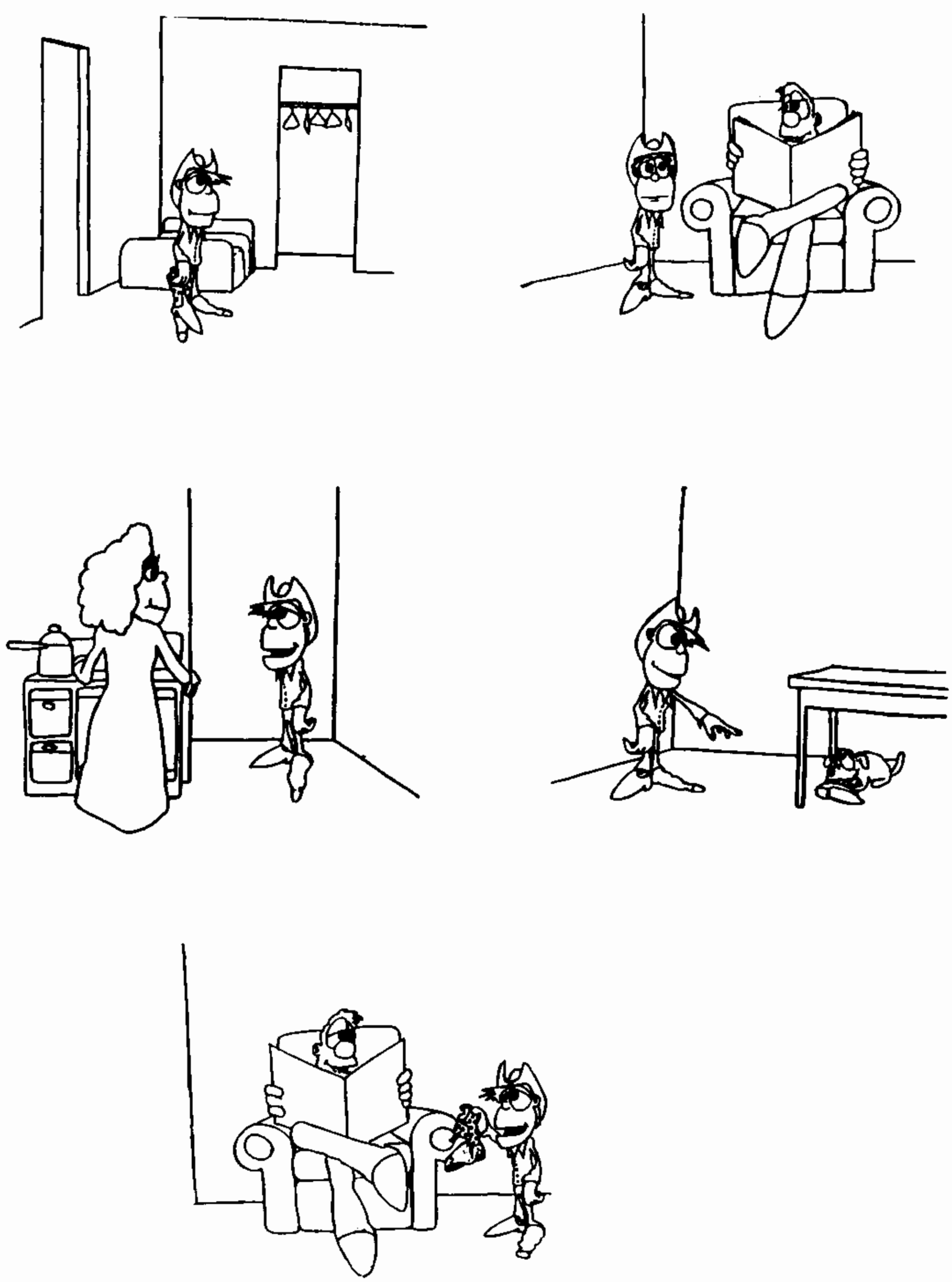

FIGURE 31. Cartoon sequence used for the story-retell procedure.

TABLE 53. Performance on the Written Story Retell (WSRT) Test.

Group	n	M	SD
1	–	–	–
2	7	30.9	18.9
3	10	39.8	25.3
4	21	39.1	24.5
5	14	59.0	18.0
6	16	49.6	23.0
7	9	57.4	24.1
8	14	50.0	22.5

TABLE 54. Rating scale for the Written Sample.

0%	No output related to story
10–20%	Isolated words (10% = nouns only; 20% = nouns and verbs)
21–39%	Some sentence structure; stereotypic sentence structure; gist of the story can be understood; only major points included
40–59%	Sequence of story correct; evidence of more detail and syntactic structure than in preceding category
60–79%	Majority of messages understood but many syntactic and grammatic errors; evidence of detail
80–100%	Content completely understood; evidence of original detail; some syntactic errors present

TABLE 55. Written Content (WC) ratings.

Group	n	M	SD
1	–	–	–
2	7	30.0	18.4
3	10	37.2	28.3
4	21	41.5	29.7
5	14	63.1	23.2
6	16	56.5	30.5
7	9	59.4	33.0
8	14	55.2	30.6

ten samples. The average ratings of the older students indicate that their stories contained more detail and more complex syntactic structure than the younger students. Performance on this measure correlated significantly with age ($r = .34$; $p < .001$), although the degree of correlation was low. Examples of the students' written samples appear in Appendix C.

Evaluation of sign sample. The story-retell procedure also was used to elicit a signed language sample from each student, as well as a written sample. The samples were videotaped and later transcribed in written form by a registered interpreter of the deaf. The sign samples were transcribed literally by the interpreter (i.e., sign-by-sign); no attempt was made to transcribe them according to English rules, American Sign Language, or to analyze the sign system used. The analyses to be described were based on the interpreter's written transcription of the signed story. These data should not be interpreted as representing an assessment of the students' sign abilities per se; rather, they should be used merely to analyze the students' ability to retell and express story detail in sign. This approach may not yield a representative analysis of the students' ability to communicate with sign, but time constraints and other practical considerations precluded a more complex analysis.

The sign samples were analyzed in a manner similar to that used to evaluate the written ones. That is, they were evaluated for the percentage of story events included in each sample by the student, which is referred to as Sign Story Retell (SSRT). The content of each sample was rated independently by two clinicians using the rating scale in Table 56. The ratings, expressed as a percentage between 0 and 100%, were averaged for the two raters and an average rating was assigned to each sample.

The results of the SSRT appear in Table 57. On the average, the performance of Group 1 was very low, and there are substantial differences on this measure between the younger and older students. As the average data show, however, only about 64% of the story events were included in the sign sample of the highest functioning group (Group 7). Performance on the SSRT task was significantly correlated with age ($r = .45$; $p < .001$). It should be noted that 12 of the students with intelligible speech used oral communication rather than signs for this and the other sign tasks. Group means and standard deviations were recomputed with the data from these subjects deleted. Be-

TABLE 56. Rating scale for Signed Sample.

0%	No output related to story
10–20%	Isolated words (10% = nouns only; 20% = nouns and verbs)
21–39%	Only major points included; gist of the story can be understood
40–59%	Sequence of the story correct; evidence of more story detail than the preceding category
60–79%	Majority of message understood; evidence of substantial detail
80–100%	Content completely understood; evidence of original detail

TABLE 57. Performance on the Story Retell (SSRT) Test.

Group	n	M	SD
1	6	21.2	14.5
2	8	44.8	22.8
3	9	48.0	23.5
4	19	44.4	17.8
5	15	53.4	15.2
6	21	56.2	19.2
7	8	54.5	22.0
8	17	57.8	12.8

cause they spanned all age groups, deletion of their data had a small or negligible effect on the mean performance for each age group. Therefore, only the results that include the data for all students are presented.

The results of the analysis of content in the signed message appear in Table 58. The students' ratings on this measure improve from Group 2 to Group 5, after which there is a slight decrement in performance. The performance of the younger age groups (Groups 2–4) indicate that their sign sample included only the major events of the story, and thus only the gist of the story was understood by the receiver. The ratings of sign samples of the older students (Groups 5–8), however, suggest that the majority of the message was conveyed to the receiver, and that the sample included substantial detail. A significant correlation was found between performance on this measure and age ($r = 42$; $p < .001$).

TABLE 58. Sign Content (SC) scores.

Group	*n*	*M*	*SD*
1	–	–	–
2	7	33.0	22.3
3	10	42.7	28.9
4	19	39.7	24.6
5	14	43.7	25.1
6	15	51.2	23.3
7	9	58.0	28.3
8	14	59.4	33.0

Correlations Between Measures

Partial correlations, adjusted for age and performance IQ, were calculated for the various expressive language measures. These data are summarized in Table 59. Significant correlations were found between all measures, with the exception of the correlation between the WJ–QC and the LAT–E. Note the high correlation between Sign Story Content (SC) and Written Story Content (WC) (.89), indicating that the ability to recall and convey the story sequence in sign and in written form is highly related, at least for the procedures used in this study. A high correlation also was found between the WSRT and the SSRT (.71), also indicating a relatively close relationship between sign and written skills for this particular measure.

Significant correlations were found between nonverbal IQ and all expressive language measures: TO–OV ($r = .32$, $p < .001$), WJ–PV ($r = .39$, $p < .001$), WJ–QC ($r = .26$, $p < .01$), WJ–A/S ($r = .30$, $p < .01$), WJ–AN ($r = .38$, $p < .001$), TO–GC ($r = .35$, $p < .001$), LAT–E ($r = .47$, $p < .001$), WSRT ($r = .31$, $p < .001$), WC ($r = .33$, $p < .001$), SSRT ($r = .34$, $p < .001$), and SC ($r = .32$, $p < .001$). Speech intelligibility (SPINT) correlated significantly with 8 of the 11 measures: TO–OV ($r = .24$, $p < .001$), WJ–PV ($r = .33$, $p < .001$), TO–GC ($r = .31$, $p < .001$), LAT–E ($r = .33$, $p < .001$), WSRT ($r = .27$, $p < .01$), WC ($r = .38$, $p < .01$), SC ($r = .23$, $p < .01$), and R–ES ($r = .35$, $p < .05$).

The students were divided into the two groups described previously (Group I = PTA < 105 dB, Group II = PTA > 105 dB) to examine the relation between hearing level and expressive language. Significant group differences were found for the TO–PV, TO–GC, WC ($p < .05$), and the WJ–PV ($p < .01$). Correlations were then calculated between PTA and the expressive language tests for the students in Group I. None of these correlations was significant.

To examine the relation between receptive and expressive skills, partial correlations, adjusted for age and performance IQ, were calculated for the receptive and expressive measures. These data are summarized in Table 60. Relatively high correlations were obtained between most of the measures. An interesting finding is the relatively high correlation between the LAT and the other language tests. Recall that the LAT is described as an experi-

TABLE 59. Partial correlations, adjusted for age and performance IQ, between the expressive tests.

Test	*SC*	*SSRT*	*WC*	*WSRT*	*LAT–E*	*TO–GC*	*WJ–AN*	*WJ–A/S*	*WJ–QC*	*WJ–PV*	*TO–OV*
TO–OV	.66**	.49**	.70**	.60**	.78**	.62**	.58**	.66**	.55**	.65**	1.0
WJ–PV	.51**	.43**	.66**	.51**	.70**	.64**	.63**	.65**	.60**	1.0	
WJ–QC	.49**	.28**	.65**	.65**	.32	.50**	.60**	.67**	1.0		
WJ–A/S	.52**	.37**	.69**	.61**	.49*	.58**	.63**	1.0			
WJ–AN	.48**	.49**	.61**	.49**	.88**	.56**	1.0				
TO–GC	.56**	.31**	.76**	.54**	.68**	1.0					
LAT–E	.50**	.68**	.66**	.56**	1.0						
WSRT	.81**	.71**	.81**	1.0							
WC	.89**	.61**	1.0								
SSRT	.71**	1.0									
SC	1.0										

Note. TO–OV and TO–GC = Oral Vocabulary and Grammatic Completion subtests of the Test of Language Development (Newcomer & Hammill, 1977); WJ–PV = Picture Vocabulary, WJ–QC = Quantitative Concepts, WJ–A/S = Antonyms/Synonyms, WJ–AN = Analogies, all subtests of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977); LAT–E = Expressive items of the Language Assessment Tasks (Kellman, Flood, & Yoder, 1977); WSRT = Written Story Retell; WC = Written Story Content; SSRT = Sign Story Retell; SC = Sign Story Content.

*$p < .01$.
**$p < .001$.

TABLE 60. Partial correlations, adjusted for age and performance IQ, between the receptive and expressive language tests.

Expressive tests[a]	*Receptive tests*[b] *PPVT*	*TO–PV*	*BOHM*	*TO–GU*	*CLAM*	*LAT–R*	*TSA*
TO–OV	.61**	.65**	.59**	.57**	.70**	.61**	.56**
WJ–PV	.68**	.63**	.42**	.53**	.55**	.51**	.70**
WJ–QC	.40**	.47**	.66**	.44**	.55**	.47**	.54**
WJ–A/S	.53**	.51**	.63**	.50**	.62**	.51**	.51**
WJ–AN	.57**	.63**	.70**	.55**	.66**	.55**	.65**
TO–GC	.53**	.47**	.62**	.63**	.73**	.62**	.75**
LAT–E	.74**	.68**	.11	.63**	.66**	.75**	.68**
SSRT	.40**	.38**	.41**	.39**	.56**	.20	.52**
SC	.43**	.38**	.56**	.51**	.74**	.33*	.60**
WSRT	.63**	.48**	.61**	.58**	.67**	.43*	.54**
WC	.66**	.50**	.63**	.61**	.83**	.54*	.82**

[a]Expressive tests: TO–OV and TO–GC = Oral Vocabulary and Grammatic Completion subtests of the Test of Language Development (TOLD) (Newcomer & Hammill, 1977); WJ–PV = Picture Vocabulary, WJ–QC = Quantitative Concepts, WJ–A/S = Antonyms/Synonyms, WJ–AN = Analogies, all subtests of the Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977); LAT–E = Expressive items of the Language Assessment Tasks (Kellman, Flood, & Yoder, 1977); SSRT = Sign Story Retell; SC = Sign Story Content; WSRT = Written Story Retell; WC = Written Story Content.

[b]Receptive tests: PPVT = Peabody Picture Vocabulary Test (Dunn, 1959); TO–PV and TO–GU = Picture Vocabulary and Grammatic Understanding subtests of the TOLD; BOHM = Boehm Test of Basic Concepts (Boehm, 1971); CLAM = Child Language Abilities Measure (Mehrabian & Moynihan, 1979); LAT–R = Receptive items of the Language Assessment Tasks; TSA = Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978).

*$p < .01$.
**$p < .001$.

mental test because it has limited standardization data with hearing children. To our knowledge, it is not used routinely to assess the expressive language of the hearing impaired. These data indicate that this procedure can yield useful information about a hearing-impaired child's language skills. Also of interest are the relatively high correlations between the CLAM (Child Language Abilities Measure, Mehrabian & Moynihan, 1979), a syntax–morphology test, and many of the other language measures.

Figures 32 and 33 illustrate the differences in expressive and receptive skills on four subtests of the TOLD. The data in Figure 32 compare receptive and expressive vocabulary skills, as measured on the TO–PV and TO–OV. As the data show, the students' performance is higher on the receptive vocabulary subtest than on the expressive one. A similar pattern of performance is seen for the receptive and expressive syntax/morphology measures (TO–GU and TO–GC), as illustrated in Figure 33. When the data are compared in Figures 32 and 33, it can be seen that the difference between receptive and expressive skills is larger on the vocabulary than on the syntax tests. This pattern of performance is similar to the order of normal language acquisition. That is, receptive skills generally precede expressive ones, although recent data (Chapman, 1974; Miller, 1981) suggest that some linguistic structures may appear in a child's expressive language before they are comprehended.

DISCUSSION

Lexical/Semantic and Syntactic/Morphological Skills

The results of the evaluation of expressive lexical/semantic and syntactic/morphological skills show that the students' performance in these areas approximates that of a 6–7-year-old child with normal hearing. Comparison of the students' performance on the two vocabulary tests is difficult because the scores of many of the older students exceeded the test ceiling of one of the tests (the TO–OV). Recall that the TO–OV subtest required the student to give a definition of the test word, whereas the WJ–PV subtest only required the student to label a picture. Both tests provide useful information about the lexical skills of hearing-impaired students. The advantage of the TO–OV is that it assesses a student's ability to isolate key attributes, an important skill for classifying and organizing information. A disadvantage of the test is that it has a low ceiling (8 years 3 months) and is designed to be only a screening measure. The WJ–PV of the Woodcock–Johnson Psycho-Educational Test Battery yields a more traditional measure of vocabulary, it can be administered rapidly, it provides age and grade scores, and it has a liberal ceiling (12th grade). The correlation between the WJ–PV and the other expressive tests also was slightly higher than for the TO–OV.

A striking feature of the data is that the students' performance on the WJ–QC and WJ–A/S is considerably higher than would be predicted from their expressive vocabulary scores. This may be due to the fact that vocabulary tests, particularly the WJ–PV, require labeling which may be affected by problems in retrieving specific content, or the students may not have been taught many of the vocabulary items which are tested. The WJ–QC and WJ–A/S subtests, however, tap application of lexical knowledge rather than retrieval of specific lexical labels.

Analysis of the students' error patterns on the WJ–A/S

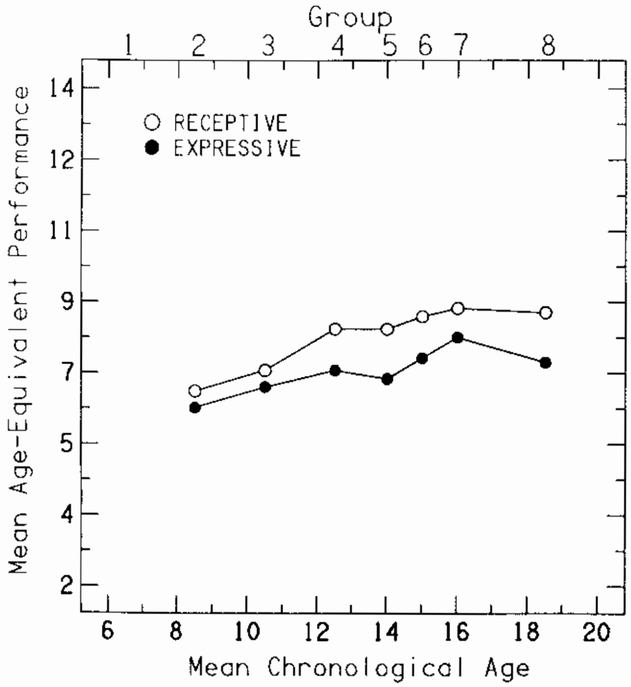

FIGURE 32. Performance on one receptive (Test of Language Development–Picture Vocabulary, by Newcomer & Hammill, 1977) and one expressive (TOLD–Oral Vocabulary) subtest. Data are plotted at the midpoint of each age group.

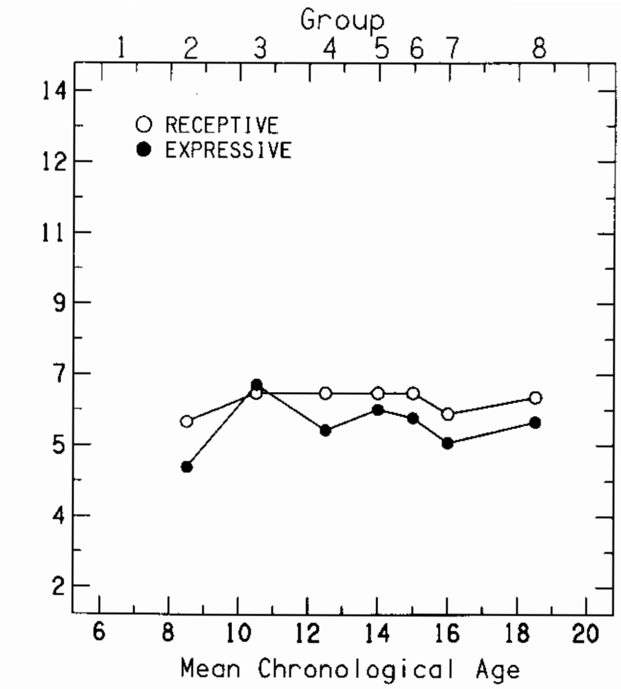

FIGURE 33. Performance on one receptive (Test of Language Development–Grammatic Understanding, by Newcomer & Hammill, 1977) and one expressive (Told–Grammatic Completion) syntax test. Data are plotted at the midpoint of each age group.

revealed that they had more difficulty providing a synonym than an antonym of the test words. This pattern of performance may reflect instructional strategies, because deaf children are often taught concepts using polar opposites (e.g., *hot–cold; hard–soft*). In addition, the vocabulary restrictiveness of most hearing-impaired children reduces the number of available labels they have for a particular referent, thus making the synonym task more difficult than the antonym task.

Conceptual tasks were also included in the assessment of content skills. Information obtained from the WJ–AN is of particular interest because it permits an estimate of concept knowledge with some control of linguistic demands. The students' performance on the WJ–AN was higher than on the expressive vocabulary tests, as was observed for the WJ–QC and WJ–A/S subtests. There was, however, little evidence of growth in the use of analogies after 11.5 years of age. It is important to note, however, that performance on this test might have been affected by the students' limited word knowledge. That is, had they known the meanings of more of the words in the test, they might have been able to comprehend even more of the subtle and abstract relationships between words.

It is of interest to note that all four of the expressive subtests from the Woodcock–Johnson Psycho-Educational Test Battery (WJ–PV, WJ–QC, WJ–A/S, WJ–AN) showed relatively high correlations with the written sample rating (WC). In addition, these measures, with the exception of the WJ–QC, bore a strong relationship with the tasks on the LAT–E. The latter test is particularly useful because it provides information about later developing language skills, including transitive and comparative relations, class inclusion and exclusion, and the use of idioms. These language concepts are critical to reading comprehension, and they are ones in which the profoundly hearing impaired demonstrate deficiencies (Quigley, 1982). As mentioned previously, the LAT has limited standardization data. The results of this study, however, indicate that both the receptive and expressive portions provide useful information about the linguistic skills of the hearing impaired.

Limited information was obtained on the students' expressive syntax skills, primarily because few appropriate and practical test measures were available at the time of this evaluation. Results obtained on the TO–GC, however, indicate low performance with negligible improvement with age. This measure did correlate highly with the written sample rating (WC), indicating a significant relation between expressive syntax skills as assessed on a formal test (the TO–GC) and those used in a more spontaneous situation. Since the time of this study, the Grammatical Analysis of Elicited Language tests (Moog & Geers, 1979, 1981) have been developed for assessing the syntax and morphology of deaf children's language. The advantage of the GAEL is that it has been standardized with a large population of orally trained hearing-impaired students as well as with students who use total communication. Ideally, an expressive language assessment should include a structural analysis of a spontaneous language sample to augment the information obtained on more formal test procedures. Even though a written language sample was obtained from each student, it was not practical to perform structural analyses because of time constraints and also because some of the students appeared to use the rules of American Sign Language rather than those of spoken English.

Functional Communicative Skills

An interesting finding was that the students' sign and written skills were highly similar, at least for the tasks analyzed in this study. A comparison between the Signed Story Retell (SSRT) and Written Story Retell (WSRT) ratings is shown in Figure 34. The students in Groups 1–4 obtained slightly higher ratings with the signed format than with the written, whereas the older students' performance was essentially the same for the different formats. Figure 35 compares performance for the Sign Story Content (SC) and Written Story Content (WC). Performance for each group is similar irrespective of expressive mode. Again, it should be stressed that the procedures used to assess written and sign skills were nonstandardized, and the results of these evaluations should be interpreted with caution. In particular, it should be recalled that we were not attempting to evaluate sign proficiency or communicative competence in sign language. Had this been the case, we would have predicted that sign skills would have exceeded written expressive skills at all ages.

