Correlates of Academic Achievement of Hearing Impaired Students

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Academic achievement test data collected from a sample of 281 hearing impaired students, 8 to 20 years of age and enrolled in school, were examined in relation to five personal and three potentially manipulable student characteristics. An a priori stepwise multiple regression model in which significant ($p<.01$) personal variables were entered first, followed by significant ($p<.01$) manipulable variables was used. The results showed that the five areas tested could be divided into two general subject areas: Reading (vocabulary, reading comprehension) and Mathematics (computation, applications, concepts). For Reading, three personal variables — age, severity of hearing loss, additional educational handicaps — and one manipulable variable — educational setting (integration) — entered the equation. Only personal variables contributed significantly to mathematics performance: age and additional handicaps to computation and applications; age to concepts. The differences between Reading and Mathematics, centred around severity of hearing loss and the greater dependence of Reading upon language, provide support for the accepted hypothesis of a general verbal deficit in the coding processes of hearing impaired students. The finding that between 28 and 47% of the variability was predicted reveals that, as with hearing students, identifying salient factors related to academic achievement of hearing impaired students is complex and difficult.

Cette étude examine la performance académique d'étudiants handicapés auditifs quant à certaines de leurs caractéristiques dont cinq sont personnelles et trois potentiellement manipulables. La population étudiée comprenait 281 étudiants handicapés agés de 8 à 20 ans. Un modèle à priori de régression multiple par étapes a été utilisé; les variables personnelles significatives ($p<.01$) y ont d'abord été entrées, suivies des variables manipulables significatives ($p<.01$). Les résultats ont démontré que les cinq domaines étudiés pouvaient être regroupés sous deux sujets généraux: la lecture (vocabulaire et compréhension) et les mathématiques (calcul, applications, concepts). Au chapître lecture, trois variables personnelles (âge, la gravité du handicap auditif, les autres handicaps éducatifs) et une variable manipulable (le milieu éducatif — l'intégration) entraient dans l'équation. Seules les variables personnelles ont influencé de façon significative la performance en mathématiques: l'âge et les autres handicaps qui agissent sur le calcul et les applications; tandis que l'âge seulement joue dans le cas des concepts. Les différences entre la lecture et les mathématiques, focalisées sur la gravité de la surdité et sur la dépendance plus marquée de la lecture envers le langage, appuient l'hypothèse répandue d'une carence verbale générale dans les processus de codification chez les étudiants souffrant de surdité. Une variance prévisible d'entre 28% à 47% révèle que l'identification des facteurs saillants de performance académique chez les handicapés auditifs demeure un problème complexe et difficile, comme d'ailleurs chez les étudiants non-handicapés.

In a recent review, Tomlinson-Keasey and Kelly (1978) described the educational picture for hearing impaired students as "never bright" (p. 452), and concluded "for the majority of hearing-impaired subjects, academic achievement lags far behind hearing subjects" (p. 452). The most comprehensive portrayal of this situation in the United States was provided by the Office of Demographic Studies (ODS) at Gallaudet College (Jensema, 1975). The 1973 Stanford Achievement Test, Special Edition for Hearing Impaired Students (SAT-HI) was used to test a national stratified sample of 6,871 students in special educational programs for the hearing impaired. Not unexpectedly, performance increased with age in vocabulary, reading comprehension, mathematics computation, and mathematics concepts. However, in comparison to hearing students, hearing impaired students' rate of progress was well below the norm.

Jensema (1975) further described the level of achievement of the hearing impaired sample in terms of several other demographic characteristics of the students. Employing age-deviation scores to account for the age differences,[1] he examined separately age at onset, severity of hearing loss, additional educational handicaps, and ethnic background, and found each to be related to achievement. For example, the mean age-deviation score tended to decline as the degree of hearing loss became more severe, with this tendency being pronounced in vocabulary and least apparent in mathematics computation. Similarly, students born deaf or deafened prior to age three performed less well than students deafened at an older age, with the greatest difference found in vocabulary. No differences in achievement existed between hearing impaired males and females. Finally, Jensema looked at the difference in performance among students attending different types of educational programs, and found "a rough inverse correspondence between the amount of time a student spends in special education for his hearing impairment and the mean age-deviation scores on the subtest" (p. 11). Because differences in the demographic make-up of the students in each type of program might have influenced this relationship, the results were further adjusted to account for the four factors which, as noted above, were related to achievement. Although this correction tended to reduce the differences among means of the various program types, the rank orders of the program types remained essentially unchanged across the four subject areas.

Following administration procedures similar to those used by ODS, Rogers et al. (1978) examined the academic achievement of hearing impaired students in British Columbia. A sample of 383 students enrolled in school was assessed using five non-dictated tests selected from the SAT-HI. As in the United States, age group differences were found for vocabulary and reading comprehension, and for mathematics computation, applications, and concepts. Again, the level of performance and rate of progress lagged behind that expected for hearing students of comparable age.

Further analysis of the data revealed significant differences attributable to severity of hearing loss and a significant age-by-hearing loss interaction for vocabulary and reading comprehension, but not for mathematics. For both vocabulary and comprehension, the achievement levels decreased with increasing severity of loss. However, examination of the interactions showed that this effect was more pronounced for the older age groups; in contrast, the age group differences noted above were more pronounced for the mildly and moderately hearing impaired groups of students.

Employing age and severity of hearing loss as covariates, the effects of six additional variables were analyzed separately. Girls outperformed boys in reading comprehension; the prelingually deaf groups performed less well than the postlingually deafened group on vocabulary; the group using personal hearing aids scored higher than the group not using such aids in reading comprehension and mathematics computation; the group with additional educational handicapping conditions scored below the group not so handicapped in all five areas; the oral communication group scored higher than the total communication group in both vocabulary and reading comprehension; and students in special classes and schools performed less well than students enrolled in regular school in vocabulary, reading comprehension, and mathematics computation. Visiting teacher service appeared not to influence test performance. For the most part, these findings agree with those reported by Jensema for the United States.

Care should be exercised when interpreting the portrayals provided for the United States and B.C. In these surveys, the complex interrelationships that exist among the demographic variables were largely ignored. Based on the patterns of results of these two surveys, it was hypothesized that variability in achievement is attributable more to personal characteristics (e.g., age, severity of loss, gender, age at onset, additional educational handicaps), and less to potentially manipulable variables such as method of communication, use of hearing aid, and educational setting. The purpose of the multiple regression analyses described in the present paper was to test the tenability of this hypothesis and, consequently, to clarify the nature of the relationships between academic achievement and these commonly considered demographic characteristics of hearing impaired students.

METHOD

During the first part of 1977, a provincial survey of hearing impaired students was conducted in B.C. Within each school district and the provincial school for the deaf, school personnel (most often teachers of the hearing impaired) completed a demographic questionnaire for each student known to have a hearing loss with some sensori-neural component; known to have been fitted with a personal hearing aid; and/or in need of special educational treatment because of hearing impairment. Altogether, 699 students from 5 to 20 years of age were identified (Clarke et al., 1977).

Achievement Tests

The SAT-HI was adapted from the Stanford Achievement Test (SAT), Form A, 1973. Essentially, tests within each level of the SAT were reassigned to the next lower or higher level to form the corresponding level of the SAT-HI. The assignment reflects the discrepancies in performance in vocabulary, spelling, and mathematics observed between hearing students and hearing impaired students, thereby providing for adequate measurement in all areas tested. Levels 2, 3, 4, and 5 of the SAT-HI include, for example, the reading comprehension test from the corresponding levels of the SAT, but the SAT vocabulary test from the next lower level and the SAT mathematics tests and spelling test from the next higher level. Only the SAT-HI primary (level 1) and advanced (level 6) are identical to their SAT counterparts.