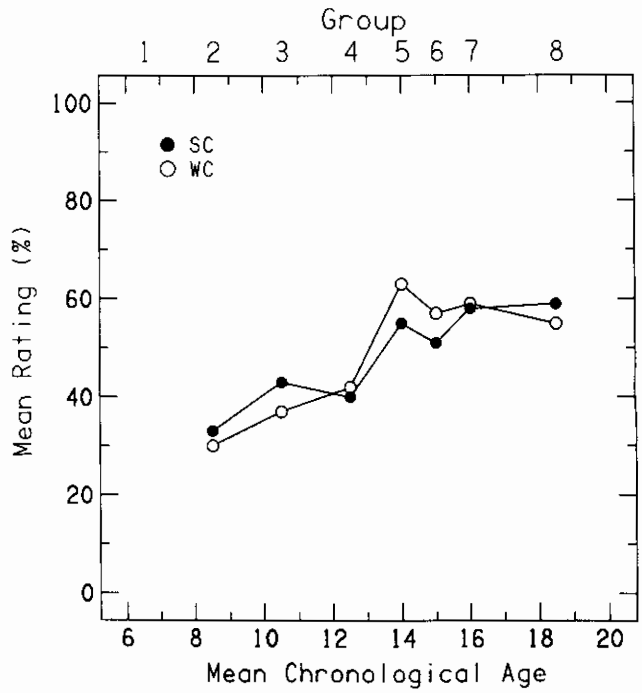

FIGURE 35. Performance on the Sign Story Content (SC) and Written Story Content (WC). Data are plotted at the midpoint of each age group.

Correlational Data

The correlations showed a significant relation between nonverbal intelligence and the majority of expressive language measures. Thus, it appears that performance IQ data can contribute to understanding a hearing-impaired child's expressive as well as receptive language performance. The data also showed a nonsignificant relation between hearing level and expressive language, a finding that is in agreement with the results of Levitt et al. (1985). Unlike the receptive measures, speech intelligibility correlated with the majority of expressive language measures. This finding suggests that if a child has good production skills in one mode, s/he is likely to demonstrate them in another mode. In addition, the correlational data showed a significant relation between many of the receptive and expressive tests, indicating that it might not be necessary to assess both comprehension and production skills. In fact, some clinicians have suggested that comprehension, particularly of syntactic structures, can be inferred from a child's production abilities. Although this might be true in some instances, our clinical experience and the reported data of other investigators (Chapman, 1974; Miller, 1981) indicate a complex interaction between skills in the two areas. In addition, the clinician may wish to examine the comprehension strategies used by the child or assess his/her performance as an information recipient. To obtain a thorough understanding of the communicative competence of the student, both comprehension and production testing are recommended (Moeller, McConkey, & Osberger, 1983).

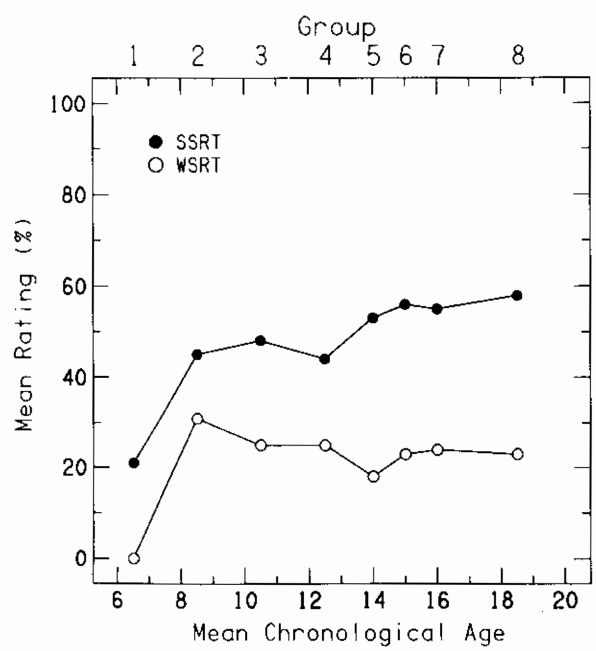

FIGURE 34. Performance on the Signed Story Retell (SSRT) and Written Story Retell (WSRT). Data are plotted at the midpoint of each age group.

SUMMARY

The results show the students to be delayed in expressive as well as receptive language. When performance is compared in the two areas, slightly higher levels of achievement were found on receptive than on expressive tests. Performance in both areas was superior on lexical/semantic items to those involving syntax/morphology. Although there were significant correlations between the majority of receptive and expressive language tests, unique information can be obtained from independent assessment of both comprehension and production abilities. A significant relation was found between expressive language and nonverbal intelligence, and many of the tests also were significantly correlated with speech intelligibility. Hearing level did not show a significant correlation with expressive language skills. Several measures were found to provide a wide range of information about expressive language skills. These consisted of the subtests of the Woodcock–Johnson Psycho-Educational Test Battery and the portions administered of the Inventory of Language Assessment Tasks. Two procedures developed for this study to analyze the written and signed language samples also appear to yield useful information about expressive language.

REFERENCES

CHAPMAN, R. (1974). Discussion summary: The developmental relationship between receptive and expressive language. In R. Schiefelbusch & L. Lloyd (Eds.), *Language perspectives: Acquisition, retardation, and intervention* (pp. 335-345). Baltimore: University Park Press.

KELLMAN, M., FLOOD, C., & YODER, D. (1977). *Inventory of Language Assessment Tasks.* Madison, WI: Madison Public Schools.

LEVITT, H., MCGARR, N., & GEFFNER, D. (1985). *Development of language and communication skills of hearing-impaired children.* Manuscript submitted for publication.

MILLER, J. (1981). *Assessing language production in children.* Baltimore: University Park Press.

MOELLER, M. P., MCCONKEY, A. J., & OSBERGER, M. J. (1983). Evaluation of the communicative skills of hearing-impaired children. *Audiology, 8,* 113-127.

MOOG, J. S., & GEERS, A. E. (1979). *Grammatical Analysis of Elicited Language–Simple Level.* St. Louis: Central Institute for the Deaf.

MOOG, J. S., & GEERS, A. E. (1981). *Grammatical Analysis of Written Language–Complex Level.* St. Louis: Central Institute for the Deaf.

NEWCOMER, P., & HAMMILL, D. (1977). *Test of Language Development.* Los Angeles: Western Psychological Services.

QUIGLEY, S. P. (1982). Reading achievement and special reading materials. *Volta Review, 84,* 95-106.

REYNELL, J. K. (1977). *Reynell Developmental Language Scales.* Windsor, England: NFER Publishing.

WOODCOCK, R., & JOHNSON, M. B. (1977). *Woodcock–Johnson Psycho-Educational Test Battery.* Boston: Teaching Resources.

Chapter 10

Academic Skills

Judith Kroese Wendy Lotz Carol Puffer Mary Joe Osberger

Boys Town National Institute

Three major areas of academic achievement were assessed: reading, spelling, and math. Testing was restricted to those subjects because they are prerequisites for most other aspects of academic performance. A range of skills was assessed in each of the three areas. The reading tests were used to evaluate comprehension of single words, sentences, and short passages. In the area of spelling, both receptive (recognition) and expressive (recall) skills were assessed. Expressive spelling skills, or the ability to spell correctly a word when cued nonorthographically, appear to be particularly important for the hearing impaired, who often must rely on fingerspelling or written messages in communicative situations. The ability to apply phonic word-attack skills also is important in learning to read and spell and is usually assessed in students with normal hearing. Such testing, however, requires the student to give an oral/spoken response when decoding the printed words. Because of the reduced speech intelligibility of many of the students, testing was not attempted in this area. Finally, the math tests evaluated both computation skills and more language-based skills involved in the application of concepts and operations.

METHOD

Procedure

The tests used to assess academic achievement are summarized in Table 61, and a brief description of each test appears in Appendix D. A list of tests and their acronyms appears in Table 62. The tests were administered to all students in Groups 3–8. Some students in Groups 1 and 2 also received the battery, depending on their chronological age and anticipated performance level.

As shown in Table 61, three reading tests were administered to the students. The Word Identification subtest of the Woodcock Reading Mastery Test (WRMT–WI) (Woodcock, 1973) assessed the student's ability to read single words (sight vocabulary skills). Two reading comprehension tests having different test formats also were administered. The Passage Comprehension subtest of the WRMT (WRMT–PC) uses a cloze procedure, requiring the student to supply one word to fill a blank in a phrase or sentence. In contrast, the Reading Comprehension subtest of the Peabody Individual Achievement Test (PIAT–RC) (Dunn & Markwardt, 1970) uses a multiple-choice format and requires the student to select a picture that represents the meaning of the sentence.

In addition to the individual tests, described above, a group test, the Stanford Achievement Test–Hearing Impaired form (SAT–HI) (Madden, Gardner, Rudman, Karensen, & Merwin, 1972) was administered at the school by the classroom teachers. Although the entire SAT–HI was administered to the students, only scores in the areas of reading, spelling, and math are reported and compared to the results obtained on the other diagnostic tests administered. The SAT was used because it has been standardized on the hearing impaired, and most previous investigations have employed this measure. On the other hand, the individual achievement tests were administered because they often are used in clinical settings to gain insight into the nature of a given student's academic difficulties. Information obtained from tests of this nature can be used to recommend remediation strategies, tailored to meet the individual needs of each student.

A few comments are necessary about the structure of the SAT–HI. The Hearing-Impaired edition was developed from the 1973 Stanford test battery by the Office of Demographic Studies at Gallaudet College as part of its 1973 National Achievement Testing Program for the hearing impaired. The SAT–HI differs from the regular SAT only in the levels at which different subtests are administered. The SAT–HI, like the SAT, has six battery levels, each geared toward a particular range of academic development. Two advantages of the SAT–HI are better matching of the subtests to the skills of hearing-impaired students and special age–rank norms, which give an examinee's rank among other hearing-impaired students of her/his own age.

Progressively more difficult tests are required at each of

TABLE 61. Summary of academic test battery.

Test	Area assessed	Standardization population	Range of norms	Response format
Reading				
Peabody Individual Achievement Test (Dunn & Markwardt, 1970)				
Reading Comprehension	Comprehension of sentences	Hearing students	K–12th grade	Selects one of four pictures
Woodcock (1973) Reading Mastery Test				
Word Identification	Sight vocabulary	Hearing students	K–12th grade	Signs, pronounces and/or defines written single word
Passage Comprehension	Comprehension of phrases, sentences, short paragraphs	Hearing students	K–12th grade	Modified cloze procedure—signs or says one word to fill in the blank
Spelling				
Peabody Individual Achievement Test				
Spelling	Spelling recognition	Hearing students	K–12th grade	Selects correct spelling out of four choices
Written Spelling Survey	Written spelling (recall)	Nonstandardized	—	Written spelling of words
Math				
Woodcock–Johnson (1979) Psycho-Educational Test Battery				
Calculations	Math computation	Hearing students	1st–2nd grade	Written
Applied Problems	Math application	Hearing students	1st–12th grade	Verbal/manual response to spoken/signed problem

the six battery levels. The levels and grades for which the subtests are intended for normal-hearing students are as follows:

Level 1: Mid 1st grade to end of 2nd grade
Level 2: Mid 2nd grade to end of 3rd grade
Level 3: End of 3rd grade to end of 4th grade
Level 4: End of 4th grade to end of 5th grade
Level 5: End of 5th grade to end of 7th grade
Level 6: Beginning of 7th grade to end of 9th grade.

Table 63 compares selected subtests administered at the levels of the SAT–HI to the levels of the subtests administered to normal-hearing students. Note that the levels of the Vocabulary subtest of the SAT–HI are lower than those of the SAT. In contrast to this, the levels of the Math Computation and Spelling subtests of the SAT–HI are at a more advanced level than that of the SAT. Each student was tested on only one level of the SAT–HI. The level selected was determined by administering the screening test that accompanies the SAT–HI. Table 64 shows the levels taken by the students in each age group, expressed in terms of percentage of students. As the data show, the majority of students took levels 2 or 3 of the SAT–HI, indicating that the level of the material on which they were tested in the reading, spelling, and language areas was intended for a 2nd–4th-grade student with normal hearing. The distribution of test levels across students is similar to that reported for other hearing-impaired students in the country (DiFrancesca, 1972). The results of the SAT–HI should be interpreted in light of the level of the material on which the students were evaluated. In the following presentation of results, test levels are not reported with the average performance data. It should be kept in mind, however, that the performance data for many of the students are based on reading material intended for young (2nd–4th grade) hearing students.

Table 61 also indicates that two different spelling tests (in addition to the spelling subtest of the SAT–HI) were administered. One test, the Spelling subtest of the Peabody Individual Achievement Test (PIAT–SP), was used to assess the student's ability to recognize the correct spelling of a word. The second test, referred to as the

Table 62. Academic tests and acronyms.

Test	*Acronym*
Reading	
Peabody Individual Achievement Test (Dunn & Markwardt, 1970)	
Reading Comprehension	PIAT–RC
Woodcock (1973) Reading Mastery Test	
Word Identification	WRMT–WI
Passage Comprehension	WRMT–PC
Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972)	
Reading Comprehension	SAT–RC
Spelling	
Peabody Individual Achievement Test Spelling	PIAT–SP
Stanford Achievement Test Spelling	SAT–SP
Written Spelling Survey	WSS
Math	
Woodcock–Johnson (1977) Psycho-Educational Test Battery	
Calculations	WJ–CAL
Applied Problems	WJ–AP
Stanford Achievement Test	
Computations	SAT–CMP
Applications	SAT–APP
Concepts	SAT–CON

Table 63. Recombination of the regular Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972) to form the SAT–HI (hearing-impaired edition).

Subtest area	*SAT–HI battery level* I	II	III	IV	V	VI
Vocabulary	1	1	2	3	4	6
Reading A	1	2	[a]	[a]	[a]	[a]
Reading B	1	2	[a]	[a]	[a]	[a]
Reading Comprehension	[b]	[b]	3	4	5	6
Word Study Skills	1	2	3	4	5	[a]
Math Concepts	1	2	3	5	6	6
Math Computation	1	3	4	5	6	6
Math Application	[a]	2	3	4	5	6
Spelling	[c]	3	4	5	6	6
Language	[a]	[a]	3	4	5	6
Social Science	[a]	2	3	4	5	6
Science	[a]	2	3	4	5	6

Note. Subtest code of regular SAT:
1 = Primary Level I; 2 = Primary Level II; 3 = Primary Level III; 4 = Intermediate Level I; 5 = Intermediate Level II; 6 = Advanced

[a]No subtest given. [b]No specific subtest is given but a score based on Reading A and Reading B is obtained. [c]An optional spelling subtest is available but is not considered appropriate for hearing-impaired students.

Table 64. Percentage of students who received the six levels of the SAT–HI (Stanford Achievement Test–Hearing Impaired edition, Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

Group	*Level* 1	2	3	4	5	6
2	82	12				
3	37	36	27			
4	14	43	38	5		
5	11	52	11	21	5	
6	4	48	34	10		4
7		45	45			10
8		33	52	5		10

Written Spelling Survey (WSS), was used to assess written expressive spelling skills. The Written Spelling Survey was developed for the project because, unlike tests available to assess spelling recognition, the vocabulary of the standardized expressive spelling tests appeared too advanced for the hearing-impaired students. Independent assessment of expressive spelling skills appeared necessary because prior clinical experience suggested that the ability to recognize the correct spelling of a word did not necessarily predict the ability to recall (write or fingerspell) a particular word, especially in learning-disabled students. The test is described in Appendix C.

Finally, two math tests (in addition to those on the SAT–HI) were administered. One test assessed the ability to perform various types of mathematical computations; the other test assessed the ability to apply math facts and concepts.

Modifications in scoring and administration procedures. All tests were administered in total communication using the procedures outlined in the test manuals, except for the WRMT–PC subtest. For this test, prior experience with the hearing impaired suggested that the most appropriate place to start testing was with Item 1 rather than with the item suggested in the manual.

Another modification involved the administration of the Applied Problems subtest of the Woodcock–Johnson Psycho-Educational Test Battery (WJ–AP) (Woodcock & Johnson, 1977). The test was administered two times to each student. One administration mode was the same as that used for all tests (i.e., manually coded English); the other mode employed a modified English version approximating American Sign Language. The latter method was used to ensure that the students' performance on this particular test, which assessed the ability to solve math problems, would not be affected by linguistic deficits in English. Order of presentation was randomized, and at least 1 hr passed between each administration.

The WRMT–WI and WRMT–PC subtests required a one-word expressive response from the students. It was not clear, however, if all of the items had a sign representation in the system used by the students. Consequently, the sign for a synonym of the test word often was accepted (e.g., "boat" for *yacht*, "laugh" for *giggle*). Further, it was noted that morphological markers were not consistently used by the teachers or students. Because of this, the student received credit if only part of the word was signed (e.g., "invent" for *invention*, "rude" for *rudely*, "play" for *playing*). The student also received credit when a word was defined correctly. Even though these scoring criteria are more lenient than those on which the tests were standardized, this method of scoring appeared to give the most accurate representation of the students' reading levels. It should be stressed that these modifications seemed necessary because of the difficulties inherent in administering tests in a signed rather than spoken mode. Thus, every attempt was made not to penalize the students for responses that appeared to be influenced by the limitations of their sign system (or use of the system in their school). Also, the method for averaging basal and ceiling scores for all the measures was the same as that described for the language measures.

RESULTS

Figure 36 shows the mean grade equivalents for Groups 2–8 on the WRMT–WI, WRMT–PC, PIAT–RC, and the SAT–RC (Reading Comprehension subtest of the SAT–HI). The mean raw scores, standard deviations, and grade equivalent ranges for each of these reading tests are listed in Table 65. The data plotted in Figure 36 and summarized in Table 65 reveal that there is very little growth in reading skills with age. The highest average performance level achieved by the hearing-impaired students is comparable to the reading level of a normal-hearing fourth grader. Weak but significant correlations were obtained between age and performance on the PIAT–RC (r = .33,

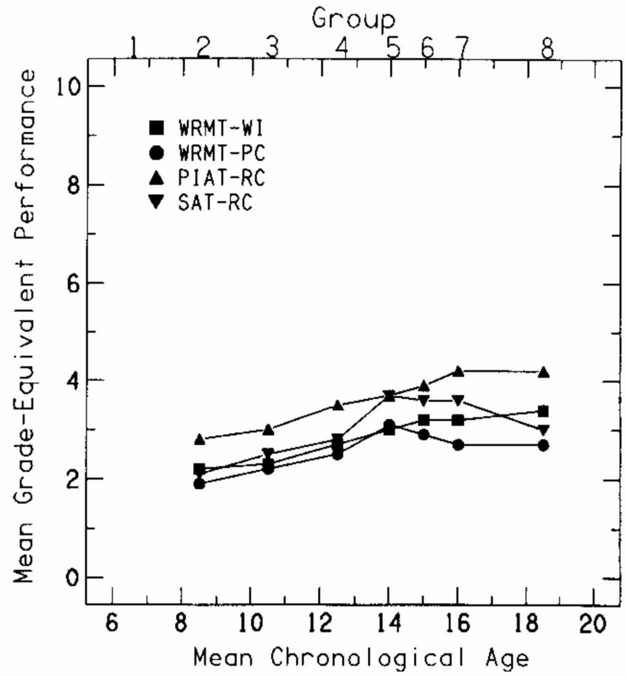

FIGURE 36. Reading performance as a function of age. Data are plotted at the midpoint of each age group. WRMT–WI, WRMT–PC = Word Identification and Passage Comprehension subtests of the Woodcock (1973) Reading Mastery Test; PIAT–RC = Reading Comprehension subtest of the Peabody Individual Achievement Test (Dunn & Markwardt, 1970); SAT–RC = Reading Comprehension subtest of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

TABLE 65. Performance on the reading tests.

		WRMT–WI			*WRMT–PC*			*PIAT–RC*			*SAT–RC*	
Group	*Age*	*Raw score*	*SD*	*Grade equiv. range*	*Raw score*	*SD*	*Grade equiv. range*	*Raw score*	*SD*	*Grade equiv. range*	*Levels*	*Grade equiv. range*
2	7.5–9.5	57 n = 11	18	1.7–2.8	10 n = 11	6	1.5–2.6	27 n = 11	6	1.9–3.8	1–2 n = 11	1.4–2.9
3	9.6–11.5	58 n = 12	24	1.2–3.6	15 n = 11	10	1.8–3.9	29 n = 12	7	2.1–5.5	1–4 n = 12	1.4–4.8
4	11.6–13.5	71 n = 21	18	1.8–4.1	19 n = 20	13	1.6–6.0	32 n = 21	9	2.2–8.4	1–4 n = 21	1.5–5.9
5	13.6–14.5	81 n = 19	18	2.1–4.8	25 n = 19	16	1.5–7.4	32 n = 19	9	2.2–9.5	1–5 n = 19	1.2–8.3
6	14.6–15.5	83 n = 32	18	1.8–6.2	22 n = 32	15	1.3–7.8	34 n = 32	9	2.4–9.5	2–4,6 n = 29	1.5–10.0
7	15.6–16.5	84 n = 11	18	2.2–5.1	21 n = 11	14	1.7–5.1	35 n = 11	11	2.2–10.0	2,3,6 n = 11	2.2–8.8
8	16.6–20.0	88 n = 25	18	1.8–5.7	21 n = 25	13	1.6–5.7	37 n = 25	9	2.1–9.2	2–4,6 n = 21	2.2–7.9

Note. WRMT–WI, WRMT–PC = Word Identification and Passage Comprehension subtests of the Woodcock (1973) Reading Mastery Test; PIAT–RC = Reading Comprehension subtest of the Peabody Individual Achievement Test (Dunn & Markwardt, 1970); SAT–RC = Reading Comprehension subtest of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

$p < .001$), the WRMT–PC ($r = .22$, $p < .01$), and the SAT–RC ($r = .30$, $p < .001$). A significant correlation also was observed between performance on the sight vocabulary test (WRMT–WI) and age ($r = .52$, $p < .001$). The lowest scores were achieved by all groups on the WRMT–PC, the test that used the cloze procedure, whereas the highest scores were achieved on the PIAT–RC, which employed a multiple-choice format.

Finally, Table 65 indicates that the grade equivalent ranges are most restricted on the WRMT–WI test, followed by the WRMT–PC test. The PIAT–RC test and the SAT–RC test show large grade equivalent ranges for each group and, thus, greater variance among students than the other two measures.

Figure 37 compares the performance of the students on the SAT–RC test to the performance of other hearing-impaired students in the country on this measure. The data for the national sample, which were obtained from the results of the 1971 survey reported by the Office of Demographic Studies (DiFrancesca, 1972, p. 39), were averaged to form age groups comparable to those in the present study. The data in Figure 37 indicate that the reading comprehension skills of the present sample, as measured by the SAT–HI, are very similar to those of other hearing-impaired students in the country.

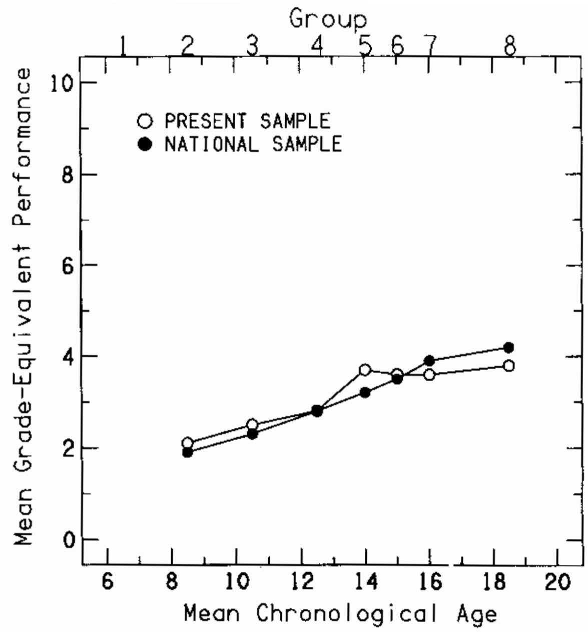

FIGURE 37. Performance on the SAT–RC (Reading Comprehension subtest of the Stanford Achievement Test, Madden, Gardner, Rudman, Karlsen, & Merwin, 1972) compared to national data (DiFrancesca, 1972). Data are plotted at the midpoint of each age group.

Spelling

The performance of the students on the spelling subtests (SP) of the PIAT and the SAT is shown in Table 66 and Figure 38. The SAT results are not reported for Group 2 because too few students took the test. The data show a small but steady improvement in receptive spelling skills with age. Significant correlations were found between performance on both spelling tests and age: PIAT–SP ($r = .62$, $p < .001$) and SAT–SP ($r = .39$, $p < .001$). As the data in Figure 38 show, the oldest age group demonstrates receptive spelling skills comparable to those of a normal-hearing sixth grader. With the exception of

TABLE 66. Performance on the spelling tests.

		PIAT–SP			*SAT–SP*		*WSS*	
Group	*Age*	*Raw score*	*SD*	*Grade equiv. range*	*Levels*	*Grade equiv. range*	*Raw score*	*SD*
2	7.5–9.5	31 $n = 11$	8	2.2–4.4	1,2	–	9 $n = 10$	7
3	9.6–11.5	34 $n = 12$	8	1.7–5.6	1–3	3.3–6.1 $n = 7$	11 $n = 12$	9
4	11.6–13.5	42 $n = 21$	7	2.5–6.5	1–4	1.5–5.9 $n = 17$	16 $n = 21$	9
5	13.6–14.5	45 $n = 19$	8	3.0–10.4	1–5	2.1–10.5 $n = 17$	19 $n = 15$	6
6	14.6–15.5	47 $n = 32$	10	1.6–10.4	2–4,6	1.3–11.5 $n = 28$	20 $n = 32$	8
7	15.6–16.5	48 $n = 11$	8	3.5–10.4	2,3,6	1.2–11.2 $n = 11$	22 $n = 11$	6
8	16.6–20.0	51 $n = 25$	7	3.8–12.9	2–4,6	1.7–10.6 $n = 21$	23 $n = 24$	6

Note. PIAT–SP = Spelling subtest of the Peabody Individual Achievement Test (Dunn & Markwardt, 1970); SAT–SP = Spelling subtest of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972); WSS = Written Spelling Survey.

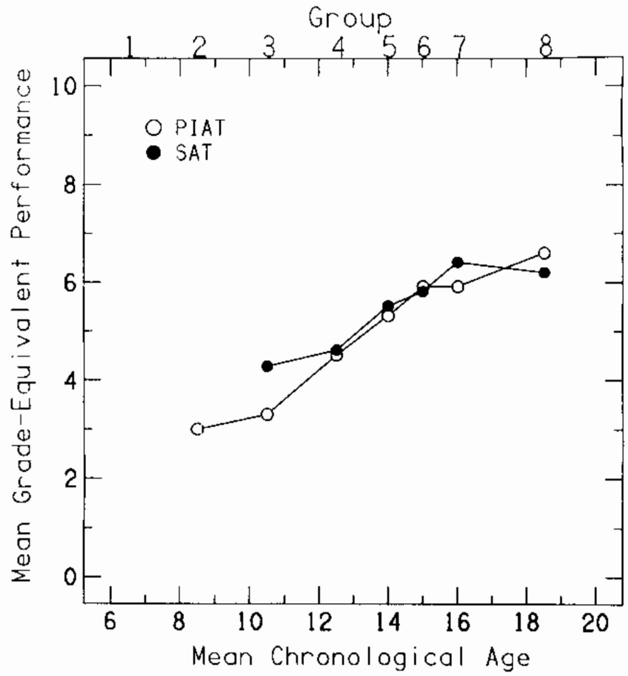

FIGURE 38. Spelling performance as a function of age. Data are plotted at the midpoint of each age group. PIAT: Peabody Individual Achievement Test (Dunn & Markwardt, 1970); SAT: Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

Group 3, the mean scores obtained on the two spelling tasks are comparable.

Figure 39 and Table 66 show the mean raw scores for Groups 2–8 on the Written Spelling Survey (WSS). There was a large improvement in expressive spelling skills with age, with a score of 8.5 for Group 1 progressing to a score of 23 for Group 8. Note, however, that even the oldest age group failed to achieve a perfect score of 32. Assuming that all the words in the WSS would have been spelled correctly by a normal-hearing eighth grader (see Appendix C), these results indicate that the hearing-impaired students' expressive spelling skills are below this performance level.

Mathematics

Recall that the Applied Problems subtest of the Woodcock–Johnson Psycho-Educational Test Battery was administered once to each student in a modified English version of American Sign Language and once in manually coded English. Examination of the scores revealed highly similar scores, on the average, for the two administration modes. Also, there appeared to be no systematic sequence effect. In view of these findings, only the higher of the two scores was included for each student in the statistical analyses.

Figure 40 and Table 67 summarize the students' performance on the math tests. These data show that, on the average, higher scores were achieved on tests involving only rote computation (WJ–CAL and SAT–CMP) than those requiring application of math skills (WJ–AP, SAT–CON, and SAT–APP). Also, there was evidence of growth in mathematical skills involving calculations with age. A significant correlation was found between performance and age on the WJ–CAL ($r = .63$, $p < .001$) and the SAT–

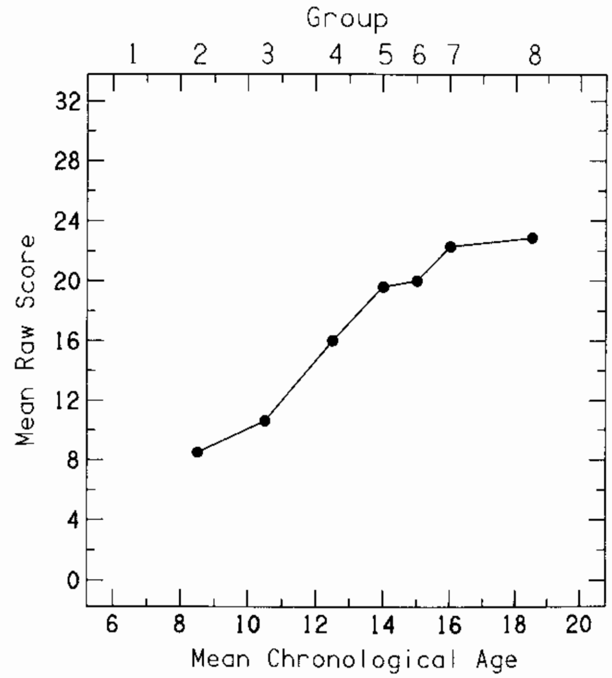

FIGURE 39. Performance on the Written Spelling Survey. Data are plotted at the midpoint of each age group.

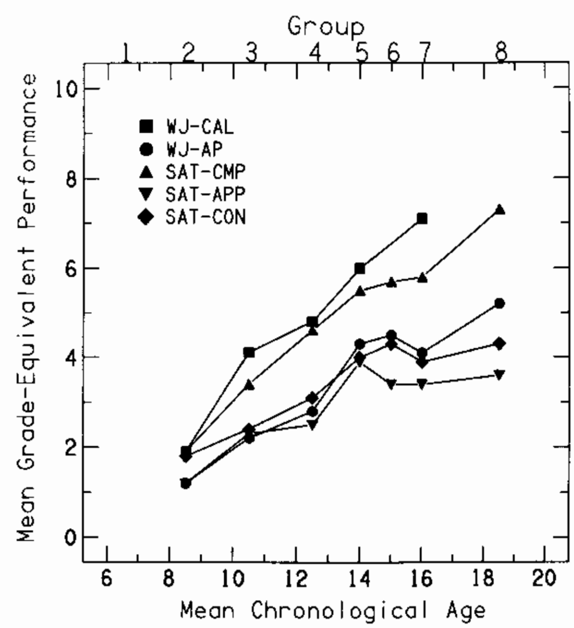

FIGURE 40. Math performance as a function of age. Data are plotted at the midpoint of each age group. W-J CAL, W-J AP = Calculations and Applied Problems subtests of the Woodcock-Johnson (1977) Psycho-Educational Test Battery; SAT-APP, SAT-CMP, SAT-CON = Applications, Computations, and Concepts subtests of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

TABLE 67. Performance on the math tests.

		WJ–CAL			WJ–AP				SAT–CON	SAT–CMP	SAT–APP
Group	*Age*	*Mean raw score*	*SD*	*Grade equiv.*	*Mean raw score*	*SD*	*Grade equiv.*	*Level*	*Grade equiv.*	*Grade equiv.*	*Grade equiv.*
2	7.5– 9.5	7 *n* = 12	2	1.0– 3.0	15 *n* = 13	6	under 1.0–2.3	1–2	K.4–3.5 *n* = 11	K.4–3.5 *n* = 11	K.2–1.2 *n* = 2
3	9.6– 11.5	13 *n* = 12	4	1.8– 6.2	19 *n* = 12	7	under 1.0–7.2	1–3	1.0–5.0 *n* = 11	1.9–4.8 *n* = 11	1.3–3.5 *n* = 7
4	11.6– 13.5	15 *n* = 21	5	1.2– 8.0	21 *n* = 22	7	under 1.0–5.8	1–4	K.6–6.2 *n* = 20	1.7–7.8 *n* = 21	1.3–5.4 *n* = 18
5	13.6– 14.5	18 *n* = 19	6	3.0– 10.6	24 *n* = 19	9	under 1.0–11.5	1–5	1.2–9.1 *n* = 19	1.8–9.9 *n* = 19	1.5–9.5 *n* = 17
6	14.6– 15.5	19 *n* = 32	7	1.0– 10.6	25 *n* = 32	7	under 1.0–12.9	2–4,6	1.7–11.0 *n* = 30	1.5–10.5 *n* = 30	1.1–10.2 *n* = 29
7	15.6– 16.5	20 *n* = 11	9	1.2– 12.5	25 *n* = 11	7	1.0–10.6	2,3,6	2.1–8.6 *n* = 11	2.2–12.8 *n* = 11	1.3–11.3 *n* = 11
8	16.6– 20.0	23 *n* = 25	6	2.6– 12.9	27 *n* = 25	7	1.6–10.6	2–4,6	1.0–10.7 *n* = 21	3.0–12.9	1.5–10.2

Note. WJ–CAL, WJ–AP = Calculations and Applied Problems subtests of the Woodcock–Johnson (1977) Psycho-Educational Test Battery; SAT–CON, SAT–CMP, SAT–APP = Concepts, Computations, and Applications subtests of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972).

CMP (r = .36, $p < .001$). Smaller improvements in performance with age occurred for the math tests involving application of math facts. The correlation between age and performance was .44 on the WJ–AP ($p < .001$), .36 ($p < .001$) on the SAT–CMP, and .36 ($p < .001$) on the SAT–APP. The data also show that even though math skills improve with age, the average performance of the hearing-impaired students is not equivalent to their hearing peers. Note also that higher scores were achieved on the WJ subtests than on the SAT–HI subtests.

Correlations Between Measures

The correlations for the tests of academic achievement appear in Table 68. All measures were correlated significantly, and in general, correlations within academic categories were higher than correlations across categories. Not unexpectedly, the subtests of the SAT–HI were relatively highly correlated, particularly the math subtests. Note also the relatively high correlations between the SAT–HI subtests and the individual reading tests (PIAT–RC, WRMT–PC, and WRMT–WI), spelling (PIAT–SP), and math subtests (WJ–AP and WJ–CAL).

Significant correlations were found between performance IQ (PIQ), as measured by the WISC–R, and all the academic tests: PIAT–RC (r = .35, $p < .001$), WRMT–PC (r = .31, $p < .001$), WRMT–WI (r = .17, $p < .05$), SAT–RC (r = .29, $p < .001$), PIAT–SP (r = .19, $p < .05$), SAT–SP (r = .39, $p < .001$), WJ–CAL (r = .33, $p < .001$), WJ–AP (r = .43, $p < .001$), SAT–CON (r = .36, $p < .001$), SAT–CMP (r = .36, $p < .001$), and SAT–AP (r = .36, $p < .001$). Speech intelligibility (SPINT) correlated significantly with performance on the four reading tests [PIAT–RC (r = .29, $p < .001$), WRMT–PC (r = .47, $p < .001$), WRMT–WI (r = .38, $p < .001$), and the SAT–RC (r = .24, $p < .001$)] and on one of the math tests, the WJ–AP (r = .28, $p < .001$).

The relation between hearing loss and academic performance was examined by again dividing the students

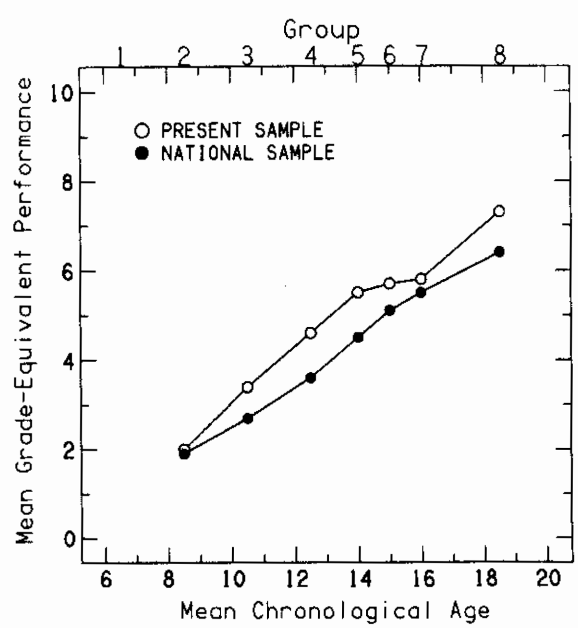

FIGURE 41. Performance on the SAT–CMP (Computation subtest of the Stanford Achievement Test, Madden, Gardner, Rudman, Karlsen, & Merwin, 1972) compared to national data (DiFrancesca, 1972). Data are plotted at the midpoint of each age group.

TABLE 68. Partial correlations, adjusted for age and performance IQ, between the academic tests.

Test	SAT–CON	SAT–APP	SAT–CMP	WJ–AP	WJ–CAL	SAT–SP	PIAT–SP	WRMT–WI	SAT–RC	WRMT–PC	PIAT–RC
PIAT–RC	.56*	.50*	.52*	.54*	.48*	.60*	.61*	.65*	.72*	.70	1.0
WRMT–PC	.63*	.59*	.50*	.74*	.54*	.62*	.65*	.78*	.82*	1.0	
SAT–RC	.68*	.65*	.62*	.64*	.55*	.77*	.64*	.69*	1.0		
WRMT–WI	.60*	.57*	.53*	.70*	.58*	.77*	.72*	1.0			
PIAT–SP	.64*	.64*	.55*	.58*	.55*	.80*	1.0				
SAT–SP	.63*	.63*	.65*	.57*	.61*	1.0					
WJ–CAL	.67*	.61*	.73*	.65*	1.0						
WJ–AP	.63*	.58*	.55*	1.0							
SAT–CMP	.78*	.80*	1.0								
SAT–APP	.90*	1.0									
SAT–CON	1.0										

Note. PIAT–RC, PIAT–SP = Reading Comprehension and Spelling subtests of the Peabody Individual Achievement Test (Dunn & Markwardt, 1970); WRMT–PC, WRMT–WI = Passage Comprehension and Word Identification subtests of the Woodcock (1973) Reading Mastery Test; SAT–RC, SAT–SP = Reading Comprehension and Spelling subtests of the Stanford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972); WJ–CAL, WJ–AP = Calculations and Applied Problems subtests of the Woodcock–Johnson (1977) Psycho-Educational Test Battery; SAT–CMP, SAT–APP, SAT–CON = Computations, Applications, and Concepts subtests of the SAT.
$*p < .001$.

into two groups, based on their better ear pure-tone average (Group I = PTA < 105 dB; Group II = PTA > 105 dB). Independent sample *t* tests, adjusted for unequal variances where appropriate, revealed significant group differences on all measures except the PIAT–SP. Correlations did not reach statistical significance between PTA and any of the academic measures for the students in Group I.

DISCUSSION

Reading

In general, the reading scores obtained from the hearing-impaired students evaluated in this project were similar to the 1971 scores reported by the Office of Demographic Studies (DiFrancesca, 1972), as measured by the SAT–HI. Additionally, the percentage of students who completed the different levels of the SAT–HI is similar to the distribution of those reported in the 1971 study. These findings suggest that, at least for reading skills, this particular group of hearing-impaired students is similar to those students who comprised the standardization sample.

The data from this study, as well as those reported by other investigators in this country (Furth, 1966; Myklebust, 1960; Trybus & Karchmer, 1977) and in Europe (Conrad, 1979), indicate that the majority of profoundly hearing-impaired students do not learn to read beyond a fourth-grade level. There were, however, some students in almost every age group whose equivalent performance score was higher than the fourth-grade level. Table 69 shows the percentage of students who achieved an equivalent performance score of fourth grade or higher on the three individual reading tests (PIAT–RC, WRMT–PC, WRMT–WI). The largest percentage of students is in the older age groups (Groups 5–8), and the majority of them achieved equivalent performance scores in the fourth–fifth-grade range. There is, however, a small percentage whose performance was above the fifth-grade level. An encouraging finding is that 52% of the students in Group 8 achieved an equivalent performance score of fourth grade or higher; only 8% of them, however, scored at or above the sixth grade. These data need to be interpreted in light of the results of Moores (1967) and O'Neill (1973), which suggest that standard reading tests yield spuriously high estimates of the reading levels of profoundly hearing-impaired individuals.

In general, the largest percentage of students achieved the highest scores on the PIAT–RC, followed by the WRMT–PC and the WRMT–WI. The finding that lower scores were achieved on the WRMT–PC than on the PIAT–RC is not surprising in view of the linguistic complexity of the reading task required on the WRMT–PC. This test requires a student to use the syntactic, semantic, and pragmatic aspects of language to supply a single missing word. In addition, it is a recall task rather than a multiple-choice (recognition) task. That is, students are required to retrieve a single vocabulary item from their lexicon rather than to identify it from among several choices.

In contrast, the highest reading scores were obtained on the PIAT–RC, which, of all the reading tests, places the fewest linguistic and processing demands on the students. The student is only required to identify one picture out of four to represent a short sentence or paragraph, a task that places limited demands on memory abilities. In addition, the nature of many of the pictures and sentences allows the student to select the correct answer by reading only one or two key words. Previous research also has shown that test format and task variables can influence the performance of hearing-impaired students on reading comprehension tests (LaSasso, 1978).

It was anticipated that hearing-impaired students would perform better on the sight vocabulary test (WRMT–WI) than on the reading comprehension tests. The sight vocabulary test required the student to read single words (without necessarily understanding them), placing limited demands on knowledge of the syntax and semantics of

TABLE 69. Percentage of students with a fourth-grade equivalent performance or higher on three reading tests.

		Grade equivalent performance							
Group	*Test*	*4–4.9*	*5–5.9*	*6–6.9*	*7–7.9*	*8–8.9*	*9–9.9*	*10–10.9*	*Total*
3	PIAT–RC		8						8
	WRMT–PC								0
	WRMT–WI								0
4	PIAT–RC	14		9		5	5		29
	WRMT–PC								0
	WRMT–WI	5							5
5	PIAT–RC	16	11				5		32
	WRMT–PC		15	5					20
	WRMT–WI	16			5				21
6	PIAT–RC	22	6	3	6		3		37
	WRMT–PC	6		6	3				15
	WRMT–WI	6	3						9
7	PIAT–RC	9							9
	WRMT–PC		27					9	36
	WRMT–WI	9	9						18
8	PIAT–RC	16	28	4			4		52
	WRMT–PC	6	8						14
	WRMT–WI	12	8						20

Note. PIAT–RC = Reading Comprehension subtest of the Peabody Individual Achievement Test (Dunn & Markwardt, 1970); WRMT–PC, WRMT–WI = Passage Comprehension and Word Identification subtests of the Woodcock (1973) Reading Mastery Test.

language, whereas the reading comprehension tasks required the understanding of phrase and sentence-length material. The mean data (Table 65) showed, however, that the students did not achieve better scores on the sight vocabulary test, but performed comparably on both types of tasks. One explanation might be that these hearing-impaired students had minimal phonic word-attack skills and therefore, did not have a strategy to effectively decode words phonetically, which reduced their performance on the sight vocabulary test (WRMT–WI). Performance on the WRMT–WI also may have been affected by their lack of knowledge of many morphological endings in oral/manual language, which, in turn, interfered with their ability to read higher level vocabulary words containing prefixes and suffixes such as *sociable, departure, produced,* and *delayed.*

Both the WRMT–PC and –WI subtests required a one-word expressive response from the students. Problems with using this type of format with sign language were noted during testing. For example, for the word *soapy,* the student usually signed the word "soap." For normal-hearing students, this would not be a correct response because the morpheme *y* had not been decoded. However, because most of the hearing-impaired students in this sample did not use morphological endings when they signed, it was felt that credit must be given for the signed response "soap." Occasionally, students added the morphological marker by fingerspelling "y," but it still was not apparent whether the student actually was decoding the *y* ending (which would turn the word into an adjective).

All correlations obtained between the SAT–RC and the individual reading achievement tests (PIAT–RC and WRMT–PC) were relatively high. As mentioned previously, the SAT–HI has been standardized on the hearing-impaired population. The high correlations between the SAT and the other measures support the use of the individual achievement tests (the PIAT–RC and WRMT–PC), standardized with normal-hearing students, for assessing reading achievement in the hearing impaired. This finding is particularly important for evaluating the performance of hearing-impaired students who demonstrate academic difficulties. For these students, the use of individual achievement tests often yields more prescriptive information than can be obtained with group achievement tests such as the SAT–HI.

Spelling

Both recognition spelling tests (PIAT–SP and SAT–SP) showed continued growth with age, with the highest level of performance approximating that of a sixth-grade student with normal hearing. With the exception of Group 3, similar performance was seen on the PIAT–SP and SAT–SP tests. One probable explanation for the superior performance of the students in Group 3 on the SAT is that only the students with the best spelling skills received the test; the other students in this age group lacked the prerequisite skills for the test. Thus, the mean data for the PIAT–SP include scores for all the students in Group 3, whereas the mean data for the SAT include the scores of a select subgroup of students in that age range.

The results of the Written Spelling Survey (WSS) showed continued growth with age, supporting the usefulness of this type of test with the hearing-impaired population. This particular measure, however, is in need of modifications before additional data are secured. For example, several of the items describe familial relationships (*wife, son, daughter, husband*), and the students may have learned to spell the words as one unit rather than as a result of normal developmental progression. That is, the ability to spell one of the more difficult words (e.g., *daughter*) does not necessarily indicate that the student is able to spell an unrelated word of equal difficulty.

A direct comparison between receptive and expressive spelling skills is not possible because of test differences. However, examination of expressive spelling skills suggests that the highest performance level approaches that of a normal-hearing sixth or seventh grader, a finding similar to that observed for the students' receptive spelling skills.

The correlation between the SAT–SP test and the PIAT–SP test is high, suggesting that the individual recognition spelling task on the PIAT is appropriate for use with the hearing-impaired population. Again, individual assessment might be preferable to group assessment, particularly for those students who demonstrate academic difficulties.

Math

Scores obtained on the computation achievement tests increased with age and were higher than scores obtained on math application tests. Performance on the SAT–CMP test was consistently lower than on the WJ–CAL. Close examination of the items on both tests reveals that the WJ–CAL subtest might be an easier task because only rote computations are required. In contrast, the SAT–CMP frequently requires the student to perform more than one operation to complete each item or occasionally to interpret word problems to set up the calculations.

The correlation between performance on the SAT–CMP test and the WJ–CAL test is high, again suggesting that an individual achievement test standardized with normal-hearing students is appropriate to use with the hearing-impaired.

It was interesting to note that this particular hearing-impaired sample scored higher on the SAT–CMP test than did other students in the country, as determined from the norms published by the Office of Demographic Studies (DiFrancesca, 1972). Recall that the data on reading comprehension showed the performance of these students to be comparable to the national average. Thus, these data suggest better math computation skills in the present sample rather than a population difference.