In the present study, a modified form of the SAT-HI was used. First, tests requiring teacher dictation were deleted, thereby circumventing many of the difficulties associated with respective language ability. Second, testing was restricted to vocabulary, reading comprehension, and mathematics computation, applications, and concepts. These subject areas are of major concern to educators of the hearing impaired and are included in school curricula regardless of the program type or educational setting of the students. The specific tests used were:

Area	*Test: Level*
Vocabulary	Reading: Part A: 1 and 2; Vocabulary: 4-6 (advanced)
Reading Comprehension	Reading: Part B: 1 and 2; Reading Comprehension: 3-6
Mathematics — Computation	Mathematics Computation: 2-6[2]
— Applications	Mathematics Applications: 3-6
— Concepts	Mathematics Concepts: 4-6

Screening tests. Generally, the appropriate level of a test battery for a hearing student is identified in terms of their age or grade. This form of assignment is frequently not appropriate for hearing impaired students, since the majority are not in the grade typically associated with their age (Moores, 1978). Consequently, the appropriate levels of the SAT-HI battery are assigned to students on the basis of screening test scores. Students estimated to be reading at or below a 4.9 grade level are assigned the Primary Screening Test; students with estimated reading levels of 5.0 or above are assigned the Intermediate form. The Primary Screening Test consists of the word reading and reading comprehension tests from the second level (Primary 2) of the SAT, Form B, 1973, while the Intermediate Screening Test consists of the reading comprehension test from the fourth level (Intermediate I) of the Form B series.

Test Administration

Screening. In the late Spring and early fall of 1977, a subsample of the students identified in the demographic study was assessed using the modified form of the SAT-HI. Using both age and present grade level as criteria, students were assigned the appropriate screening test. Pupils who were mentally retarded ($n = 35$) or less than eight years old ($n = 96$) were not tested.

The screens were administered by school personnel, most often a teacher of the hearing impaired. The administrators were advised to use the same method of communication ordinarily used with each student in the classroom when giving the test instructions and reviewing the sample questions. They were encouraged to demonstrate, explain, rephrase — in short, to do whatever they felt necessary to ensure that their students understood what was expected on the test. However, no assistance was to be provided once the actual test began, and the time limits set for the test were to be strictly adhered to.

Sufficient copies of each screening test were sent to each test administrator to allow alteration of the initial assignment if the administrator felt it to be incorrect. Further, if an administrator believed that a student initially assigned a screen was not able to do the test, the student was to be excluded; if an administrator felt an unassigned student could respond to the screen, he/she was to be included. Altogether 367 Primary Screening Tests and 133 Intermediate Screening Tests were returned.

SAT-HI assignment and administration. Each screening test was independently scored by two members of the research staff; discrepancies were resolved jointly. Using these scores, the appropriate SAT-HI test level was identified following the item correct criteria developed by ODS.

The achievement batteries, like the screening tests, were administered by school personnel. Administrators were again advised to use the same method of communication used in the classroom and to observe the time limits set for each test in the battery. To avoid problems associated with possible fatigue, the proposed administration schedule allowed two testing periods (of 20 to 75 minutes with a rest period) for levels 1, 2, and 3, and three periods (40 to 70 minutes with a rest period) for levels 4, 5, and 6.

Table 1 contains a summary of the number of test batteries distributed, returned, and item analyzed at each level. Altogether 479 batteries were distributed. Four students were not assigned a battery because they did not complete their screening test due to low reading ability. An additional 17 students from schools in which testing was conducted in the fall were not assigned a battery because they had left school (graduation, relocation) during the time between screening and testing. Of the number assigned, 423 (88.3%) were returned.

TABLE 1

Number of SAT-HI Test Batteries Distributed, Returned, and Item Analyzed

Battery Level	Number		
	Distributed	Returned	Item Analyzed
1	134	125	120
2	128	124	121
3	94	74	74
4	35	31	25
5	35	32	32
6	53	37	34
Total	479	423 (88.3%)	402 (83.9%)

Data Analysis

Item analysis. Item responses for each test were coded and keypunched. The resulting file for each student was then verified against his/her test booklet. Twenty-one students who failed to respond to at least two tests within their battery or who, based on their response pattern, appeared to be guessing were eliminated from further analyses. Item analyses (Nelson, 1974) revealed that, for the B.C. sample of hearing impaired students, all items within each achievement test functioned in the appropriate direction. Internal consistency measures (Hoyt, 1941) ranged between .77 and .95.

Score conversion. As shown in Table 1, the sample size at each battery level was insufficient to allow any meaningful investigation of the relationships between test performance and selected characteristics of the students. To realize adequate sample sizes, it was therefore necessary to combine the samples at each test level to form one total sample for each academic area. Derived scores, developed by the test publisher and adopted for use with the hearing impaired, were used:

> A scaled score of 132 was set to correspond to the median raw score obtained by *normal hearing* students in the second month of the third grade. Similarly, a scaled score of 182 was set to correspond to the median raw score of *normal hearing* students in the second month of the eighth grade. Each scaled score unit then represents an equal amount of academic growth for *normal hearing* students, using the specified five year period as a baseline. The advantage of scaled scores over other types of derived scores is that they provide equal interval units of growth which are comparable from battery to battery and which are thus more appropriate for statistical manipulation than are grade equivalents or other more commonly used normative scores. (Jensema, 1975, p. 1)

Demographic description of academic area samples. The derived scores were merged with the data collected from the earlier demographic survey. At this point, 121 students who were less than eight years of age, for whom age at onset was unknown, and/or for whom audiometric data were unavailable were deleted. The resulting sample size for each academic area was: vocabulary — 231; reading comprehension — 281; mathematics computation — 206; mathematics applications — 110; and mathematics concepts — 60.

Table 2 contains a description of each academic area sample in terms of the number of students with each of the student characteristics considered. Additionally, the mean and standard deviation are presented for both age and severity of hearing loss. Since only students enrolled in regular classes were eligible for visiting-teacher service and for three of the academic areas this group constituted less than half the sample, visiting teacher was dropped from the initial set of demographic variables examined by Rogers et al. (1978).

Student ages were calculated as of December 31, 1976, and rounded to the nearest whole number. Severity of hearing loss, expressed in decibels (dB), equals the arithmetic mean, rounded to the nearest whole number, of the pure tone thresholds at 500, 1,000, and 2,000 Hz for the better ear, using the American National Standards Institute (ANSI) criteria. Students deafened prior to the age of two were classified as prelingually deaf, while those deafened at or subsequent to this age were labelled postlingually deafened. The primary communication used by each student was classified as either oral or total communication (manual, oral/manual). Lastly, educational setting, considered a surrogate for integration, was categorized as follows for each student:

1. Attends a regular class located in a regular elementary or secondary school (Reg. Sch.);
2. Attends a class for the hearing impaired located in a regular elementary or secondary school (CHI in Reg. Sch.): Special classes consisting entirely of hearing impaired children. Generally students spend some of their time in regular classes with hearing students;
3. Attends a class for the hearing impaired located at the provincial schools for the deaf (Sch. for Deaf): A school exclusively for hearing impaired students. Approximately 70% live at home and attend school during the day; the remaining students are housed and cared for at the school.