Scores on the SAT–HI were lower than the scores on the Woodcock–Johnson in the area of math application as well as computation. It might be argued that higher scores were achieved on the WJ–AP because it was administered twice to each student. This, however, cannot entirely account for the students' better performance on the test because not all students achieved their higher score on the second administration. Also, the superior performance of the students on the computation subtest of the Woodcock–Johnson, which was given to each student only one time, suggests that some factor related to test design renders the subtest of the Woodcock–Johnson easier for the students than the subtests of the SAT. One difference between the tests is that all word problems are signed and said to the students on the WJ–AP, whereas on the SAT–APP students must read their own questions. Furthermore, the most important features of the problems are either pictured or written for the student on the WJ–AP. Because the WJ–AP is an individual test, the examiner also has the advantage of probing and repeating items on it, which is not possible with the format of the SAT–APP.

Although both SAT–HI and Woodcock–Johnson scores on math applications show growth with age, there seems to be a plateau beginning with the 13.6–14.5 age group. It is interesting to note a "spurt" of growth with the highest age group. This might be related to the heavy emphasis on vocational training with students this age, which may, in fact, improve the students' ability to apply math. Math application scores are lower than math calculation scores because the former requires use of language to understand both the questions asked and the underlying meaning of the problems. Also, the lower math concept and math application scores relative to math computation scores is not surprising. The ability to apply math is assessed on the math concept and application tests by asking questions that are often linguistically quite complex. Therefore, hearing-impaired students' ability to use math knowledge, particularly in everyday situations, may not be assessed adequately by a format that places heavy demands on linguistic competency.

Correlational Data

The results showed a significant relationship between performance IQ and all the academic measures. The majority of correlations were in the .30–.40 range, which is similar to the reported median correlation of .33 between the WISC Performance IQ and academic achievement in normal-hearing students (Zimmerman & Woo-Sam, 1972). However, data reported by Watson, Goldgar, and Kroese (1983) show that correlations between the Hiskey–Nebraska Test of Learning Aptitude (H–NTLA) (Hiskey, 1966) and various measures of academic achievement in a group of profoundly hearing-impaired students more closely approximated the correlations typically reported for hearing students than the correlations between the Wechsler scales and achievement. Giangreco (1966) found correlations ranging from .40 to .60 between the H–NTLA and academic achievement for profoundly hearing-impaired students in lower grades (2nd–4th) and for students in upper grades (11th–12th), but considerably lower correlations for the students in the intermediate grades.

In the present study, correlations were not performed between the H–NTLA and academic performance because of differences in the norms (deaf or hearing) that were used to score the results, as described in chapter 7. Overall, the results of the present study and previous investigations suggest that nonverbal intelligence can contribute to interpretations of individual differences in the academic achievement of hearing-impaired students. There appears to be some question as to whether the WISC–R or the H–NTLA is the most appropriate measure. However, the strength of the correlations, irrespective of the measure used, suggests that nonverbal IQ is only one of several factors that are related to academic achievement in this population.

Speech intelligibility correlated significantly with all four of the reading tests and one of the math application tests (WJ–AP). Conrad (1979) also found a significant relationship between speech intelligibility and reading. In particular, he observed that the quality of a hearing-impaired child's vocal (oral) speech determines the extent to which s/he developed useful internal speech. According to Conrad, internal speech relies on a phonetic coding scheme that provides the individual with an efficient way of processing and storing spoken English. This scheme, in turn, is instrumental in decoding printed words, a process that presumably is required for interpretation and comprehension of written material. The present study did not assess the students' use of internal speech. Nevertheless, the data of Conrad suggest that meaningful interpretation of the relation between speech production and reading lies in the child's use of a phonetic coding system, that is, internal speech. That is, it is not speech intelligibility in and of itself that is important for reading, but rather, good speech production skills indicate the use of a phonetic code and an apparent knowledge of the sound-symbol system of English.

Finally, when academic performance was examined in terms of degree of hearing loss, there was a significant difference between the students with a pure-tone average of less than 105 dB HL and those with a PTA of greater than 105 dB on nearly all the measures. Correlations did not reach statistical significance between PTA and the academic measures for those students with more residual hearing (i.e., those with a PTA of 105 dB). In contrast, data reported by Conrad (1979), Jensema (1975), and Rogers and Clarke (1980) show a significant relation between hearing loss and academic performance. The present sample, however, was composed largely of students with profound hearing losses, unlike the other investigations that included subjects with a range of hearing losses.

Summary

The reading performance of students in this sample is similar to that reported for other populations of hearing-impaired children. In contrast, the math scores were slightly higher for students in this study than for other students in the country. On the average, the highest score achieved was equivalent to that for a fourth-grade child with normal hearing. The students' performance on the reading tests was affected by test format in that slightly higher scores were achieved with a multiple-choice test than with one that used a cloze procedure. Math computation skills and spelling abilities showed growth with age whereas reading skills did not. The ability to apply math facts showed some improvement with age, although not to the same extent as did the math computation skills. Speech intelligibility bore a significant relationship with the reading comprehension tests and one of the math application tests, whereas hearing level did not. Performance on the individual achievement tests correlated highly with the subtests of the SAT–HI, indicating that the former are appropriate to measure academic achievement in the hearing impaired.

REFERENCES

Conrad, R. (1979). *The deaf school child.* London: Harper & Row.

DiFrancesca, A. (1972). *Academic achievement test results of a national testing program for hearing-impaired students—United States: Spring, 1971* (Series D, No. 9). Washington, DC: Gallaudet College, Office of Demographic Studies.

Dunn, J. M., & Markwardt, F. C., Jr. (1970). *Peabody Individual Achievement Test.* Circle Pines, MN: American Guidance Service.

Furth, H. G. (1966). A comparison of reading test norms of deaf and hearing children. *American Annals of the Deaf, 111,* 461-462.

Giangreco, C. J. (1966). The Hiskey–Nebraska Test of Learning Aptitude (Revised) compared to several achievement tests. *American Annals of the Deaf, 8,* 566-577.

Hiskey, M. S. (1966). *Hiskey–Nebraska Test of Learning Aptitude.* Lincoln, NE: Union College Press.

Jensema, C. (1975). *The relationship between academic achievement and the demographic characteristics of hearing-impaired children and youth* (Series R, No. 2). Washington, DC: Gallaudet College, Office of Demographic Studies.

LaSasso, C. (1978). *An investigation of the validity and reliability of the cloze procedure as a measure of readability and comprehension for prelingually profoundly deaf students.* Unpublished doctoral dissertation, University of Maryland, College Park.

Madden, R., Gardner, E. F., Rudman, H. C., Karlsen, B., & Merwin, J. C. (1972). *Stanford Achievement Test.* New York: Psychological Corporation/Harcourt Brace Jovanovitch.

Moores, D. (1967). *Applications of "cloze" procedures to the assessment of psycholinguistic abilities of the deaf.* Unpublished doctoral dissertation, University of Illinois, Champaign–Urbana.

Myklebust, H. (1960). *The psychology of deafness.* New York: Grune & Stratton.

O'Neill, M. (1973). *The receptive language competence of deaf children in the use of the base structure rules of transformational generative grammar.* Unpublished doctoral dissertation, University of Pittsburgh.

Rogers, W. T., & Clarke, B. R. (1980). Correlates of academic achievement of hearing-impaired students. *Canadian Journal of Education, 5,* 27-39.

Trybus, R., & Karchmer, M. (1977). School achievement scores of hearing-impaired children: National data on achievement status and growth patterns. *American Annals of the Deaf, 122,* 62-69.

Watson, B. U., Goldgar, D. E., & Kroese, J. M. (1983). *A note on the use of the Hiskey–Nebraska Test of Learning Aptitude with deaf children.* Paper presented at the meeting of the American Psychological Association, Anaheim, CA.

Woodcock, R. W. (1973). *Woodcock Reading Mastery Test.* Circle Pines, MN: American Guidance Service.

Woodcock, R. W., & Johnson, M. B. (1977). *Woodcock–Johnson Psycho-Educational Test Battery.* Hingham, MA: Teaching Resources Corporation.

Zimmerman, I. L., & Woo-Sam, J. (1972). Research with the Wechsler Intelligence Scale for Children: 1960–1970. *Psychology in the Schools, 9,* 232-271.

Chapter 11

Visual Processing, Short-Term Memory, and Visual–Motor Coordination Skills

Wendy Lotz Judith Kroese Carol Puffer

Boys Town National Institute

Variables such as level of intellectual functioning, oral/manual language development, and hearing level are known to have an effect on academic learning in the hearing-impaired population. Less obvious and well-established is the effect of other learning abilities such as various forms of visual processing and memory, which have been found to be important to academic success in hearing children (Bryan & Bryan, 1975). It has been hypothesized that, in these areas, problems may be present in the hearing impaired that contribute to delays in academic achievement in addition to those imposed by the hearing handicap (Hagger, 1972; Hook, 1979).

This chapter contains a description of the tests used to assess abilities that are known to affect academic achievement in the normal-hearing population and that may affect the performance of some hearing-impaired students. These abilities consist of visual processing, memory, and visual–motor coordination. Visual processing includes the discrimination, analysis, synthesis, memory, and retrieval of information at the central level. Short-term memory is defined as the assimilation, storage, and recall of stimuli. In this study, only visual memory was assessed, although it was done so using signed as well as pictured items. Visual–motor coordination requires the integration of visual–perceptual skills and motor behavior (Bryan & Bryan, 1975; Johnson & Myklebust, 1967; Wiig & Semel, 1980). Another component typically assessed in normal-hearing students who are suspected to have learning disabilities is auditory processing. Performance could not be evaluated in this area because of the students' peripheral hearing losses.

METHOD

Procedure

The tests used to assess visual processing, memory, and visual–motor coordination are summarized in Table 70. A brief description of each test also appears in Appendix D. Table 71 contains a list of the tests and the acronyms used to refer to them throughout the monograph. The tests are ones that are employed routinely to identify learning disabilities in students with normal hearing (cf. Bryan & Bryan, 1978; Shinn, Algozzine, Marston, & Ysseldyke, 1982). The method for averaging basal and ceiling scores was the same as that described in previous chapters. Standard scoring and administration procedures were followed on all tests. In addition, two memory tests were developed, based on the format of the Detroit Tests of Learning Aptitude (DTLA) (Baker & Leland, 1967), because the existing measures in this area were inappropriate for use with the hearing impaired. These tests, referred to as Memory for Signed Words and Memory for Pictured Words, are explained fully in Appendix E.

RESULTS

Visual Processing

The results of the two tests used to measure visual processing, the Woodcock–Johnson Visual Matching (WJ–VM) subtest and the Woodcock–Johnson Spatial Relations (WJ–SR) subtest (Woodcock & Johnson, 1977), are plotted in Figure 42, along with the normal-hearing standardization data. Raw scores have been converted to an equivalent age score and averaged across students in each of the eight age groups. Table 72 contains the means and standard deviations of the raw scores on these two subtests for each age group.

Performance on both subtests shows improvement with age, but the hearing-impaired students' performance on the WJ–VM is poorer than that on the WJ–SR subtest. Significant correlations were found between performance level and age on both the WJ–SR subtest ($r = .44$, $p < .001$) and the WJ–VM ($r = .59$, $p < .001$). Performance on the WJ–VM subtest is comparable to that of hearing students for the first two age groups. Above 11.5 years of age, however, performance on the WJ–VM is consistently below that of the normal-hearing standardization sample. The hearing-impaired students' performance on the WJ–SR subtest is similar to normal-hearing students' for Groups 2, 4, 5, and 6. Scores for Groups 1 and 3, howev-

TABLE 70. Summary of test battery.

Test	Area assessed	Standardization population	Range of norms	Response format
Visual Processing				
Woodcock–Johnson (1977) Psycho-Educational Test Battery				
Spatial Relations	Part–whole relationships	Hearing students	1st–12th grade	Points to shapes needed to make a whole shape
Visual Matching	Visual scanning	Hearing students	1st–12th grade	Circles two identical number sequences out of a row of six
Memory				
Knox Cubes (Arthur, 1947)	Short-term visual memory	Hearing students	4.5–15.5 years	Imitates a block touching sequence
Memory for Pictured Words	Short-term memory	Nonstandardized	–	Names/signs series of pictures seen for short period of time
Memory for Signed Words	Short-term memory	Nonstandardized	–	Repeats series of signed words
Visual–Motor Integration				
Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967)	Eye–hand coordination	Hearing students	2.10–5.11 years	Copies geometric figures of increasing complexity

TABLE 71. Processing tests and acronyms.

Test	Acronym
Visual Processing	
Woodcock–Johnson (1977) Psycho-Educational Test Battery	
Visual Matching	WJ–VM
Spatial Relations	WJ–SR
Memory	
Knox Cubes (Arthur, 1947)	KNOX
Memory for Pictured Words	MPW
Memory for Signed Words	MSW
Visual–Motor Integration	
Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967)	VMI

er, are below expected levels, whereas performance of Groups 7 and 8 is above that of the normal-hearing students.

To determine if the performance of the hearing-impaired students differed significantly from the normal-hearing standardization sample, age quotient scores were computed for every subject by dividing the age score by the chronological age. The mean age quotient score on the WJ–VM was equal to .88 (SD = .27; n = 137); this value is significantly different from 1.0 (one sample t test; p < .001), indicating that the hearing-impaired sample achieved significantly lower scores than those expected for a comparable normal-hearing sample. On the other hand,

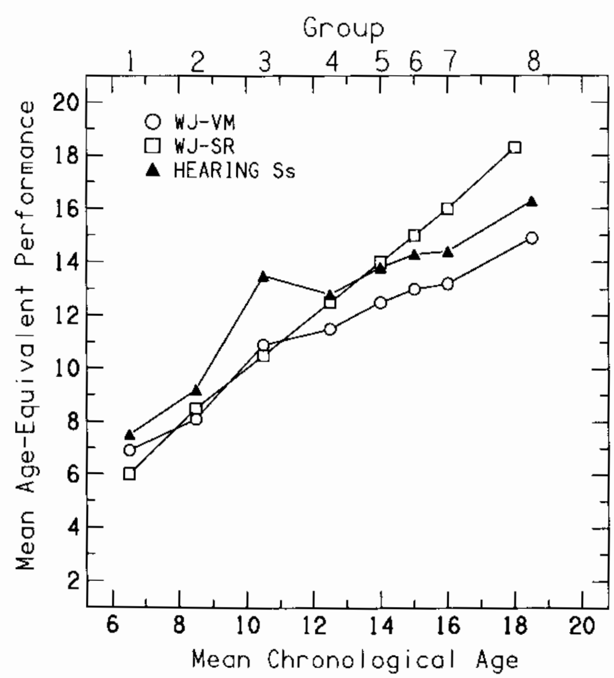

FIGURE 42. Performance of the hearing-impaired students on the Visual Matching and Spatial Relations subtests (WJ–VM and WJ–SR) of the Woodcock–Johnson (1977) Psycho-Educational Test Battery. Data are plotted at the midpoint of each age group.

TABLE 72. Performance on the visual processing tests.

Group	Age	WJ–VM n	WJ–VM M	WJ–VM SD	WJ–SR n	WJ–SR M	WJ–SR SD
1	4.5– 7.5	4	10.5	3.3	4	33.0	7.6
2	7.6– 9.5	14	13.3	3.2	14	36.7	8.6
3	9.6–11.5	12	16.6	2.8	12	44.6	6.9
4	11.6–13.5	21	18.1	3.2	21	43.4	8.2
5	13.6–14.5	19	19.0	2.6	19	45.1	6.9
6	14.6–15.5	32	19.2	4.2	32	45.9	7.9
7	15.6–16.5	11	19.3	3.7	11	45.5	6.9
8	16.6–20.0	25	20.9	2.3	25	49.1	7.2

Note. WJ–VM = Visual Matching subtest; WJ–SR = Spatial Relations subtest, both of the Woodcock–Johnson (1977) Psycho-Educational Test Battery.

the mean age quotient score on the WJ–SR was equal to 1.00 (*SD* = .39, *n* = 138) and did not differ significantly from the normal-hearing standardization sample.

Memory

The students' performance on the Knox Cubes (KNOX) (Arthur, 1947) test is plotted as a function of age in Table 73 and Figure 43. Values for the normal-hearing data points in Figure 43 are an average of the reported (standardized) scores within each age group. For example, for Group 1, consisting of children between 4.5 and 7.5 years of age, the reported scores for those four age intervals were averaged (a reported score of 4 for age 4.5 years, a reported score of 5.5 for age 5.5 years, etc.). Scores are available only through 15.5 years of age for the normal-hearing population. As the data in Figure 43 show, the

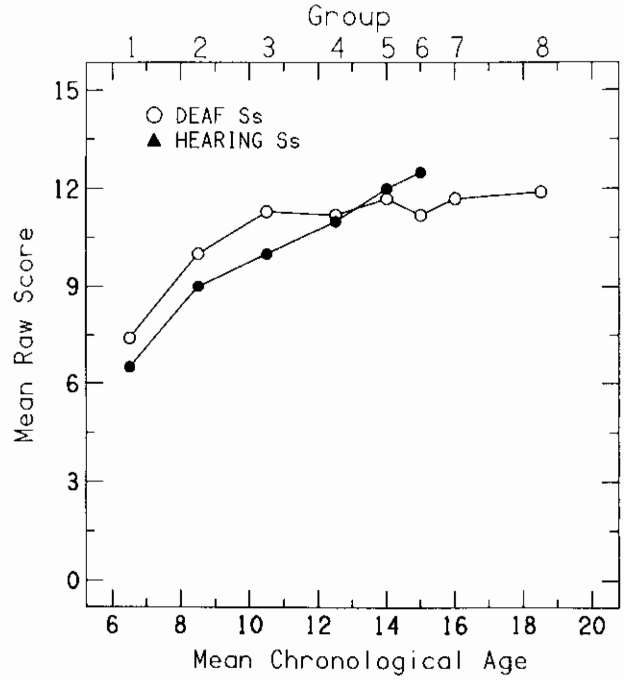

FIGURE 43. Raw scores of the hearing-impaired students on the KNOX test, compared to the performance of the normal-hearing standardization sample (Arthur, 1947). Data are plotted at the midpoint of each age group.

performance of the hearing-impaired students closely parallels that of the normal-hearing sample. In fact, the performance of the hearing-impaired students is slightly higher than that of the hearing sample up to 11.6–13.5 years of age (Group 4), after which the performance of both groups is essentially the same. There is a sharp improvement in performance between 4.5 and 11.5 years of age for both the normal-hearing and hearing-impaired students. The correlation between performance on this test and age is .37, which also was significant at the .001 level of confidence.

TABLE 73. Performance on the short-term memory tests.

Group	Age	KNOX M	KNOX SD	MSW M	MSW SD	MPW M	MPW SD
1	4.5– 7.5	7.4 *n* = 11	3.1	36.4 *n* = 11	7.0	33.1 *n* = 10	7.4
2	7.6– 9.5	10.0 *n* = 13	2.8	37.2 *n* = 14	8.5	39.8 *n* = 14	6.9
3	9.6–11.5	11.3 *n* = 12	2.1	41.5 *n* = 12	6.8	46.0 *n* = 12	4.8
4	11.6–13.5	11.2 *n* = 22	2.2	41.86 *n* = 21	8.9	46.7 *n* = 22	8.8
5	13.6–14.5	11.7 *n* = 19	1.8	44.3 *n* = 19	4.8	49.5 *n* = 19	3.6
6	14.6–15.5	11.2 *n* = 31	2.2	43.4 *n* = 31	6.9	51.3 *n* = 31	8.6
7	15.6–16.5	11.7 *n* = 11	2.9	40.4 *n* = 11	5.9	50.5 *n* = 11	5.8
8	16.5–20.0	11.9 *n* = 25	2.5	45.6 *n* = 25	5.5	53.6 *n* = 25	5.0

Note. KNOX = Knox Cubes (Arthur, 1947); MSW = Memory for Signed Words; MPW = Memory for Pictured Words.

Table 73 and Figure 44 also show the students' performance on the other two memory tests, the Memory for Signed Words (MSW) and Memory for Pictured Words (MPW). Included in the figure is the average performance of the normal-hearing students in the standardization sample on the two subtests of the Detroit Tests of Learning Aptitude (DTLA): Auditory Attention Span for Unrelated Words and Visual Attention Span for Objects. The Memory for Signed Words test is based on the former test of the DTLA and the Memory for Pictured Words test is based on the latter one. It should be noted that the stimulus words on the MSW and MPW differed from those in subtests of the DTLA. In addition, the MSW and the Auditory Attention Span for Unrelated Words on the DTLA are different in that the latter task employs spoken words only, whereas the MSW presents stimulus words using both sign and speech. As mentioned in Appendix D, the range of reported scores for each age group on the DTLA was averaged to correspond to the age groups used for the

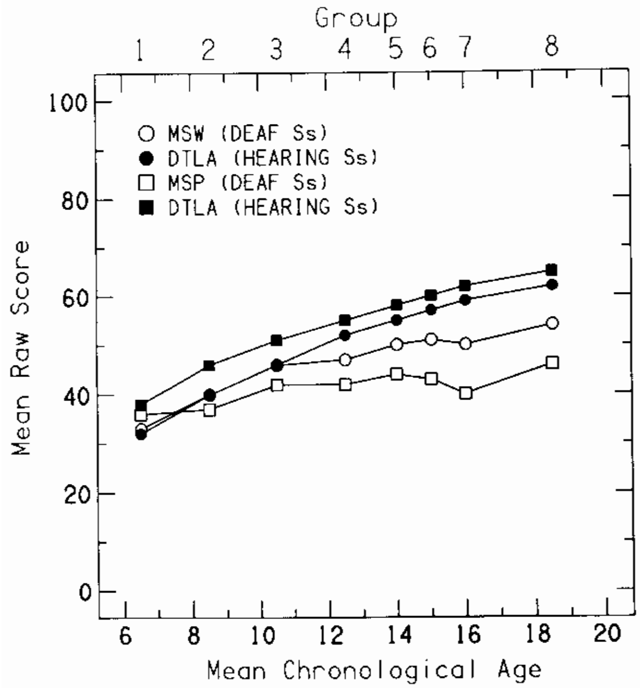

FIGURE 44. Raw scores of the hearing-impaired students on the MSW (Memory for Signed Words) and MPW (Memory for Pictured Words) adapted from the Auditory Attention Span for Unrelated Words and the Visual Attention Span for Objects subtests of the Detroit Tests of Learning Aptitude (DTLA) (Baker & Leland, 1967). Standardization data for the DTLA subtests are shown. Data are plotted at the midpoint of each age group.

hearing-impaired population. Because the DTLA data are reported in 3-month intervals, 13 different scores were averaged for each of the eight groups (i.e., 4 years 6 months; 4 years 9 months, 5 years 0 months, and so on).

The data in Figure 44 show that scores for the hearing-impaired population on the MPW are similar to those of the normal-hearing population through the 9.6–11.5 years of age (Group 3). For all other age groups, scores for the hearing-impaired population are below the normal-hearing population, and the gap widens with age. On the MSW, the scores for the hearing-impaired population are consistently below those for the normal-hearing population, and again the gap widens with age. In general, the hearing-impaired students achieved higher scores on the MPW than on the MSW.

Visual–Motor Coordination

The performance of the students on the Developmental Test of Visual–Motor Integration (VMI) (Beery & Buktenica, 1967) is listed as a function of age group in Table 74 and plotted in Figure 45. Again, raw scores were averaged for the normal-hearing standardization sample within groups for ages reported. Normative data for this test are available through 15 years 11 months of age. On the average, performance of the hearing-impaired students is substantially poorer than that of the hearing students for all but the youngest age group. Examination of the individual data (not shown in the figure) revealed that only 11 students achieved a perfect or near perfect score. The difference between the two groups of students increases with age until Group 5, after which the performance of the hearing-impaired students reaches a plateau. A significant correlation was found between performance on this measure and age ($r = .51$, $p < .001$).

TABLE 74. Performance on the Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967).

Group	*Age*	*n*	*M*	*SD*
1	4.5– 7.5	11	11.0	2.4
2	7.6– 9.5	14	12.6	2.4
3	9.6–11.5	12	16.6	3.4
4	11.6–13.5	22	15.9	3.8
5	13.6–14.5	19	17.6	3.8
6	14.6–15.5	32	17.7	4.2
7	15.6–16.5	11	18.1	3.8
8	16.6–20.0	25	18.3	3.3

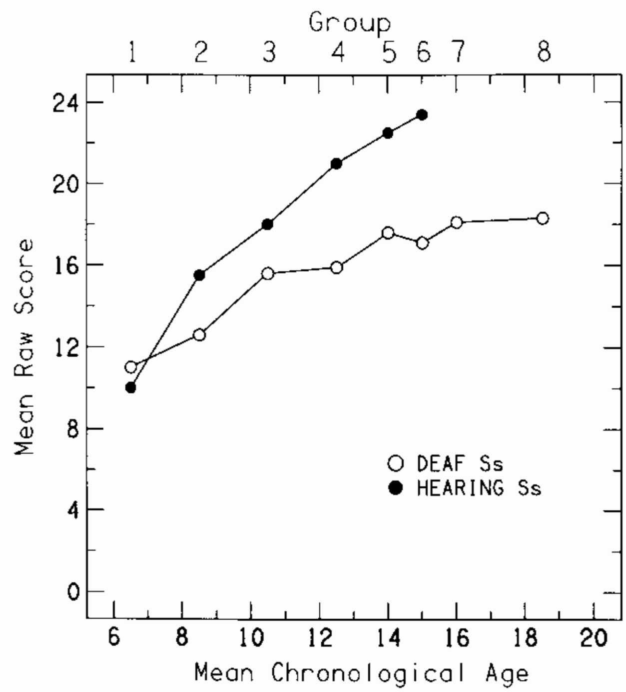

FIGURE 45. Raw scores of the hearing-impaired students on the VMI compared to the performance of the normal-hearing standardization sample (Beery & Buktenica, 1967). Data are plotted at the midpoint of each age group.

Correlations Between Measures

The partial correlations, adjusted for age and performance IQ, were computed between the visual processing, memory, and visual–motor integration. The correlation matrix appears in Table 75. The results reveal low but statistically significant correlations between a majority of the

TABLE 75. Correlations between tests of visual processing, memory, and visual–motor coordination.

Test	*VMI*	*MPW*	*MSW*	*KNOX*	*WJ–SR*	*WJ–VM*
WJ–VM	.16*	.25*	.34**	.28**	.38**	1.0
WJ–SR	.10	.17*	.09	.10	1.0	
KNOX	.28**	.20*	.19*	1.0		
MSW	−.05	.45**	1.0			
MPW	.10	1.0				
VMI	1.0					

Note. WJ–VM, WJ–SR = Visual Matching and Spatial Relations subtests of the Woodcock–Johnson (1977) Psycho-Educational Test Battery; KNOX = Knox Cubes (Arthur, 1947); MSW = Memory for Signed Words; MPW = Memory for Pictured Words; VMI = Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967).

*$p < .05$.

**$p < .001$.

tests. Of the six tests, the WJ–VM was the only one that correlated significantly with all the other measures. In contrast, the VMI was found to correlate least often with the other tests. The correlational data thus indicate that many of the tests, and in particular the VMI, assess different components of visual perception and memory.

Significant correlations were found between performance IQ (PIQ), as measured by the WISC–R, and all of the tests included in this part of the evaluation: WJ–SR (r = .38, $p < .001$), WJ–VM (r = .39, $p < .001$), KNOX (r = .48, $p < .001$), MPW (r = .21, $p < .001$), MSW (r = .37, $p < .001$), and VMI (r = .56, $p < .001$). Speech intelligibility correlated significantly only with the WJ–SR (r = .29, $p < .001$). It must be emphasized, however, that all significant correlations ranged only from .16 to .45.

To examine the relation between residual hearing and performance on the tests, the students were divided into two groups based on their better ear pure-tone average (Group I = PTA < 105 dB HL; Group II = PTA > 105 dB HL). Independent sample t tests, adjusted for unequal variance where appropriate, revealed significant group differences on the KNOX ($p < .05$) and VMI ($p < .01$). Correlations between PTA and the tests in this area revealed a significant relation between PTA and the WJ–SR (r = .36, $p < .01$), WJ–VM (r = .32, $p < .01$), KNOX (r = .37, $p < .01$), and VMI (r = .19, $p < .05$), but, again, the correlations are quite low.

DISCUSSION

Memory

Previous studies on the memory abilities of profoundly hearing-impaired students generally have shown that they perform similarly to normal-hearing subjects, provided a nonlinguistic task is used (Belmont & Karchmer, 1978; Blair, 1975; Doehring, 1960; Ross, 1969). In contrast, hearing-impaired subjects' performance on memory tasks that involve linguistic materials generally has been found to be poorer than that of normal-hearing subjects (Conrad, 1970, 1973, 1979; Craig, 1973; Wallace & Corballis, 1973). This finding has been explained by differences in the coding strategies used by the two groups. That is, normal-hearing persons tend to use a speech-based (phonetic) code to aid short-term retention and recall of linguistic information (Baddeley, 1966; Conrad, 1962, 1964; Hintzman, 1967; Kintsch & Buschke, 1969; Wickelgren, 1965, 1966). Deaf subjects, however, are hypothesized to be less able to use this kind of strategy because of their language deficiencies (Blanton, Nunnally, & Odom, 1967; Conrad, 1979; MacDougall, 1979; Pinter & Patterson, 1917). Recent research has shown that the majority of profoundly hearing-impaired subjects encode printed words according to their physical form (Conrad, 1979) and that deaf users of American Sign Language (ASL) employ a sign-based code for short-term retention of signs (Beluggi, Klima, & Siple, 1975). Sign-based coding also is used by profoundly hearing-impaired subjects for short-term retention of English words (Conlin & Paivio, 1975; Hanson, 1982; Moulton & Beasley, 1975; Odom, Blanton, & McIntyre, 1970).

The results of the present study are in general agreement with previous research. That is, when the memory task was nonlinguistic, as was the case with the Knox Cubes, the hearing-impaired students' performance was similar to that of the normal-hearing standardization sample. The other two memory tests, Memory for Pictured Words (MPW) and Memory for Signed Words (MSW) [adapted from a test standardized on normal-hearing students, the Detroit Tests of Learning Aptitude (DTLA)] required free-order recall of lexical items. As the results show in Figure 43, performance of the hearing-impaired students was inferior to that of the normal-hearing standardization sample on both the MPW and MSW, presumably because both required the recall of linguistic information. It should be kept in mind, however, that the MSW and MPW contained different stimulus items than the subtests of the DTLA, and the MSW test used a signed/spoken presentation mode, whereas the comparable subtest of the DTLA (Auditory Attention Span for Unrelated Words) used an oral/spoken mode.

A finding of interest is that the students achieved higher scores on the MPW than on the MSW. That is, the students recalled more lexical items when they were pictured than when they were signed. One possible explanation can be found in the research literature on the effect of type of stimulus material on memory. Because of the rich and abundant detail in pictures, recognition memory for this type of material has been found to be better than that observed for printed words (Shepard, 1967). In the context of the present study, the pictures had more detail than the signs, making them the most memorable stimuli. The performance difference on the MSW and MPW also raises a question as to whether these students were using a sign-based code to aid short-term retention. Most previous investigations that have examined coding strategies in signers have used subjects who are highly skilled in ASL (Beluggi et al., 1975; Siple, Fisher, & Beluggi, 1977). As noted in chapters 8 and 9, the students in this study appeared to use a Pidgin sign system, and the majority of them were not proficient users of either ASL or an English-based sign system. Thus, it appears unlikely that they employed an effective sign-based coding strategy.

Visual–Motor Coordination

The performance of the students on the Developmental Test of Visual–Motor Integration (VMI) indicates that they may have significant deficits in visual–motor coordination. Poorer performance by this population on the VMI suggests problems in eye–hand coordination and raises some crucial questions regarding its effect on handwriting and precision of signs. This area is of particular concern because all forms of communication (i.e., signing and writing) for nonoral, hearing-impaired persons depend on adequate visual–motor coordination. Research conducted by other investigators (Clarke & Leslie, 1971; Wiegersma & Van Der Velde, 1983) also has shown deficits on visual–motor tasks in the profoundly hearing impaired. It should be noted, however, that reduced performance in this area might reflect different instructional priorities in educational programs for the hearing impaired. That is, activities that help the normal-hearing child develop visual–motor coordination skills, such as handwriting, may not be emphasized in the hearing-impaired student's program. Additional research is needed to address this issue.

Visual Processing

A finding of significance is the performance of the hearing-impaired students on the visual processing tests. It was anticipated that they would perform comparably to the normal-hearing population because the hearing impairment should not interfere with visual perceptual skills. The results of the Spatial Relations subtest (WJ–SR) supported this notion, whereas the results of the Visual Matching subtest (WJ–VM) did not. These results should be interpreted with the knowledge that visual acuity problems may have interfered with some of the students' performance on the WJ–VM (or the VMI). As noted in chapter 2, technical difficulties precluded assessment of visual acuity in every student. It is unlikely, however, that visual acuity problems alone account for the reduced performance of the students.

One factor that might have affected performance on the WJ–VM is that normal-hearing students often verbally encode the number sequences in the test. Because of their linguistic deficits, it is possible that hearing-impaired students did not use such a strategy to assist them in the processing task. Reduced performance on the WJ–VM might also reflect differences in academic experiences between hearing and hearing-impaired students. Although hearing students are not taught visual scanning skills directly, such skills are probably developed through various reading activities. One such activity involves learning phonic word-attack skills, which is an area generally not emphasized in hearing-impaired education programs. Consequently, the hearing-impaired students may have had limited practice in the left-to-right visual scanning which is used to decode printed words.

Although either of the above factors may have an effect on visual processing, it also is possible that there is a real deficit in this ability in hearing-impaired students. Further research in this area is needed. Other areas of visual processing which need exploration include visual analysis skills, such as figure–ground perception, and visual synthesis skills, such as visual closure.

Correlational Data

The data revealed few significant intercorrelations between tests in this area. The VMI and WJ–SR correlated least often with the other tests, suggesting that these measures, in particular, tap skills that the other measures in processing and memory do not. In contrast, significant correlations were found between the WJ–VM and all tests. The data also showed low correlations between the three memory tests (KNOX, MSW, and MPW), presumably because two of them, the MPW and the MSW, are dependent on the use of verbal coding strategies that are not required for successful performance on the KNOX.

Performance IQ correlated significantly with all the measures, which is not unexpected in view of the type of behaviors and abilities sampled on the WISC–R and on the visual processing, memory, and visual–motor coordination tests. Speech intelligibility, on the other hand, does not appear to be related significantly to these abilities. Pure-tone average correlated significantly with 4 of the 6 measures, but the correlations were weak, suggesting that hearing level, at least in severely and profoundly hearing-impaired students, does not appear to be a major factor related to performance in this area.

SUMMARY

A group of tests was administered to assess selected learning skills that are known to affect academic achievement in students with normal hearing. These skills consisted of visual processing, memory, and visual–motor coordination. Scores of the hearing-impaired students were comparable to those of the normal-hearing students in the standardization samples on one visual processing test (WJ–SR) and one memory test (KNOX). Performance was below normal on the following tests: (a) WJ–VM, which required the use of left-to-right visual scanning skills; (b) the MPW and MSW, the two memory tests that presumably required the use of verbal encoding strategies; and (c) the VMI, which assesses the integration of visual–perceptual skills and motor behavior. It is possible that the educational experiences of the hearing impaired might account for their reduced performance on the visual scanning task (WJ–VM) and the VMI task, which required integration of visual–motor. Performance in this area correlated significantly with nonverbal intelligence, but did not appear to be strongly related to speech intelligibility or hearing level.

REFERENCES

ARTHUR, G. (1947). *A point scale of performance tests.* New York: Psychological Corporation.

BADDELEY, A. D. (1966). Short-term memory for word sequences as a function of acoustic, semantic, and formal similarity. *Quarterly Journal of Experimental Psychology, 18,* 362-365.

BAKER, H. J., & LELAND, B. (1967). *Detroit Tests of Learning Aptitude.* Indianapolis: Bobbs–Merrill.

BEERY, K. E., & BUKTENICA, N. A. (1967). *Developmental Test of Visual–Motor Integration.* Chicago: Follett Publishing.

BELMONT, J. M., & KARCHMER, M. (1978). Deaf people's memory: There are problems testing special populations. In M. Greenberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory.* New York: Academic Press.

BELUGGI, U., KLIMA, E. S., & SIPLE, P. (1975). Remembering in signs. *Cognition, 3,* 93-125.

BLAIR, F. X. (1975). A study of visual memory of deaf and hearing children. *American Annals of the Deaf, 102,* 254-263.

BLANTON, R., NUNNALLY, J. C., & ODOM, P. B. (1967). Graphemic, phonetic, and associative factors in the verbal behavior of deaf and hearing subjects. *Journal of Speech and Hearing Research, 10,* 225-231.

BRYAN, T. H., & BRYAN, J. (1978). *Understanding learning disabilities.* Sherman Oaks, CA: Alfred Publishing.

CLARKE, B., & LESLIE, P. (1971). Visual–motor skills and reading ability of deaf children. *Perceptual and Motor Skills, 33,* 263-268.

CONLIN, D., & PAIVIO, A. (1975). The associative learning of the deaf: The effects of word imagery and signability. *Memory and Cognition, 3,* 335-340.

CONRAD, R. (1962). An association between memory errors and errors due to acoustic masking of speech. *Nature, 193,* 1314-1315.

CONRAD, R. (1964). Acoustic confusions in immediate memory. *British Journal of Psychology, 55,* 75-84.

CONRAD, R. (1970). Short-term memory processes in the deaf. *British Journal of Psychology, 61,* 179-195.

CONRAD, R. (1973). Some correlations of speech coding in the short-term memory of the deaf. *Journal of Speech and Hearing Research, 16,* 375-384.

CONRAD, R. (1979). *The deaf school child.* London: Harper & Row.

CRAIG, E. M. (1973). Role of mental imagery in free recall of deaf, blind, and normal subjects. *Journal of Experimental Psychology, 97,* 249-253.

DOEHRING, D. G. (1960). Visual spatial memory in aphasic children. *Journal of Speech and Hearing Research, 3,* 138-149.

HAGGER, D. (1972). Specific learning disabilities in deaf children. *Australian Teacher of the Deaf, 13,* 13-19.

HANSON, V. (1982). Short-term recall by deaf signers of American Sign Language: Implications of encoding strategy for order recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 572-583.

HINTZMAN, D. L. (1967). Articulatory coding in short-term memory. *Journal of Verbal Learning and Verbal Behavior, 6,* 312-316.

HOOK, P. E. (1979). Learning disabilities in the hearing impaired. *Ear, Nose and Throat Journal, 58,* 40-52.

JOHNSON, D. J., & MYKLEBUST, H. (1967). *Learning disabilities: Educational principles and practices.* New York: Grune & Stratton.

KINTSCH, W., & BUSCHKE, H. (1969). Homophones and synonyms in short-term memory. *Journal of Experimental Psychology, 80,* 403-407.

MACDOUGALL, J. C. (1979). The development of visual processing and short-term memory in deaf and hearing-impaired children. *American Annals of the Deaf, 124,* 16-22.

MOULTON, R. D., & BEASLEY, D. S. (1975). Verbal coding strategies used by hearing-impaired individuals. *Journal of Speech and Hearing Research, 18,* 559-570.

ODOM, P., BLANTON, R., & MCINTYRE, R. (1970). Coding medium and word recall by deaf and hearing subjects. *Journal of Speech and Hearing Research, 13,* 54-58.

PINTER, R., & PATTERSON, D. G. (1917). A comparison between deaf and hearing children in visual memory for digits. *Journal of Experimental Psychology, 2,* 96-98.

ROSS, B. M. (1969). Sequential visual memory and the limited magic of the number seven. *Journal of Experimental Psychology, 80,* 339-347.

SHEPARD, R. (1967). Recognition memory for words, sentences, and pictures. *Journal of Verbal Learning and Verbal Behavior, 6,* 156-163.

SHINN, M., ALGOZZINE, B., MARSTON, D., & YSSELDYKE, J. (1982). A theoretical analysis of the performance of learning disabled students on the Woodcock–Johnson Psycho-Educational Battery. *Journal of Learning Disabilities, 15,* 221-226.

SIPLE, P., FISCHER, S., & BELLUGI, U. (1977). Memory for nonsemantic attributes of American Sign Language signs and English words. *Journal of Verbal Learning and Verbal Behavior, 16,* 561-574.

WALLACE, G., & CORBALLIS, M. C. (1973). Short-term memory and coding strategies in the deaf. *Journal of Experimental Psychology, 99,* 334-348.

WICKELGREN, W. A. (1965). Distinctive features and errors in short-term memory for English vowels. *Journal of the Acoustical Society of America, 38,* 583-588.

WICKELGREN, W. A. (1966). Distinctive features and errors in short-term memory for English consonants. *Journal of the Acoustical Society of America, 37,* 388-398.

WIEGERSMA, P. H., & VAN DER VELDE, A. (1983). Motor development of deaf children. *Journal of Child Psychiatry, 24,* 103-111.

WIIG, E. H., & SEMEL, E. M. (1980). *Language assessment and intervention for the learning disabled.* Columbus, OH: Charles Merrill.

WOODCOCK, R., & JOHNSON, M. B. (1977). *Woodcock–Johnson Psycho-Educational Test Battery.* Boston: Teaching Resources.

Part III

SUMMARY AND CONCLUSIONS

Chapter 12

Factors Related to Academic Achievement

David Goldgar Mary Joe Osberger

Boys Town National Institute

This chapter presents the results of the multivariate analyses that were performed to examine the relation between academic achievement and the other skills evaluated. Twenty-five tests were selected for the analyses. The tests were chosen to reflect a wide range of abilities and to maximize the number of subjects available for the multivariate analyses. Of the 150 students, data for these tests were complete for 85. The 25 tests and their assumed skill areas appear in Table 76. Tests that were not administered to a sufficiently large number of students were excluded from the analyses. To remove any possible age effects, all measures were converted to age-adjusted residual scores prior to analysis. The correlation matrix for the 25 measures is shown in Appendix F.

RESULTS

First, assessment of the relation between academic achievement and the other skill areas required combining the nine measures of academic achievement into a single index of performance for use as the dependent variable in a regression analysis. To obtain this index, a factor analysis of the age adjusted scores of the nine academic tests was performed, using principal factoring and the common criterion of a minimum eigenvalue of 1.0 for factor extraction. As expected from the high intercorrelations among the academic tests, which is discussed in chapter 10, a single factor accounting for about 67% of the variance was extracted. The factor score for each subject was computed and was used as the dependent variable in a stepwise regression analysis. The independent variables in the analysis were the 16 nonacademic measures. The correlation of each independent variable with the academic factor score is shown in Table 77. Five variables were selected from stepwise regression as contributing significantly to the regression equation. These were, in order of their entry, Woodcock–Johnson Picture Vocabulary (WJ–PV), Woodcock–Johnson Visual Matching (WJ–VM), Woodcock–Johnson Analogies (WJ–AN), Woodcock–Johnson Antonyms/Synonyms (WJ–A/S), and the Peabody Picture Vocabulary Test (PPVT). These five variables accounted for about 84% of the variation in the academic-factor scores. Four of the five tests assessed language; three of these evaluated expressive skills (WJ–PV, WJ–AN, and WJ–A/S). Thus, language (primarily expressive language) appears to be the major determinant of academic achievement in this population. Also, it is noteworthy that four of the five tests are from the Woodcock–Johnson Psycho-Educational Test Battery.

The 16 nonacademic tests also were factor analyzed. Four factors, accounting for 72% of the original variance, were extracted again using principal factoring and the common criterion of a minimum eigenvalue of 1.0. Varimax rotation was performed. The sorted, rotated, factor loadings are shown in Table 78. Loadings less than .25 in absolute value are replaced by .0. From the factor loadings, the four factors can be interpreted as Factor 1: Language, Factor 2: Visual perception, Factor 3: Speech–Hearing, and Factor 4: Memory. These factors differ from the assumed content areas in several ways. First, the analysis did not split receptive and expressive language, although higher loadings on the language factor are observed for the expressive measures. Secondly, the KNOX test appears to involve visual processing rather than memory skills, and this measure, together with two visual perception tests, the VMI and the WJ–VM, also load highly on the language factor.

The correlations of these four factors with the academic factor are shown in Table 79. The high correlation of the language factor with the academic factor (.80) is not surprising considering the results of the previous regression analysis. In fact, if one includes all 25 measures in a factor analysis, a similar solution is obtained with the academic and language tests together comprising the first factor. Together, the four factors account for about 81% of the variation in the academic factor.

DISCUSSION

The results of the multivariate analyses indicate that language, particularly expressive language, is the major determinant of academic achievement in the sample studied.

TABLE 76. Tests included in the multivariate analyses.

Area	*Test*
Academic	PIAT–RC, PIAT–SP Peabody Individual Achievement Test–Reading Comprehension and Spelling subtests (Dunn & Markwardt, 1970) SAT–RC, SAT–CAL, SAT–CON Stanford Achievement Test–Reading Comprehension, Calculations, and Concepts subtests (Madden, Gardner, Rudman, Karlsen, & Merwin, 1972) WRMT–WI, WRMT–PC Woodcock Reading Mastery Test–Word Identification and Passage Comprehension subtests (Woodcock, 1973) WJ–AP, WJ–CAL Woodcock–Johnson Psycho-Educational Test Battery–Applied Problems and Calculations subtests (Woodcock & Johnson, 1977)
Visual Perception	VMI Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967) WJ–SR, WJ–VM Woodcock–Johnson Psycho-Educational Test Battery–Spatial Relations and Visual Matching subtests
Memory	KNOX Knox Cubes (Arthur, 1947) MSW, MPW Memory for Signed Words and Memory for Pictured Words (see chapter 11)
Expressive Language	TO–OV Test of Language Development–Oral Vocabulary subtest (Newcomer & Hammill, 1977) WJ–PV, WJ–A/S, WJ–AN Woodcock–Johnson Psycho-Educational Test Battery–Picture Vocabulary, Antonyms/Synonyms, and Analogies subtests
Receptive Language	TO–PV, TO–GU Test of Language Development–Picture Vocabulary and Grammatic Understanding subtests PPVT Peabody Picture Vocabulary Test (Dunn, 1959)
Intelligence	WISC–R Performance IQ Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974)
Speech Hearing	SPINT: speech intelligibility PTA: pure-tone average in better ear, unaided

This finding should not be interpreted to mean that academic achievement is not influenced by receptive language as well. The three tests from the Woodcock–Johnson (WJ–PV, WJ–A/S, WJ–AN), which entered the regression equation, were labeled *expressive* because they required the student to provide a verbal (spoken or signed) response. However, receptive and expressive language processes do not operate independently of one another. In this situation, the student had to comprehend the language before an appropriate expressive response could be given. The results of the factor analysis, which loaded expressive and receptive skills on the same factor, further demonstrate the interrelation between expressive and receptive skills. It should be kept in mind, however, that although the results of this analysis showed no obvious distinction between receptive and expressive skills, several of the expressive measures (WJ–PV, TO–OV, WJ–A/S) did correlate more highly with academic achievement than did the receptive measures. Presumably, those students who demonstrated good expressive skills also demonstrated good receptive skills, although our clinical experience suggests there are exceptions to this pattern. Because of individual differences, as well as for the reasons discussed in chapter 8, assessment of both receptive and expressive skills appears to provide the most comprehensive information about a particular child's language performance.

TABLE 77. Correlations of independent variables with academic factor.