Statistical analyses. Two multiple regression analyses were performed to determine, for each academic area, the relationship between achievement and the eight demographic variables considered. Because of the unequal sample sizes, it was not possible to perform a canonical analysis. Further, given the low sample size to number of independent variables ratios, it was necessary to conduct each subject area analysis in two stages. First, a step-wise regression analysis was completed using the five per-

TABLE 2

Demographic Characteristics of Each Academic Area Sample Number of Students by Category

Demographic Variable		Vocabulary	Reading Compre-hension	Mathematics Compu-tation	Mathematics Appli-cations	Mathematics Concepts
Age	8-10 yrs	68	79	38	15	4
	11-13	75	93	73	34	16
	14-16	59	71	60	36	24
	17+	29	38	35	25	16
	Mean age	12.57	12.66	13.32	13.96	14.57
	SD	3.01	2.99	2.79	2.78	2.58
Severity of Hearing Loss	0-14 dB	3	5	3	3	1
	15-29	8	9	5	5	4
	30-44	8	13	13	13	8
	45-59	19	25	23	20	14
	60-74	46	54	45	23	15
	75-89	40	46	33	13	7
	90-104	48	62	40	22	8
	105+	59	67	44	11	3
	Mean Hearing Loss	82.16	81.09	78.69	69.15	63.32
	SD	25.32	25.99	25.54	27.13	24.54
Age at Onset	< 2 yrs	215	258	185	94	51
	⩾ 2 yrs	16	23	21	16	9
Gender	Male	116	143	97	49	22
	Female	115	138	109	61	38
Additional Educational Handicaps	None	126	159	129	82	49
	One or More	105	122	77	28	11
Personal Hearing Aid	Yes	168	211	157	88	45
	No	63	70	49	22	15
Method of Communication	Oral	107	142	122	84	52
	Total	124	139	84	26	8
Educational Setting	Reg. Sch.	76	99	89	75	52
	CHI in Reg. Sch.	72	92	69	24	4
	Sch. for Deaf	83	90	48	11	4
Total		231	281	206	110	60

sonal student characteristics — age, severity of hearing loss, age at onset, gender, number of additional educational handicaps — as independent variables. At the second stage, a combined a priori-stepwise approach was adopted. Significant variables identified at Stage 1 were first entered into the regression equation, followed, using stepwise procedures, by the remaining potentially manipulable student variables — personal hearing aid use, method of communication, and educational setting. In effect, the two stages combined permitted the examination of the contribution of the manipulable student characteristics over and above the contribution of the significant non-manipulable characteristics.

To control excessive Type I errors (Kupper et al., 1976), the .01 level of significance was used at each step of the analyses for each academic area. All analyses were completed using the UBC TRP Triangular Regression Package (Le & Tenisci, 1977). Dummy coding (Kerlinger & Pedhazur, 1973) was used for age at onset, gender, number of additional handicaps, and personal hearing aid use. Both age and severity of loss were employed in their continuous (i.e., non-categorical) form; likewise, educational setting was treated as a quantitative variable, reflecting its integration hierarchy.

RESULTS AND DISCUSSION

The results of the two regression analyses conducted for each subject area are summarized in Table 3. The mean and standard deviation on each test are expressed in the previously described derived score units. The zero order correlations (r) provide an unadjusted measure of the relationship between the independent and dependent variables. Inspection of the corresponding scatter plots revealed no non-linear relationships. The partial correlations for each of the manipulable independent variables and the dependent variables (pr) show the extent of the relationship between these variables after the influence of the significant nonmanipulable variables (shown above the dotted line) was removed. The coefficients of determination (R^2) reflect, in ascending order, both the order of entry and the magnitude of explained subject area variance. Successive differences between these coefficients (i.e., the squared semi-partial correlations) indicate the contribution of each independent variable to the explained variance.