Variable		*r*
Developmental Test of Visual–Motor Intègration (Beery & Buktenica, 1967)	VMI	.58
Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977)		
Visual-Matching subtest	WJ–VM	.64
Spatial Relations subtest	WJ–SR	.36
Knox Cubes (Arthur, 1947)	KNOX	.50
Memory for Signed Words	MSW	.32
Memory for Pictured Words	MPW	.38
Woodcock–Johnson		
Picture Vocabulary subtest	WJ–PV	.81
Antonyms/Synonyms subtest	WJ–A/S	.79
Analogies subtest	WJ–AN	.77
Test of Language Development (Newcomer & Hammill, 1977)		
Oral Vocabulary subtest	TO–OV	.70
TOLD		
Picture Vocabulary subtest	TO–PV	.68
Grammatic Understanding subtest	TO–GU	.63
Peabody Picture Vocabulary Test (Dunn, 1959)	PPVT	.73
Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974)		
Performance IQ	WISC PIQ	.45
Speech Intelligibility	SPINT	.28
Pure-Tone Average	PTA	.17

The results also are of interest because the four language measures (WJ–PV, WJ–A/S, WJ–AN, and PPVT), which had the strongest relation with academic achievement, assessed lexical/semantic skills. Keeping in mind that the academic tests primarily evaluated reading abilities, except for those that involved math calculations, this finding is consistent with the research on reading in children with normal hearing, which has shown that word

TABLE 78. Factor-loading matrix for nonacademic variables.

Measure	Factor 1 (Language)	Factor 2 (Visual Perception)	Factor 3 (Speech–Hearing)	Factor 4 (Memory)
WJ–PV	.80	.31	.00	.00
TO–OV	.80	.00	.00	.26
WJ–A/S	.79	.36	.00	.00
WJ–AN	.77	.31	.00	.00
TO–PV	.77	.00	.00	.00
PPVT	.76	.00	.00	.00
TO–GU	.76	.00	−.31	.00
WISC PIQ	.00	.84	.00	.00
WJ–SR	.00	.80	.00	.00
VMI	.33	.77	.00	.00
KNOX	.38	.64	.00	.00
WJ–VM	.45	.52	.00	.26
PTA	.00	.00	.90	.00
SPINT	.30	.00	−.87	.00
MSW	.28	.00	.00	.80
MPW	.00	.28	.00	.80

Note. WJ–PV = Picture Vocabulary subtest of the Woodcock–Johnson (1977) Psycho-Educational Test Battery; TO–OV = Oral Vocabulary subtest of the Test of Language Development (Newcomer & Hammill, 1977); WJ–A/S, WJ–AN = Antonyms/Synonyms and Analogies subtests of the Woodcock–Johnson; TO–PV, TO–GU = Picture Vocabulary and Grammatic Understanding subtests of the TOLD; PPVT = Peabody Picture Vocabulary Test (Dunn, 1959); WISC PIQ = Performance IQ of the Wechsler (1974) Intelligence Scale for Children–Revised; WJ–SR, WJ–VM = Spatial Relations and Visual Matching subtests of the Woodcock–Johnson; VMI = Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967); KNOX = Knox Cubes (Arthur, 1947); PTA = pure-tone average; SPINT = speech intelligibility; MSW = Memory for Signed Words; MPW = Memory for Pictured Words.

TABLE 79. Correlation of derived factors with academic factor.

Factor	*r*
Language	.80
Visual Perception	.37
Speech–Hearing	−.08
Memory	.14

knowledge is one of the critical components of reading comprehension (cf. Johnson, Toms-Bronowski, & Pittelman, 1982). Additionally, one of the measures, the WJ–AN, assessed verbal reasoning skills, which has been identified as another significant skill in reading, at least in normal-hearing subjects (Davis, 1942).

Quigley and his associates (cf. Quigley, 1982) have approached the reading problems of the hearing impaired by assessing comprehension of syntax in relation to the syntactic structures that commonly occur in reading material. On the basis of Quigley's research, it might have been predicted that syntactic skills are a major factor in academic achievement. Unfortunately, because of the task demands of the TSA [Test of Syntactic Abilities (Quigley, Steinkamp, Power, & Jones, 1978)], it was not administered to a sufficient number of students to be included in the multivariate analyses. However, another receptive syntax test, the TO–GU, was included. This test did not enter the regression equation, and the results of the factor analysis showed that of all the language measures, it had one of the lowest correlations with academic performance (r = .76). This is not to say that knowledge of English syntax is unimportant in reading comprehension. Rather, the results suggest that lexical/semantic skills are relatively more important in reading (and academic performance) than syntactic skills, at least for the sample of hearing-impaired students under study. It also might be argued that the expressive language measures included in the multivariate analyses assessed limited expressive skills because only one-word responses were required from the student. However, the data in the correlation matrix in chapter 9 (Table 59) show that performance on the WJ–PV, WJ–A/S, and WJ–AN correlated highly with the ratings of the students' expressive (written) language samples (WC).

The multivariate analyses also indicate that visual perception skills, particularly those assessed on the WJ–VM, have a significant relation with academic achievement. Further, the results of the factor analysis suggest these skills are related to expressive language performance as well. These findings are of interest because they suggest that some of the students might have learning disabilities in addition to those imposed by the hearing handicap. In fact, it has been conservatively estimated that roughly 25% of all profoundly hearing-impaired children have an additional handicap (Gentile & McCarthy, 1973; Power & Quigley, 1971); the most frequent one cited is a "learning disability" (Karchmer, Rawlings, Trybus, Wolk, & Milone, 1979). The presence of multiply handicapping conditions in the deaf child is not surprising in view of the reduction in infant and child mortality over the years.

There are a number of problems with identifying additional learning problems in the profoundly hearing impaired. First, there is little agreement among experts as to what constitutes a learning disability even in a child with normal hearing. In fact, the estimated incidence of learning disabilities in the normal-hearing population ranges from 3% to almost 30%, depending on the criteria used to define the problem (Bruinincks, Glaman, & Clark, 1971; Clements, 1966; Tucker, Stevens, & Ysseldyke, 1983). There is general consensus that the learning-disabled child demonstrates a major discrepancy between expected achievement and his/her actual ability that is not the result of other known and generally accepted handicapping conditions or circumstances (Bryan & Bryan, 1975). It is not clear, however, how large the discrepancy must be between ability and achievement. Further, not all learning-disabled children demonstrate deficits in the same skills (Doehring, Trites, Patel, & Fiedorowicz, 1981; Watson, Goldgar, & Ryschon, 1983).

The definition most frequently used by school districts to identify learning-disabled students (U.S. Office of Education, 1977) emphasizes language deficits as central to the learning problem. Because of the general hierarchical manner in which language develops, problems at earlier learned levels of receptive oral language, expressive oral language, or both, will interfere with later developing receptive or expressive written language. Although it is not always clear why such a language problem exists, the learning-disabled child almost always demonstrates a deficit in language, either in isolation or together with various types of processing (auditory or visual) deficits. The problem of identifying a learning disability in a child with a peripheral hearing loss becomes obvious. Most of these children have severe language delays, documented in chapters 8 and 9 of this report, as a direct consequence of their hearing impairment. There is no reason to believe, however, that a primary learning disability could not coexist with a primary hearing loss. The problem becomes one of distinguishing between students whose severe language delays (and hence academic failure) are accounted for, in part, by an additional learning disability and students whose language problems are secondary to the combined effects of a peripheral hearing loss and various behavioral and environmental factors (quality of education, age of identification, etc.). Perhaps this is why investigators fail to provide criteria for the identification and classification of students with learning disabilities, even though the existence of this problem in the hearing impaired is acknowledged in the literature (Flathouse, 1979; Hagger, 1972; Karchmer et al., 1979).

One approach to the identification of hearing-impaired students with a learning disability is to identify those students whose delays are larger than those that would be expected to occur from the hearing loss alone. This approach requires normative data on hearing-impaired students' performance on academic, language, and related learning tests to determine average and below-average performance. Such data could then be used to identify those students whose academic performance is substantially below that of their hearing-impaired peers (such as one standard deviation below the mean), despite normal intelligence (as determined from nonverbal intelligence data). If these students also demonstrate lower-than-average (re hearing-impaired mean) performance on the language and processing tests, they might have an additional learning disability.

The performance of the poor achievers who have greater language delays than their hearing-impaired peers in the absence of any other processing deficits is more difficult to interpret. Before these students can be considered "learning disabled," the confounding effects of behavioral and environmental factors must be ruled out. Clinically, it often is possible to gain insight into the underlying cause for a given student's academic failure. Test data, as well as impressions from parents and teachers, can be used to examine an individual's learning style and learning difficulties. In fact, this is an integral part of the multidisciplinary team evaluation at the Boys Town National Institute (BTNI) (Hook, 1979; Moeller & Eccarius, 1980). Because of the problems mentioned above, it is more difficult to develop valid and reliable procedures than can be applied scientifically to identify such students from group data. Although the data collected in this study provide a unique opportunity to examine performance in the areas of academics, language, and processing, we have been unable to develop satisfactory criteria to identify students who might have an additional learning disability. A preliminary examination of the data, however, indicates that these students do exist. In addition, the nature of their learning problems appears to require remediation techniques that differ from those used routinely with hearing-impaired students. Clearly, further research is warranted in this area. Further, to our knowledge, visual perception skills are not routinely assessed in the hearing impaired. Even though the role of these skills in the reading process is not clearly understood, the results of this study indicate that the hearing-impaired student should be evaluated in this area, particularly if the student is demonstrating severe reading difficulties.[3]

The results of the regression analysis showed four of the five tests that accounted for the variance among students were from the Woodcock–Johnson Psycho-Educational Test Battery. This test battery assesses a wide range of skills and abilities (many of which were not sampled in this study) and all of the subtests have been standardized on the same population of students with normal hearing. During recent years, this test battery has gained widespread use in the identification of students with learning disabilities (Shinn, Algozzine, Marston, & Ysseldyke, 1982). The data from the present study indicate that subtests from the Woodcock–Johnson Psycho-Educational Test Battery yield useful information about the performance of hearing-impaired students as well. Another issue regarding the individual measures is the loading of the KNOX on the visual perception factor. Recall that this test was included as a memory test, yet the results of the factor analysis suggest that it assesses visual processing rather than memory skills. This split between the memory tests (MSW, MPW, and KNOX) also might reflect the linguistic demands and verbal coding strategies required for the MSW and MPW, which presumably were not necessary for the KNOX. The factor analysis showed a high correlation between the WISC–R Performance IQ and visual processing skills. This is not surprising in view of the visual perceptual skills required to perform some of the tasks, such as those involving puzzles and block designs. This finding does affirm that performance IQ should be applied with caution when attempting to interpret a student's performance on verbal measures such as language and reading tests.

Finally, the correlations in Table 79 indicate that speech intelligibility and degree of hearing loss are not correlated highly with academic achievement. This finding is not surprising in view of the correlation data presented in chapter 10. As pointed out in chapter 10, it should be kept in mind that most of the students in this study were profoundly hearing impaired. Had students been included with less

[3]Clinical approaches to the identification of hearing-impaired students with learning disabilities, and many of the concepts discussed in this report regarding learning disabilities in the hearing impaired, have been developed and implemented by three members of the BTNI staff (W. K. Lotz, J. M. Kroese, and C. Puffer).

severe hearing impairments, a significant relation between degree of hearing loss and academic achievement might have been found. With respect to the role of speech intelligibility, previous research has shown that this variable is not significantly related to academic achievement (Jensema, Karchmer, & Trybus, 1978). A weak relation also was found between the two memory tests, MSW and MPW, and academic achievement. This finding should be interpreted in light of the type of memory skills assessed. That is, both tests assessed short-term memory with a free-order recall task. Other tests such as those that assess ordered recall or retrieval abilities might have a more significant relation with academic achievement.

REFERENCES

ARTHUR, G. (1947). *A point scale of performance tests.* New York: Psychological Corporation.

BEERY, K. E., & BUKTENICA, N. A. (1967). *Developmental Test of Visual–Motor Integration.* Chicago: Follett Publishing.

BRUINICKS, R., GLAMAN, G., & CLARK, C. (1971). *Prevalence of learning disabilities: Findings, issues, and recommendations* (Research Rep. No. 20). Washington, DC: Department of Health, Education and Welfare.

BRYAN, T. H., & BRYAN, J. (1978). *Understanding learning disabilities.* Sherman Oaks, CA: Alfred Publishing.

CLEMENTS, S. D. (1966). *Minimal brain dysfunction in children* (NINCDS Monograph No. 3, Public Health Service Bulletin No. 1415). Washington, DC: U.S. Department of Health, Education and Welfare.

DAVIS, F. B. (1942). Two new measures of reading ability. *Journal of Experimental Psychology, 33,* 365-372.

DUNN, L. (1959). *Peabody Picture Vocabulary Test.* Circle Pines, MN: American Guidance Service.

DOEHRING, D. G., TRITES, R. L., PATEL, P. G., & FIEDOROWICZ, C. (1981). *Reading disabilities.* New York: Academic Press.

FLATHOUSE, V. (1979). Multiply-handicapped deaf children and Public Law 94-142. *The Council of Exceptional Children, 45,* 560-565.

GENTILE, A., & MCCARTHY, B. (1973). *Additional handicapping conditions among hearing-impaired students, United States: 1971–72* (Series D, No. 14). Washington, DC: Gallaudet College, Office of Demographic Studies.

HAGGER, D. (1972). Specific learning disabilities in deaf children. *Australian Teacher of the Deaf, 13,* 13-19.

HOOK, P. E. (1979). Learning disabilities in the hearing impaired. *Ear, Nose and Throat Journal, 58,* 40-52.

JENSEMA, C., KARCHMER, M., & TRYBUS, R. (1978). *The rated speech intelligibility of hearing-impaired children: Basic relationships and a detailed analysis* (Series R, No. 6). Washington, DC: Gallaudet College, Office of Demographic Studies.

JOHNSON, D. D., TOMS-BRONOWSKI, S., & PITTELMAN, S. D. (1982). Vocabulary development. *Volta Review, 84,* 11-23.

KARCHMER, M., RAWLINGS, B., TRYBUS, R., WOLK, S., & MILONE, M. (1979). *Educationally significant characteristics of hearing-impaired students in Texas, 1977–78* (Series C, No. 4). Washington, DC: Gallaudet College, Office of Demographic Studies.

MOELLER, M. P., & ECCARIUS, M. A. (1980). Evaluation and intervention with hearing-impaired children: A multi-disciplinary approach. *Journal of the Academy of Rehabilitative Audiology, 3,* 13-31.

NEWCOMER, P., & HAMMILL, D. (1977). *Test of Language Development.* Los Angeles: Western Psychological Services.

POWER, D. J., & QUIGLEY, S. P. (1971). *Problems and programs in the education of multiply-disabled deaf children.* Urbana: University of Illinois, Institute for Research and Exceptional Children.

QUIGLEY, S. P. (1982). Reading achievement and special reading materials. *Volta Review, 84,* 95-106.

QUIGLEY, S. P., STEINKAMP, M., POWER, D., & JONES, B. (1978). *Test of Syntactic Abilities.* Beaverton, OR: Dormac.

SHINN, M., ALGOZZINE, B., MARSTON, D., & YSSELDYKE, J. (1982). A theoretical analysis of the performance of learning disabled students on the Woodcock–Johnson Psycho-Educational Test Battery. *Journal of Learning Disabilities, 15,* 221-226.

TUCKER, J., STEVENS, L., & YSSELDYKE, J. (1983). Learning disabilities: The experts speak out. *Journal of Learning Disabilities, 16,* 6-14.

U.S. OFFICE OF EDUCATION. (1977). Procedures for evaluating specific learning disabilities. *Federal Register, 41*(230), 65082-65085.

WATSON, B. U., GOLDGAR, D. E., & RYSCHON, K. (1983). Subtypes of reading disability. *Journal of Clinical Neuropsychology, 5,* 377-399.

WECHSLER, D. (1974). *Wechsler Intelligence Scale for Children.* New York: Psychological Corporation.

WOODCOCK, R., & JOHNSON, M. B. (1977). *Woodcock–Johnson Psycho-Educational Test Battery.* Boston: Teaching Resources.

Chapter 13

Summary and Implications for Research and Educational Management

Mary Joe Osberger

Boys Town National Institute

SUMMARY OF MAJOR FINDINGS

Population Studied

The majority of students demonstrated a severe-to-profound sensorineural hearing loss. In roughly one quarter of the cases, the etiology of the hearing loss was due to recognizable genetic etiology, and in another one quarter of the students, the hearing loss was attributed to nongenetic causes, including rubella and meningitis. The etiology was unknown in the other half of the students. Compared to other populations of hearing-impaired students (Brown, 1969; Fraser, 1964, Rose, 1975), genetic deafness appeared to be underrepresented, and unknown causes were correspondingly overrepresented in the present sample. This finding appeared to be due to underascertainment rather than to an inherent population difference. It is likely that a percentage of the unknown cases represent genetic syndromes that would be identified with more extensive diagnostic testing and familial information.

A screening pediatric examination revealed the presence of physical problems in addition to a hearing loss in roughly one fifth of the students, the most common ones involving dental problems or the presence of minor anomalies. A definitive diagnosis of many of the physical findings also could not be made without additional diagnostic testing and familial information.

The results of the otolaryngologic examination revealed a wide range of physical findings, most commonly involving middle-ear disease. In fact, in roughly one fifth of the students, a middle-ear problem coexisted with the sensorineural impairment. Although the incidence was highest in the younger students, middle-ear problems occurred in the older students as well. It is unknown how long the middle-ear disease existed in these students, but the results of previous investigations (Osberger & Danaher, 1974) indicate that ear infections and even obstructions in the external ear canal can go undetected for months and even years in individuals with severe and profound sensorineural hearing loss.

The audiological data revealed that the hearing loss was confirmed earliest in those students who demonstrated the most severe impairments. However, the relative amount of time between identification of the hearing loss and acquisition of a hearing aid was the same, irrespective of the degree of hearing loss. For students in the younger age groups (under 13 years of age), the hearing loss was confirmed around 2 years of age, and a hearing aid was acquired roughly 6 months later. On the average, the hearing losses of the older students were not confirmed until nearly 3 years of age, with amplification secured 1–2 years later. Electroacoustic analysis revealed that 30–40% of the students' hearing aids were nonfunctional. This figure actually underestimates the incidence of nonfunctioning hearing aids because it does not include the number of aids (and earmolds) found to be defective when a real-ear check was performed at the school prior to the time of the evaluation and electroacoustic analysis. The majority of the students used monaural amplification, and hearing aid usage tended to decrease as age and degree of hearing loss increased. Also, as age increased there was a tendency for increased use of behind-the-ear instruments rather than body hearing aids.

Vestibular problems, as determined from caloric data, were present in roughly one fifth of the students. Of these, approximately one half demonstrated a unilateral hypoactivity and one half demonstrated bilateral hypoactivity. Postural tests revealed spontaneous or positional nystagmus in one fifth of the students, the majority of whom also demonstrated abnormal caloric responses. Only a small percentage of the sample showed gaze nystagmus on the ocular-tracking test.

The speech of the students was highly unintelligible as determined by a speech intelligibility rating. A panel of speech-language pathologists, with no extensive experience in evaluating the speech of the hearing impaired, rated approximately 18% of what the students produced as intelligible. Analysis of segmental production revealed systematic error patterns depending on the manner and place of articulation for consonants and on tongue height and tongue position for vowels. There was no difference in speech skills across age groups. The correlational data revealed a significant relation between speech production and the age when the hearing loss was suspected and confirmed.

As a group, the students demonstrated nonverbal intelligence within the average range. Mean data were consistent with those reported for the normal-hearing standardization samples, although there was a significant difference between the distribution of IQ scores for this sample and the standardization sample. This was due to a large number of subjects within the range of mental retardation. There were no statistically significant differences among age-group means. The verbal IQ scores of the students were significantly below average, presumably due to their language deficits.

The characteristics of the students in terms of degree of hearing loss, age of identification of the hearing loss, hearing aid usage, speech production abilities, and intellect are similar to those reported for other samples of hearing-impaired students in comparable educational settings (Jensema, Karchmer, & Trybus, 1978; Karchmer & Kirwin, 1977; Karchmer, Rawlings, Wolk, & Milone, 1979; Karchmer & Trybus, 1977; Quigley, 1982). That is, on the average, they are profoundly hearing impaired and of normal intelligence (at least as determined from the nonverbal IQ data). As a group, they do not appear to make optimal use of amplification, which is indicated by the relatively high frequency of nonfunctioning hearing aids and the decrease in hearing aid usage with age. Their speech is highly unintelligible, a pattern that shows very little change with age. Of interest is the trend of better speech in those students whose losses were suspected and were confirmed the earliest.

The above information is of interest not only to the present study, but it also serves to document the population characteristics in a state-supported residential setting since the introduction of Public Law 94-142, the Federal Education of the Handicapped Act (U.S. Department of Health, Education and Welfare, Office of Education, 1977). It might be hypothesized that this law would result in an increased number of alternative educational programs, which, in turn, would affect the type of student who attended a residential school. The characteristics of this sample, however, are highly similar to those reported for other samples of hearing-impaired students prior to the introduction of PL 94-142 in 1975. Since the introduction of 94-142, there appears to be a negligible change in the characteristics of the students who attend this school. This situation may not be true, however, in states which are less rural and are more heavily populated than Nebraska.

Language Skills

A battery of tests was used to evaluate the lexical/semantic, syntactic/morphological, and when possible, functional communicative skills in receptive and expressive language. On the average, the students demonstrated severe delays in all aspects of receptive and expressive language. Performance on most of the measures did not correlate significantly with age, and there was negligible growth in language skills after 12–13 years of age. The correlational data revealed essentially no significant relationship between hearing level and either receptive or expressive language. Low but significant correlations were obtained between nonverbal intelligence and most of the language measures. The majority of expressive language tests correlated significantly with speech intelligibility, whereas most of the receptive measures did not. A significant relation was found between receptive and expressive language skills.

The data showed a trend toward higher performance on receptive than on expressive language tests. Within the areas of receptive and expressive language, there was a trend toward higher scores on tests assessing lexical/semantic rather than syntactic/morphological skills. Also, the data suggested the students were better able to perform tasks that required *application* of lexical knowledge rather than *retrieval* of specific lexical labels. In general, the language data suggest that the subjects in this sample have mastered the verbal concepts, vocabulary, and syntactic structures necessary to comprehend and produce only the simplest sentences of English.

The tasks that appeared to tap the linguistic skills most strongly related to academic achievement were subtests from the Woodcock–Johnson (1977) Psycho-Educational Test Battery. In addition to assessing diversified language and cognitive abilities, the subtests of the Woodcock–Johnson have been standardized on students spanning a wide age range (1st–12th grades). This latter aspect is particularly important because few standardized measures are available that are appropriate for use with older hearing-impaired students. The subtests of the Woodcock–Johnson also showed a high correlation between the items on the Inventory of Language Assessment Tasks (LAT) (Kellman, Flood, & Yoder, 1977), a test that provides unique information about later developing language skills not routinely assessed on other language measures. Several procedures were developed to analyze the content of the students' signed and written language measures. Performance on these tests correlated highly with the other standardized samples. Thus, these procedures, which are practical to administer, appear to provide useful information about the students' expressive language abilities.

Academic Performance and Related Learning Skills

A battery of individual achievement tests, and one group test [the Stanford Achievement Test–Hearing Impaired edition (DiFrancesca, 1972)] were used to assess a range of skills in reading, spelling, and math. Severe delays were found in reading comprehension. The highest average performance was comparable to that of a fourth-grade child with normal hearing, a finding consistent with those of previous investigators (see Quigley, 1982). Deficits were observed in the students' sight vocabulary as well as in reading comprehension skills. The students also were delayed in receptive and expressive spelling, although to a lesser extent than in the area of reading. Further, there was a trend toward improved performance with age on the spelling tests, which was not apparent on the reading measures.

In the area of math, higher scores were achieved on those tasks involving calculations than on those requiring application of language to solve the problems. Performance in all areas of math increased with age, and this trend was most pronounced for tests involving only calculations. The math abilities of this sample of students appeared better than those reported for other groups of hearing-impaired subjects (DiFrancesca, 1972).

Skills known to affect achievement in normal-hearing students, consisting of visual processing, visual–motor coordination, and short-term memory, also were assessed. The students' performance on a test that involved visual scanning skills (WJ–VM) differed significantly from the normal-hearing standardization data, whereas their performance on a spatial relations test (WJ–SR) did not. Also, scores achieved on a test of visual–motor coordination (VMI) [Developmental Test of Visual–Motor Integration (Beery & Buktenica, 1967)] tended to be poorer than those reported for the normal-hearing standardization sample. The reduced performance on these two tests (WJ–VM and WJ–SR) might be due, in part, to differences in academic priorities in education programs for the normal-hearing and the hearing impaired.

Deficits in short-term memory were observed only when the task required the student to recall linguistic information. Free-order recall of pictured items was superior to recall of signed items. The short-term memory data suggest that the students, as a group, were not effectively using phonetic- or sign-based coding strategies to assist in the recall of information.

Finally, high intercorrelations were observed between the academic tests, particularly between those measures that assessed component skills in the same area. Stepwise regression analysis identified five variables [WJ–PV, WJ–VM, WJ–AN, WJ–A/S, and PPVT (Peabody Picture Vocabulary Test, by Dunn, 1959)] that accounted for 84% of the variation in academic performance. These findings suggest language—in particular, expressive language—is the primary determinant of academic achievement in this sample. However, receptive language also contributes to academic performance, which is demonstrated by the results of the factor analysis that loaded receptive and expressive language on the same factor. Degree of hearing loss, speech intelligibility, and short-term memory for linguistic information contribute less to understanding academic achievement than do language abilities and visual processing skills, at least for the sample under study.

IMPLICATIONS OF THE FINDINGS

Language Performance and Assessment Procedures

The major finding of this study may seem intuitive. That is, reading is generally considered parasitic upon the spoken language, and in view of this, it is not surprising that language was found to be the major determinant of academic achievement. To our knowledge, however, there are few, if any, reported studies that have quantified this relationship in the hearing impaired. Of significance is the range of language skills found to contribute to academic performance. These consist of receptive and expressive vocabulary, as measured by the PPVT and WJ–PV, respectively, knowledge of antonyms and synonyms (WJ–A/S), and the ability to formulate analogies (WJ–AN). In particular, the tasks tapped recognition (PPVT) and retrieval (WJ–PV) of specific lexical labels, application of lexical knowledge (WJ–A/S and WJ–AN), and verbal conceptual skills. Thus, the findings of this study indicate that language programs for the hearing impaired should focus on a conglomerate of linguistic skills to assist the child in learning to read.

Indeed, it has long been recognized that reading requires a complement of language abilities in the individual with normal hearing (Chall, 1967). Only a limited number of studies on component language skills in the hearing impaired appear in the literature, and in general, this has been a neglected area of research. Available data indicate that required reading skills, such as word analyses, vocabulary, syntax, inferencing ability, and figurative language, all present difficulties to the hearing-impaired child learning to read (Conley, 1976; Iran-Nejad, Ortony, & Rittenhouse, 1981; Pickens, 1978; Quigley, 1982). These findings are in general agreement with the skills of this investigation. The importance of these various language skills is highlighted by Wilson's (1979) comments that most reading tests up to the third-grade level evaluate word analysis skills and vocabulary. Above this level, the tasks place increasing demands on the ability to infer meanings that are not explicitly stated in the text. In view of this situation, the consistent finding of a fourth-grade reading level in the profoundly hearing impaired is not surprising.

Skills such as those assessed on subtests of the Woodcock–Johnson Psycho-Educational Test Battery (as well as other measures not included in the multivariate analyses) are not routinely evaluated in the hearing impaired for purposes of educational management. In fact, even the language research with the hearing impaired generally has focused on the structural aspects of written language samples or comprehension of syntactic structures (see Kretschmer & Kretschmer, 1978; Quigley & Kretschmer, 1982). It is hopeful that the information in this study will provide educators and clinicians with tools to examine the language skills of their students in a more comprehensive manner. At the same time, limitations of the applied measures are recognized, which are addressed below.

First, for the most part, comprehension and production of words and sentences were evaluated in isolation and in the absence of other contextual information. The more pragmatic aspects of language were not tapped primarily because few procedures were available to quantify this aspect of communication, at least with a large group of subjects. In the clinical situation, informal procedures may be applied to assess pragmatic aspects of language, such as verbal problem solving, the ability to perceive and express relationships, and question comprehension and related aspects of discourse. The application of such techniques to assessment and teaching is described elsewhere (Moeller & McConkey, 1984; Moeller, McConkey, & Osberger, 1983). There continues to be a need, however, to develop practical procedures to evaluate pragmatic skills in the hearing impaired and to describe deficits in this area of language performance quantitatively. Further, a need exists to design and implement procedures that emphasize development of pragmatic skills in the teaching situation. Wilbur (1977) contended that many of the syntactic errors in the language of the hearing impaired reflect inappropriate teaching methods. That is, language training often focuses on the correct structure of single sentences in the absence of supporting contextual information. As a consequence, hearing-impaired individuals often are unaware that the syntactic structure of a sentence depends on the contextual environment in which it occurs.

Some additional comments regarding testing protocol are necessary. The majority of measures administered to the students were developed for a spoken rather than a signed presentation. As already noted in chapter 8, the iconic nature of some signs makes it possible to select correct items on multiple-choice, receptive language tests using a perceptual matching strategy rather than linguistic knowledge. This is not to say a signer should not take advantage of iconic cues. Rather, the presence of such cues can confound test results when attempting to assess an individual's ability to recognize a specific lexical label in a multiple-choice format. To circumvent this problem when assessing vocabulary knowledge, it may be necessary to develop tests with foils that have sign-formation characteristics similar to the test item. Another problem noted with a sign presentation is that the length of some sentences may place an excessive load on short-term memory. For example, research (Bellugi & Fischer, 1972) has shown that manually coded English systems can take up to 2½ times as long as spoken English to transmit the same information. It is unclear to what extent these variables interfere with accurate assessment of language skills. Our extensive experience in evaluating the language skills in the hearing impaired suggests that factors such as these need to be investigated systematically. It may be that tests need to be developed that take a signed mode of administration into consideration.

Another issue that needs to be addressed is assessment of both comprehension and production skills. Even though it is generally assumed that a child's production skills are a direct reflection of his/her comprehension skills, research with normal-hearing children has shown that comprehension of linguistic information does not always precede its production (Chapman, 1978; Miller, 1981). Because of the complex interaction between receptive and expressive language, it seems necessary to assess skills in both areas. In addition, comprehension testing permits examination of the child's ability to function as an information recipient. Of particular importance is the need to determine if the child relies on comprehension strategies (Chapman, 1978) to understand information presented to him/her. This determination often becomes important when a hearing-impaired child is administered a test designed for younger children with normal hearing. In this situation, the hearing-impaired child approaches the task with more sophisticated comprehension strategies than his/her language level suggests. Use of such comprehension strategies can assist the child in identifying a test sentence on the basis of one or two key words rather than linguistic knowledge of the entire sentence. Even though the use of comprehension strategies occurs during the normal language-development process, there are times when the clinician needs to know if the child comprehends a particular linguistic structure that is being assessed.

Finally, the concept of a "developmental age level" or "equivalent language age" should be applied with caution when interpreting the performance of hearing-impaired students on standardized tests. If a child achieves a score comparable to that of a normal-hearing 7-year old, this should not be interpreted literally. That is, the hearing-impaired child's language skills should not be assumed to be the same as those of a 7-year-old child with normal hearing. Even though there is some evidence to suggest that the stages of language acquisition in children who use manually coded English are similar to those observed in children with normal hearing (Schlesinger & Meadow, 1972), the data are far from conclusive in this area. Our qualitative analysis of hearing-impaired children's error patterns on standardized tests, as noted in chapter 8, suggests that their language knowledge is influenced by instructional priorities. Because this study analyzed language performance on a cross-sectional rather than longitudinal basis, this issue cannot be addressed quantitatively.

Reading Performance and Related Factors

For children with normal hearing who have mastered a complement of linguistic skills, the early stages of reading primarily involve learning another code (written symbols) for the oral language they already have mastered. The profoundly hearing-impaired child, however, approaches the task of reading with severe language deficits, as this study documents. As a consequence, reading often becomes a language-learning task. Even if successful at decoding the printed words, comprehension may not occur because the hearing-impaired child often does not possess a basic understanding of the language s/he is attempting to read. Given this situation, and the results of the present study, it seems obvious that the most effective way to improve the reading skills of the hearing-impaired is to assist them in developing the language foundation needed to read successfully. It should be noted that improved reading abilities in the profoundly hearing impaired is not an unrealistic expectation, as demonstrated by the success in this area by individual school programs (Calvert, 1981; Lane & Baker, 1974).

Concurrent with the language-development process, there appears to be a need to emphasize other skills involved in reading. Identification of these skills is not a straightforward process because disagreement exists about their relative contribution to reading. There seems to be general consensus that learning to read involves decoding, which is the translation of printed words into a representation of spoken language, and comprehension, which is the understanding of decoded material. Traditionally, two approaches have been used to teach reading to children with normal hearing. One is known as the phonics approach, which emphasizes the phonetic structure of words and the *code breaking* process (Flesch, 1955). The other, known as the *whole-word approach*, emphasizes the meaning that should be derived from reading with essentially no need to first decode the written symbols into spoken language (Smith, 1971). An extensive review of the research (Chall, 1967) on the effectiveness of the two strategies in teaching reading to normal-hearing children has shown equivocal results for the two methods. Within recent years, however, emphasis seems to be placed on the whole-word approach because available evidence suggests that decoding the written symbols, and then recoding them into their phonologic representation is not necessary to obtain access to the information stored in the reader's internal lexicon (Baron, 1973). However, research has also shown that good readers are better able to access phonetic representation than poor readers (Mark, Shankweiler, Liberman, & Fowler, 1977). Even though the exact role of decoding in reading is unclear, it appears that the ability to decode is a skill characteristic of good readers. At this point, it seems appropriate to make a distinction between beginner and advanced readers. According to Fries (1963), beginning reading focuses on the problem of decoding, whereas advanced reading is primarily concerned with comprehension and reading rate. Thus, once a certain level of reading proficiency is attained, decoding appears to be less important than during the early stages of reading, although some investigators would argue that decoding skills are seldom critical to the reading process (Ewoldt, 1982).

Early teaching procedures for the hearing impaired stressed the structural aspects of language in both language and reading activities (Fitzgerald, 1929). More recent approaches deemphasize the role of phonics and syntax in deriving meaning from the text. Ewoldt (1982) argued that hearing-impaired readers can construct meaning from what they read, based on information provided by the text and their own sense of plausibility. It is only when the reader has no experiential background and/or semantic support from the text that they must rely on lower levels of processing, such as graphics or syntactic information. Although it seems apparent that comprehension is not dependent exclusively on structural cues, it also seems reasonable that the reader must possess a basic knowledge of the syntax of the language s/he is attempting to read. Without this basic language foundation, which many profoundly hearing-impaired students lack, it appears questionable that they can comprehend the linguistic information presented. Even if a basic understanding of syntax is not critical, the extremely limited lexical knowledge of most hearing-impaired students raises a question as to how much meaning they can derive from printed material.

The foregoing discussion stresses the need to keep in mind the interrelatedness of the syntax and semantics of language. It appears that the issue involves determining when, and to what degree, each component should be emphasized in each child's reading program. Clearly, research is needed to investigate systematically and to quantify the relative contribution of form and content at various stages of language and reading development in the hearing impaired.

It is also our impression that structured work in the area of phonics has a place in the hearing-impaired child's educational curriculum. This does not mean that phonics should be used to teach reading. Rather, we suggest that hearing-impaired children be taught the sound–symbol system of English to provide a conceptual framework for the organization of the English language. Because English is an auditorily based language, it seems reasonable that the most efficient way to organize and store it is with phonetic-based coding strategies. The goal of this approach is to provide the child with a working knowledge of the rules that govern the English sound system in its spoken or written form, even if s/he is unable to hear or produce all the sounds. The work of Conrad (1979) provides convincing evidence of the importance of helping hearing-impaired children develop phonetic-based coding strategies.

Fostering the development of a phonetic code might appear inappropriate in view of the data suggesting that the hearing impaired use a sign-based (visual) system to store and organize language (see chapter 11). Indeed, this raises an important issue with respect to the use of a visual (sign) representation of an auditory language (English). For many profoundly hearing-impaired children, the use of a manually coded sign system may facilitate the comprehension and production of oral language. It is not known, however, if the use of signs to represent an auditory-based language interferes with decoding its written form and the reading process. As Quigley and King (1981) noted, if the language on which reading is based differs from auditorily based standard English, then the relationship between it and the reading process needs to be known. Perhaps the inconsistency between the nature of the language (auditory) and the mode (visual) in which it is presented to the profoundly hearing impaired is a major obstacle in improving their reading skills. We are not suggesting that manually coded English is inappropriate to use with this population, but the effect of its use on learning to read needs to be investigated systematically. Because of the widespread use of total communication, this issue, as well as others involving the use of sign, requires rigorous investigation.

Another area that warrants investigation is the role of visual processing in the hearing impaired as it relates to reading performance and academic achievement. As noted in chapter 11, the students showed reduced performance on a measure that assessed visual scanning skills (WJ–VM). Performance on the test might have been affected by the students' failure to use verbal coding strategies or by their limited practice with various types of reading activities involving left-to-right visual scanning. Because performance on this measure was significantly related to academic achievement, it constitutes an important area of research.

Finally, some comments need to be made about the heterogeneity of the population. As noted in chapter 12, there appears to be a substantial number of students in programs for the hearing impaired who might demonstrate learning problems in addition to those imposed by the hearing handicap. These are the students whom teachers usually identify as "different" from the other students because of their failure in school. Because the underlying cause of their learning problems is not understood, the teacher is often at a loss to determine appropriate teaching strategies for them. Thus, there appears to be a critical need to develop procedures to identify these students and to define the nature of their learning problems.

In conclusion, the findings of this study are somewhat discouraging because they continue to demonstrate that profoundly hearing-impaired students are severely delayed in language and language-based academics. At the same time, the results permit a better understanding of the nature of the language and learning problems in this population, particularly as they relate to reading abilities and academic performance. Selected language and learning skills have been identified as predictors of academic achievement. This information should assist the educator and clinician in determining aspects of language that should be emphasized in language training and remediation programs. In addition, we are hopeful that the clinician and educator will benefit from the extensive information provided on the assessment procedures themselves and that the researcher will be motivated to investigate further the nature of the language and learning skills of the hearing impaired.

REFERENCES

BARON, J. (1973). Phonemic stage not necessary for reading. *Quarterly Journal of Experimental Psychology, 25,* 241-246.

BEERY, K. E., & BUKTENICA, N. A. (1967). *Developmental Test of Visual-Motor Integration.* Chicago: Follett Publishing.

BELLUGI, U., & FISCHER, S. (1972). A comparison of sign language and spoken language. *Cognition, 1,* 173-200.

BROWN, K. S. (1969). Genetic and environmental factors in profound prelingual deafness. *Medical Clinics of North America, 53,* 741-772.

CALVERT, D. (1981). Experimental project in instructional concentration. *American Annals of the Deaf, 126.*

CHALL, J. (1967). *Learning to read: The great debate.* New York: McGraw-Hill.

CHAPMAN, R. (1978). Comprehension strategies in children. In J. Kavanaugh & W. Strange (Eds.), *Speech and language in the laboratory, school, and clinic* (pp. 308-327). Cambridge: MIT Press.

CONLEY, J. E. (1976). The role of idiomatic expressions in the reading of deaf children. *American Annals of the Deaf, 121,* 381-385.

CONRAD, R. (1979). *The deaf school child.* London: Harper & Row.

DIFRANCESCA, A. (1972). *Academic achievement test results of a national testing program for hearing-impaired students—United States: Spring 1971* (Series D, No. 9). Washington, DC: Gallaudet College, Office of Demographic Studies.

DUNN, L. (1959). *Peabody Picture Vocabulary Test.* Circle Pines, MN: American Guidance Service.

EWOLDT, C. (1982). Diagnostic approaches and procedures and the reading process. *Volta Review, 84,* 83-94.

FITZGERALD, E. (1929). *Straight language for the deaf.* Staunton, VA: McClure.

FLESCH, R. F. (1955). *Why can't Johnny read: And what you can do about it.* New York: Harper.

FRASER, G. R. (1964). Profound childhood deafness. *Journal of Medical Genetics, 1,* 118-161.

FRIES, C. C. (1963). *Linguistics and reading.* New York: Holt, Rinehart & Winston.

IRAN-NEJAD, A., ORTONY, A., & RITTENHOUSE, R. K. (1981). The comprehension of metaphorical uses of English by deaf children. *Journal of Speech and Hearing Research, 24,* 31-36.

JENSEMA, C., KARCHMER, M., & TRYBUS, R. (1978). *The rated speech intelligibility of hearing-impaired children: Basic relationships and a detailed analysis* (Series R, No. 6). Washington, DC: Gallaudet College, Office of Demographic Studies.

KARCHMER, M., & KIRWIN, L. (1977). *The use of hearing aids by hearing-impaired students in the United States* (Series S, No. 2). Washington, DC: Gallaudet College, Office of Demographic Studies.

KARCHMER, M., RAWLINGS, B., TRYBUS, R., WOLK, S., & MILONE, M. (1979). *Educationally significant characteristics of hearing-impaired students in Texas, 1977–78* (Series C, No. 4). Washington, DC: Gallaudet College, Office of Demographic Studies.

KARCHMER, M., & TRYBUS, R. (1977). *Who are the deaf children in "mainstream" programs?* (Series R, No. 4). Washington, DC: Gallaudet College, Office of Demographic Studies.

KELLMAN, M., FLOOD, C., & YODER, D. (1977). *Inventory of Language Assessment Tasks.* Madison, WI: Madison Public Schools.

KRETSCHMER, R., & KRETSCHMER, L. (1978). *Language development and intervention with the hearing impaired.* Baltimore: University Park Press.

LANE, H., & BAKER, D. (1974). Reading achievement of the deaf: Another look. *Volta Review, 76,* 489-499.

MARK, L., SHANKWEILER, D., LIBERMAN, I., & FOWLER, C. (1977). Phonetic recoding and reading difficulties in beginning readers. *Memory and Cognition, 5,* 623-629.

MILLER, J. (1981). *Assessing language production in children.* Baltimore: University Park Press.

MOELLER, M. P., & MCCONKEY, A. J. (1984). Language intervention with preschool deaf children: A cognitive linguistic approach. In W. H. Perkins (Ed.), *Hearing disorders* (pp. 11-25). New York: Thieme-Stratton.

MOELLER, M. P., MCCONKEY, A. J., & OSBERGER, M. J. (1983). Evaluation of the communicative skills of hearing-impaired children. *Audiology, 8,* 113-127.

OSBERGER, M. J., & DANAHER, E. M. (1974). Temporary conductive hearing loss in students with sensorineural deafness. *Volta Review, 76,* 52-56.

PICKENS, J. D. (1978). *Figurative language used by deaf and hearing college students.* Unpublished doctoral dissertation, University of Tennessee, Knoxville.

QUIGLEY, S. P. (1982). Reading achievement and special reading materials. *Volta Review, 84,* 95-106.

QUIGLEY, S. P., & KING, C. (1981). Syntactic performance of hearing-impaired and normal-hearing individuals. *Applied Psycholinguistics, 1,* 329-356.

QUIGLEY, S. P., & KRETSCHMER, R. E. (1982). *The education of deaf children.* Baltimore: University Park Press.

ROSE, S. P. (1975). *Genetic studies of profound prelingual deafness.* Unpublished doctoral dissertation, Indiana University, Indianapolis.

SCHLESINGER, H. S., & MEADOW, K. P. (1972). *Sound and sign: Childhood deafness and mental health.* Berkeley: University of California Press.

SMITH, F. (1971). *Understanding reading.* New York: Holt, Rinehart & Winston.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,

OFFICE OF EDUCATION. (1977, August). Education of the handicapped, implementation of Part B of the Education of the Handicapped Act. *Federal Register, 42*(No. 163), 42474-42518.
WILBUR, R. B. (1977). An explanation of deaf children's difficulty with certain syntactic structures of English. *Volta Review, 79*, 85-92.
WILSON, K. (1979). *Inference and language processing in hearing and deaf children.* Unpublished doctoral dissertation, Boston University.
WOODCOCK, R., & JOHNSON, M. B. (1977). *Woodcock–Johnson Psycho-Educational Test Battery.* Boston: Teaching Resources.

Appendix A
Receptive Language Tests

Boehm Test of Basic Concepts (BOHM) (Boehm, 1971)

This test is designed to measure a hearing student's mastery of concepts considered necessary for achievement in the first years of school. The student is asked to circle an object in a series of pictures in response to a verbal instruction (e.g., "Circle the one that is medium-sized"). Concepts assessed include space, position, quantity, size, plus a category of miscellaneous items.

Child Language Ability Measures (CLAM) (Mehrabian & Moynihan, 1979)

Grammar Comprehension subtest. This test is designed to assess syntactic structures emerging through 8 years of age in hearing children. The test uses a two-alternative, picture-selection format that consists of minimal grammatical contrasts. A wide range of grammatical forms are assessed, such as number, tense, voice, negation, pronominalization, modification, and conjunction.

Inventory of Language Assessment Tasks (LAT–R) (Kellman, Flood, & Yoder, 1977)

The LAT is an informal survey of tasks that assess language skills typical of the concrete or formal operational periods of development (9–14+ years). This test is designed to yield a profile of the student's strengths and weaknesses in comprehension and production of abstract language tasks. Only two portions of the test were employed: (a) comparative relations, for example, "Are watermelons bigger than apples?" (expected age range is 7–10 years); and (b) conjunctions, for example, cloze task assessing coordinating, temporal, and causal conjunctions (expected age range is 6–12 years).

Test of Grammatic Comprehension (TGC) (Miller & Yoder, 1975)

This four-alternative, picture-selection test consists of 42 sentence pairs designed to assess syntactic structures emerging between 3-to-6 years of age in hearing children. The sentence pairs are constructed to differ only in terms of the particular syntactic feature being probed, and the child is to identify correctly each of the two sentence probes, presented in random order, to receive credit for the item (e.g., "Spot is barking at *her*" and "Spot is barking at *him*" must both be correctly identified to obtain credit for the pronoun form). Syntactic forms assessed include active voice, prepositions, possession, negative-affirmative, objective and subjective pronouns, singular/plural noun and verb markers, verb inflections, modification, passive reversible, and reflexivization.

Peabody Picture Vocabulary Test (PPVT) (Dunn, 1959)

This test measures a student's comprehension of isolated vocabulary using a four-alternative picture format. Normative data are available for hearing children from 2.5 to 18.0 years.

Reynell Developmental Language Scale: Verbal Comprehension Scale (R–VCS) (Reynell, 1977)

This scale, standardized on children in England, measures understanding of content for children ranging in age from 1.5 to 7.0 years. A range of tasks is included, progressing from realistic object/toy manipulation in response to simple directives to abstract and syntactically complex demands. The test assesses ability to identify objects, follow relational directions, identify representational objects on the basis of a functional description (e.g., "Which one barks?"), and follow directions involving an increased number of critical elements (e.g., "Put the small black pig behind the pink pig").

Test of Language Development (TOLD) (Newcomer & Hammill, 1977)

This test measures syntactic and semantic skills in the age range 4.0 years to 8 years 11 months. Receptive subtests administered consist of (a) the Picture Vocabulary (TO–PV) subtest, a four-alternative, picture vocabulary test, and (b) the Grammatic Understanding (TO–GU) subtest, a three-alternative, picture-selection task that assesses comprehension of a range of syntactic forms and morphological markers.

Test of Syntactic Abilities (TSA) (Quigley et al., 1978)

This test measures comprehension of nine major syntactic structures (negation, conjunction, determiners, question formation, verb processes, pronominalization, relativization, complementation, and nominalization) through written/read language. The student is required to answer 120 multiple-choice items written at a second-grade reading level. The test was developed for use with deaf students aged 10–19 years, and normative data have been obtained with hearing-impaired students in this age range.

Vocabulary Comprehension Scale (VCS) (Bangs, 1975)

This test assesses comprehension of concepts that emerge between 2 and 6 years of age in normal-hearing children. Comprehension of pronouns and concepts of position, size, quantity, and quality are measured in three-dimensional space with object manipulation.

Appendix B
Expressive Language Tests

Inventory of Language Assessment Tasks (LAT) (Kellman, Flood, & Yoder, 1977)

The expressive portions of this test assess form and content skills emerging during the formal operational period (9–14+ years). These consisted of the following categories of items: (a) Vocabulary: assesses understanding of double-function words (e.g., "bright" person); (b) idioms: tests ability to explain the meaning of colloquial language; (c) conjunctions: requires the student to complete a sentence using coordinating, temporal, causal, and conditional conjunctions; (d) temporal relations: assesses time measurement concepts; (e) class inclusion: tests ability to group, regroup, and provide a rationale for the grouping of verbal labels; and (f) classification: assesses grouping and regrouping of verbal labels.

Reynell Developmental Language Scale: Expressive Scale (Reynell, 1977)

This portion of the test assesses syntax, vocabulary, and expression of meaning through object naming, object description, and picture description. The syntax scale rates the complexity of spontaneous language. Vocabulary is assessed through picture and object naming and by asking the child to define terms with the referent removed (e.g., "What is an apple?"). Content is assessed by asking the child to describe simple action pictures; the complexity of the idea expressed is reflected in the score. As with the receptive portion of this test, normative data are available on 1.5–7.0-year-old British children with normal hearing.

Test of Language Development (TOLD) (Newcomer & Hammill, 1977)

The two expressive subtests employed were (a) Oral Vocabulary (TO–OV) subtest, which evaluates a student's ability to define objects and concepts (e.g., "What is a *bird?*" "What does *rest* mean?"). The student must formulate a definition that includes appropriate attributes; and (b) Grammatic Completion (TO–GC) subtest, which measures a student's ability to apply appropriate morphological markers to nouns, verbs, and attributes. Morphological markers assessed include verb tense, plural markers, comparative/superlative, and derivational suffix *+er*. The student is required to read a sentence and supply the missing word (e.g., "Joan is a woman. Mary is a woman. They are both ______.").

Woodcock–Johnson Psycho-Educational Test Battery (Woodcock & Johnson, 1977)

The subtests administered include (a) Picture Vocabulary (WJ–PV), which requires the student to label pictured words; (b) Antonyms/Synonyms (WJ–A/S), which is a test of word meanings and requires the student to provide the opposite of a set of printed words or provide a word with the same meaning as the stimulus word; (c) Analogies (WJ–AN), a test requiring a student to complete a verbally analogous relationship (e.g., when shown the printed words "mother–father, sister–______," the student is expected to supply "brother" to complete the analogy); and (d) Quantitative Concepts (WJ–QC), a test to assess a student's comprehension of mathematical concepts. The child is shown numerals or a picture and is required to respond to a query (e.g., viewing 5, 10, 15, ____, 25, the student is asked "What number is missing?"). Norms are available for hearing children from the 1st–12th grades.

Appendix C
Written Language Samples

EXAMINER'S NARRATIVE OF THE TOM STORY

Here is a boy. His name is Tom. He enjoys wearing cowboy clothes. He has cowboy boots, a shirt, and a hat. He likes to wear these to school and show off to the other kids. One morning, he woke up and he couldn't find one boot. He looked around his room . . . in the closet . . . under the bed, but he still could not find his boot. He wondered, "Where's my other boot? Maybe I'll go ask dad. Maybe he knows where my other boot is."

Then Tom went to see his father. His father was reading the newspaper. Tom interrupted and asked, "Dad, do you know where my boot is?" His father replied, "No, I don't know where your boot is, and please don't bother me, I'm busy reading the newspaper. You go ask your mother where the boot is." Tom replied, "Oh, all right."

Mother was busy fixing breakfast in the kitchen. Tom said, "Mom, I can't find my other boot. Do you know where it is?" Mother answered, "No, Tom, I don't know where your boot is. You sit down and eat your breakfast first, then I will help you look for it." Tom replied, "Oh, thank you, Mother."

Then suddenly Tom heard a noise coming from under the table. He looked and saw his pet dog. His dog was chewing on his boot. Tom said, "You stupid dog. That is my boot. You cannot have it. It does not belong to you." Then he grabbed the boot, and it tore. Tom was very disappointed.

Tom went to the living room to show his father what happened to the boot. Tom explained that the stupid dog chewed his boot. "Now I can't wear it to school," Tom said. His father was surprised and said, "Oh, I'm sorry about your boot. What do you think we should do about it?" [Student completes story with novel end.]

The following are examples of six students' written language samples. Punctuation and spelling are the same as that used by the students. The rating is the average of the values assigned to each sample by the two raters, as described in chapter 9.

EXAMPLE 1: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 5

(Average Rating: 100%)

This is Tom, he loves to wear the cowboy hat, vest, pants and boots. He loves to wear it to school and show off to other kids. He wear the cowboy hat & clothes everyday to school.

Tomorrow morning Tom woke up and get out of bed. He can't find other boots, he looked around bedroom and closet. He couldn't find it, he was wondering where it supposed be. So he went to father to ask him if he know where is his other boot, his father say "no, I don't know. Please don't bother me, I am busy reading the newspaper. Go and ask mother. I think she might know where your boot is, so he went in the kitchen and ask his mother if she know where his other boot is. She say "no, I don't know where is your boot. I can't go and help you now because I am busy fitting the breakfast for our family, maybe after breakfast I will help you to find other boot ok" and Tom say "Thank you very much", he heard the noise, he turned and saw the dog is biting his boot. He was very upset and say what is stupid dog, I have been told you not to go in my bedroom. You stupid dog! He grab his boot from the dog's mouth, the dog was afraid of him. Tom looked at his boot, and he say it is torn. I can't use my boot to school. What will I do? So he went to father and ask him to buy other boot for him & father say what happened with your boot. Tom replied that his dog chewed his boot. Will you buy other boot? Father say "well, maybe I will buy other one, but when will we go to the store?" Tom say tomorrow. His father say ok. Father bought other boots for Tom, Tom is happy because he can wear it to school everyday.

EXAMPLE 2: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 6

(Average Rating: 100%)

The boy who loves to wear & act as a cowboy. He loves to do it again and again but he doesn't get tired of being cowboy. But on one morning, he got up and he was excited to get into cowboy outfit, he hurried brushed his teeth, washed his face and took a short bath. After he got dry, he ran to his drawer to get all of his cowboy outfit then he put them on fast even a less than a minute! Can you imagine a little boy getting dressed in a minute. And he ran to the closet where his boots are sitting after he opened the closet, he looked down and saw that one boot was gone. He was so mad because he wanted to wear it to school for "show & tell" but he can't go to school without his boot missing, so he walked into the livingroom where his father is sitting on chair reading newspaper. The boy asked his father "Did you ever seen my boot anywhere?" The father said "No, but you can ask your mother to help you look for it." The boy was so upset so he walked into the kitchen where his mom was. Mom was cooking breakfast on stove. The boy asked the same question that he asked his father. Mom said "No, but I'll help you to look for the boot after breakfast. But he got worse upset and walked to start looking for the boot himself. He looked under the kitchen table. Guess what he found? He found that his dog had the boot. He got mad and scolded the dog. The dog began to run. Then the boy started to chase the dog. Finally, he caught the dog and got the boot out of the dog's mouth. After he got his boot back, he found a hole in his boot. He got very, very mad and he spanked the dog. He walked to his father what happened to the boot. The boy said that he wanted to get new pair of boots. His father said "OK, I'll take you to the shoe store and get you new ones but I want you to take care of boots good." So the boy was happy again.

EXAMPLE 3: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 5

(Average Rating: 86%)

The boy name is Tom. he love cowboy. he have a boots, clothes and hat. This morning he wake up and he saw one boot. he look other one boot. he look at closet and not there. he look under bed and not there and he walk and ask his father Do you know where one more boot is his father no, I am bussiness to read newspaper and he say to kitchen and ask mother. Tom say ok, walk to kitchen, Do you know other one boot is Mother say no, I don't know I am bussiness to cook breakfast for family. I will help you after breakfast ok Tom say ok Thank you. and tom heard noise and look under table and oh, no you damage my boot. dump dog damage my boot. he get his boot carry to father to show his boot is damage. his father said what happen Tom Dump dog damage my boot. his father said. I am sorry for it. Tom want buy new boot.

EXAMPLE 4: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 4

(Average Rating: 60%)

Tom look in his room can't found his boot, Tom ask day read then Tom say where is my boot dad say ask mom may will found your boot Tom ask mom where my boots please help found a my boot mom say I don't have time I need for breakfast. Tom found dog chew on the teeth Tom say get your off that off mouth. Tom show my boots dog chew it dad say don't worry about boots will get new boot. The end

EXAMPLE 5: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 2

(Average Rating: 18%)

tom cant. Find the my Boot
tom cant Find my Boot
mother Said after Breakfast
It wilt help you
tom see chew the my boot
tell to father said to buy store.

EXAMPLE 6: LANGUAGE SAMPLE WRITTEN BY A STUDENT IN GROUP 2

(Average Rating: 10%)

The shirt no have one.
Father think know.
mother all eat.
Boy my dog no shoe eat.
Father and Boy Buy stor.

Appendix D
Academic Tests

Peabody Individual Achievement Test: Reading Comprehension (PIAT–RC)

This test contains 56 items consisting of two pages per item. The first page contains a sentence that the student reads once silently. The second page, which is exposed to the student after s/he has read the passage, has four alternative illustrations on it. The student is asked to select the one that best represents the meaning of the sentence s/he has just read. Items are arranged accordingly in increasing difficulty. Grade equivalents are available for kindergarten through 12th grade.

The two-page per item format introduces a short-term memory factor that a one-page format does not. The rationale given by the test developers for this format is that an effective reader should be able to retain at least briefly what s/he has read.

Peabody Individual Achievement Test: Spelling (PIAT–SP)

This test consists of 84 multiple-choice items. The first 10 items require pointing to a printed letter of the alphabet from three other illustrations. Items 11–14 require the identification of a printed letter or a word from the oral presentation of letter or word name and the speech sound associated with it. The test procedure was modified so that no speech sound was presented. For items 15–84, individual words were signed and pronounced by the examiner, and the student was instructed to point out the correct spelling for each word among four choices. The task is to recognize correct spelling and involves no writing on the part of the student. The test procedure was modified so that sentences (provided in the test) were given only if it appeared that the sign was not understood by the student or no sign was available.

Woodcock Reading Mastery Test: Word Identification (WRMT–WI)

This test consists of a set of 150 words (Form B) ranging in difficulty from the first words presented in typical beginning reading programs for normal-hearing students to words of above–average reading difficulty for superior students in the 12th grade. The student's task on this test is to "decode" the word. Acceptable responses for this test included signing the word, providing a meaning of the word (either by using the word in a sentence or providing a definition), or verbally pronouncing each word. Grade equivalents for normal-hearing students for kindergarten through 12th grade are available.

Woodcock Reading Mastery Test: Passage Comprehension (WRMT–PC)

This test contains 85 items (Form B) and uses a modified cloze procedure. The student's task is to read silently a passage that has one word missing and then tell the examiner an appropriate word to fill in the blank space. Passages for the easier items often consist of a phrase or a short sentence accompanied by a picture. In order to provide an appropriate word for the blank space in the passage, the student must make use of information contained in the picture as well as the passage itself. After this level, most passages consist of two sentences which were drawn from textbooks, newspapers, magazines, and other sources of reading material. These passages range in difficulty from first grade to college level. To supply the missing word in a passage, the reader must use syntactic and semantic cues. Grade scores are available for normal-hearing kindergarten through 12th-grade students.

Woodcock–Johnson Psycho-Educational Test Battery: Calculation (WJ–CAL)

This test assesses the student's ability to perform mathematical calculations, including addition, subtraction, multiplication, division, combinations of these, and some geometric, trigonometric, logarithmic, and calculus operations. Decimals and fractions, as well as whole numbers, are involved in the calculations. This subtest involves carrying out indicated calculations, and no decisions about what operations to use or what data to include in the calculations are required. The student works the calculation items on a special sheet of paper that the examiner provides along with a pencil with an eraser. The 42 test items included were selected to represent a range of calculations from the simplest arithmetic operations to calculations associated with more advanced mathematics.

Woodcock–Johnson Psycho-Educational Test Battery: Applied Problems (WJ–AP)

This test measures the student's ability to solve practical problems in mathematics. In order to solve the problems, it is necessary for the student to recognize the operation(s) to be used, identify the relevant data, and then perform the relatively simple calculations required. Because some of the problems present more information than is involved in solving the problem, the student must decide not only on the appropriate mathematical operation to use, but also which data are appropriate to include in the calculation. The student may use paper and pencil to help solve written problems if desired. The essential information related to each problem is written or illustrated on the student side of the test book in order to accommodate memory difficulties. However, the examiner reads all test items to the student and may repeat questions if needed. The 49 items range in difficulty from simply counting the number of items specified to problems involving decimals and fractions. Several problems include money, measurement, and time concepts.

Written Spelling Survey (WSS)

The test was developed for this project and thus, no standardization data are available. It is a test of recall (written) spelling. The words in the test were selected from spelling lists developed for students with normal hearing (Forbes, 1968), and they represent a range of different spelling rules and sound/symbol correspondences. A core of five words was selected for grade levels 2–7; only two words were selected for Grade 8 because of vocabulary restrictions. In addition, one to two alternative words were selected for grade levels 2–7 in the event that the vocabulary of the core words was unfamiliar to a student. Each word is spoken and signed by the examiner (or interpreter) and, if necessary, used in a sentence. The student is required to write each word. If a student's handwriting is difficult to decipher, the student is asked to fingerspell each of the words. Any word that presents vocabulary difficulty is eliminated from the scoring. Testing begins with the words in the lowest grade level and proceeds until all words are missed on two consecutive grade levels, due either to vocabulary or spelling difficulties. Items are scored on a pass/fail basis, and no credit is given for words spelled partially correct. A total number correct out of a total possible score is obtained for each grade level, as well as for the entire test.

The words used in the Written Spelling Survey appear below. The words in parentheses are the alternate words, used if the vocabulary of the core words was unfamiliar to the student.

Grade 2	1.	head
	2.	paper
	3.	him
	4.	fish
	5.	tell
	(6.)	think
Grade 3	1.	light
	2.	word
	3.	pencil
	4.	jump
	5.	lock
	(6.)	around
Grade 4	1.	picture
	2.	young
	3.	people
	4.	friend
	5.	quiet
	(6.)	myself
	(7.)	ticket
Grade 5	1.	freeze
	2.	witch
	3.	wedding
	4.	wife
	5.	son
	(6.)	problem
	(7.)	telephone
Grade 6	1.	equal
	2.	daughter
	3.	paragraph
	4.	ugly
	5.	improve
	(6.)	secret
Grade 7	1.	operation
	2.	magazine
	3.	wealth
	4.	husband
	5.	religion
	(6.)	introduce
	(7.)	struggle
Grade 8	1.	cancel
	2.	lecture

Stanford Achievement Test (Hearing-Impaired edition) (SAT–HI)

This test is a series of comprehensive achievement tests developed to provide measurement and assessment of learning at different levels of the educational process. The tests are divided into levels, progressing from kindergarten through high school grades. Normative data are available on the performance of hearing-impaired students on the reading comprehension and calculation subtests. Of the six levels available, Levels 2–5 are adjusted in accordance with the observed performance trend of hearing-impaired students. In general, this means that the vocabulary and communication comprehension subtests are keyed at a lower level than the reading comprehension subtest, whereas the spelling and mathematics computation subtests (and in some cases the mathematics concepts subtest) are keyed at a higher level than the reading comprehension subtest. Almost all tests have time limits that are calculated to give students enough time to answer the questions they are able to answer. Tests consist of a multiple choice format where the student is to select one out of four answers as the correct response.

REFERENCE

FORBES, C. T. (1968). *Graded and classified spelling lists for teachers, grades 2–8*. Cambridge, MA: Educators Publishing Service.

Appendix E
Visual Processing, Short-Term Memory, and Visual–Motor Coordination Tests

Memory for Signed Words (MSW) and Memory for Pictured Words (MPW)

The test format and procedures from two subtests of the Detroit Tests of Learning Aptitude, Visual Attention Span for Objects and Auditory Attention Span for Unrelated Words, were used as models in the development of the Memory for Pictured Words and Memory for Signed Words, respectively. A pretest was added to ensure that the student knew the vocabulary and that the examiner used the same signs as the student for each item. Vocabulary items were selected from Ling and Ling (1977). Only words that could be signed with a single hand motion were chosen. Additionally, the same vocabulary was used on both tests. The pretest was administered at the beginning of the entire test session, and the two memory tests were administered approximately 1½ hr later.

During the pretest, the student is required to sign and say each pictured vocabulary item. For those items not signed (identified) correctly, a sign is taught and the picture is presented again after all pictures are identified.

The Memory for Pictured Words test consists of presentation of a series of pictures ranging in length from two to eight items for a period of 1 s per picture. Two sets of pictures are provided for each series. When the pictures are removed, the student is to name, sign, or name and sign simultaneously all of the pictures that s/he can remember. Once the student pauses after recalling picture names, s/he is provided with five additional seconds. Stopping the student after 5 s is done to prevent the student from randomly naming pictures previously seen during the pretest.

The Memory for Signed Words test consists of presenting a series of unrelated signed and spoken words ranging in length from two to eight items at a rate of one item per second. The procedures described for the Memory for Pictured Words are followed.

Knox Cubes (KNOX)

This is a subtest from the Arthur Performance Scale, Revised Form II (1947). The test consists of repetition of a sequential motor pattern. Four 1-in. (2.5 cm) blocks are placed in a row in front of the student. The examiner and the student each have one block. The examiner taps various sequences (ranging between two and seven taps) of the blocks, and the student is asked to tap the same sequence. Standardization for normal-hearing students for the age levels 4.5–15.5 years are available.

Beery–Buktenica Developmental Test of Visual–Motor Integration (VMI)

The VMI assesses the degree to which visual perception and motor behavior are integrated in students. The student is required to copy geometric forms with a pencil, without erasing or working over the forms. Only one attempt on each form is allowed. The forms are arranged in order of increasing difficulty. Copying geometric forms is well suited to this task because, unlike letter forms, geometric forms are equally familiar to students of varying backgrounds. An age score equivalent is available for normal-hearing students between the ages of 2 years 10 months and 15 years 11 months.

Woodcock–Johnson Psycho-Educational Test Battery: Visual Matching (WJ–VM)

This test requires the student to identify and circle two identical numbers in a row of six numbers. The task increases in difficulty from single-digit to five-digit numbers. All students are first presented two sample items; if necessary, the examiner explains further until the student understands the task. After completing the two sample items, all students begin the test with the first item and continue working for exactly 2 min. The subtest contains 30 items arranged in blocks of six items for each level of difficulty.

Woodcock–Johnson Psycho-Educational Test Battery: Spatial Relations (WJ–SR)

This test requires the student to compare shapes visually within a 3-min time limit. The student's task is to select from a series of shapes the component shapes needed to make a whole shape. The shapes become progressively more abstract and complex. All students are first administered a demonstration item and two sample test items. A modification implemented in our testing, also suggested in the manual, was to have the interpreter identify each item as the student pointed to it.

Normative data are available on normal-hearing students from preschool through 12th grade for both Woodcock–Johnson subtests.

REFERENCE

Ling, D., & Ling, A. (1977). *Basic vocabulary and language thesaurus for hearing-impaired children.* Washington, DC: A. G. Bell Association for the Deaf.

Appendix F
Correlation Matrix for Measures in the Multivariate Analyses

Partial correlations of dependent variables removing linear effects of independent variables.

		PTA 2	PIQ 3	SPINT 4	WJ-CAL 5	WJ-AP 6	SAT-CON 8	SAT-CMP 9	PIAT-SP 11	PIAT-RC 12	WRMT-WI 13	WRMT-PC 14	SAT-RC 15	VMI 17
PTA	2	1.000												
PIQ	3	-.136	1.000											
SPINT	4	-.673	.092	1.000										
WJ-CAL	5	-.106	.485	.136	1.000									
WJ-AP	6	-.133	.458	.272	.770	1.000								
SAT-CON	8	-.124	.420	.127	.769	.737	1.000							
SAT-CMP	9	-.117	.485	.152	.838	.729	.841	1.000						
PIAT-SP	11	-.016	.272	-.029	.611	.570	.655	.630	1.000					
PIAT-RC	12	-.182	.412	.328	.618	.636	.616	.657	.628	1.000				
WRMT-WI	13	-.247	.259	.445	.590	.651	.487	.541	.538	.578	1.000			
WRMT-PC	14	-.239	.295	.447	.637	.767	.664	.642	.650	.708	.735	1.000		
SAT-RC	15	-.155	.314	.281	.648	.738	.694	.686	.688	.744	.616	.850	1.000	
VMI	17	-.119	.691	.074	.590	.572	.604	.580	.387	.447	.270	.418	.477	1.000
KNOX	18	-.133	.525	.102	.604	.451	.425	.474	.315	.394	.406	.354	.350	.521
WJ-SR	19	.040	.647	-.160	.377	.345	.400	.432	.195	.276	.132	.231	.294	.477
WJ-VM	20	-.026	.440	-.036	.661	.598	.599	.641	.436	.449	.451	.478	.488	.500
MPW	21	-.091	.391	.029	.261	.321	.270	.298	.187	.314	.249	.244	.289	.281
MSW	22	-.065	.256	.087	.280	.300	.338	.324	.330	.396	.284	.332	.303	.160
TO-OV	23	-.119	.285	.280	.500	.625	.579	.550	.615	.527	.596	.693	.615	.327
WJ-PV	25	-.167	.467	.361	.697	.708	.636	.660	.653	.735	.643	.729	.710	.529
WJ-A/S	26	-.051	.412	.145	.678	.738	.676	.660	.645	.598	.603	.671	.703	.490
WJ-AN	27	-.229	.430	.213	.653	.717	.657	.595	.599	.655	.543	.698	.713	.497
TO-PV	30	-.196	.361	.263	.532	.651	.556	.549	.572	.598	.563	.590	.565	.441
TO-GU	31	-.236	.224	.510	.454	.578	.501	.428	.378	.593	.619	.647	.579	.221
PPVT	34	-.174	.315	.291	.557	.611	.571	.543	.577	.711	.570	.654	.734	.468

		KNOX 18	WJ-SR 19	WJ-VM 20	MPW 21	MSW 22	TO-OV 23	WJ-PV 25	WJ-A/S 26	WJ-AN 27	TO-PV 30	TO-GU 31	PPVT 34
KNOX	18	1.000											
WJ-SR	19	.389	1.000										
WJ-VM	20	.504	.444	1.000									
MPW	21	.247	.302	.370	1.000								
MSW	22	.141	.150	.314	.462	1.000							
TO-OV	23	.356	.231	.514	.374	.378	1.000						
WJ-PV	25	.398	.309	.432	.261	.310	.694	1.000					
WJ-A/S	26	.525	.389	.538	.250	.315	.682	.691	1.000				
WJ-AN	27	.486	.305	.474	.378	.384	.630	.674	.711	1.000			
TO-PV	30	.365	.175	.488	.376	.298	.660	.713	.595	.716	1.000		
TO-GU	31	.372	.040	.305	.272	.292	.595	.568	.590	.645	.527	1.000	
PPVT	34	.384	.166	.391	.313	.327	.571	.740	.575	.662	.608	.550	1.000