Based upon the patterns shown in Table 3, the five academic areas can be divided into two generic sets — Reading and Mathematics. For both vocabulary and reading comprehension, the same three personal variables entered the regression equations and in the same order — age followed by additional educational handicaps followed by severity of hearing loss. Age at onset, a critical factor frequently posited to account for differences in the linguistic development of hearing impaired students, did not enter these equations. This finding may be attributed to the larger proportion

TABLE 3

Summary of A Priori — Stepwise Multiple Regression Analysis for Each Academic Area

	Vocabulary			Reading Comprehension			Mathematics Computation			Mathematics Applications			Mathematics Concepts		
n	231			281			206			110			60		
$\overline{X}$	131.49			133.82			163.52			156.34			175.50		
SD	26.17			27.58			25.78			33.45			32.69		
	r	*pr*	R^2	*r*	*pr*	R^2	*r*	*pr*	R^2	*r*	*pr*	R^2	*r*	*pr*	R^2
Personal Variables															
Age	.402		.162	.348		.121	.534		.285	.432		.186	.620		.384
Severity of Hearing Loss	—.267		.308	—.333		.335	.036			—.040			.076		
Age at Onset	.253			.202			.039			.095			.171		
Gender	.086			.137			.090			.084			—.013		
Additional Educational Handicaps	—.313		.262	—.335		.236	—.225		.352	—.304		.275	—.116		
Potentially Manipulable Variables															
Personal Hearing Aid	.029	.082		.120	.159		.065	.152		—.055	.003		—.153	—.059	
Major Communication	.394	.285		.435	.315		.001	.075		.086	.225		.095	.007	
Educational Setting	—.435	—.339	.388	—.539	—.443	.466	—.017	—.070		—.123	—.193		.099	—.039	

of the postlingual group in this study who were deafened within two years of the age of two.

For the two academic areas, only one of the manipulable variables, educational setting, entered both equations after the three significant personal variables had been forced to enter. Further, educational setting tended to supplant severity of hearing loss. This result, and the fact that method of communication did not enter (even though the zero order and partial correlations were of comparable magnitude to those for educational setting), may be explained by the moderately strong relationships among these three variables. Their respective correlations varied between .58 and .74 in absolute value; in contrast, all other correlations among the independent variables were somewhat lower. Thus, for vocabulary and reading comprehension, the hypothesis that academic performance is more a function of the personal characteristics of hearing impaired students and less a function of educational program variables was only partially supported. For both areas educational setting, a surrogate for integration, added to the explained variability in performance. As indicated by the partial correlations between educational setting and vocabulary, —.339, and reading comprehension, —.443, there is an inverse relationship between the extent of integration and performance in reading, a finding in agreement with that previously reported by Jensema (1975).

Examination of the results for mathematics (see Table 3) reveals that, in contrast to reading, no manipulable variables entered the equations. For mathematics computation and applications, age and additional educational handicaps, two nonmanipulable variables, contributed significantly to the explained variability in performance, while only one, age, contributed to the performance in mathematics concepts. These results support the hypothesis that, for mathematics, achievement is more influenced by personal characteristics of the students than by manipulable variables. Unlike reading and language development, where hearing impairment is known to retard language acquisition, mathematics performance appears to be more a function of maturation and time in school.

SUMMARY

The general hypothesis that differences in the academic achievement of hearing impaired students enrolled in school is more a function of their personal characteristics (age, severity of hearing loss, gender, age at onset, and additional educational handicaps) and less a function of "manipulable" variables was only partially supported by the data in the present study. Application of an a priori-stepwise multiple linear regression model revealed that the five academic areas examined — vocabulary, reading comprehension, and mathematics computation, applications, and concepts — could be divided into two general subject areas: Reading and Mathematics. For vocabulary and reading comprehension, three of the personal variables — age, severity of loss, and additional educational handicaps — and one potentially manipulable variable — educational setting (a surrogate for integration into the regular mainstream) — entered the equations. And, as explained above, educational setting, when entered, tended to take the place of severity of loss. In contrast, for the mathematics areas, only personal variables contributed significantly to the explained variability in achievement; both age and additional educational handicaps entered the equations for mathematics computation and applications, while only age entered the equation for mathematics concepts. These differences between reading and mathematics, centred around the independent variables associated with severity of hearing loss, reflect the greater dependence of reading upon language skills. The well-documented general verbal deficit in the coding processes of hearing impaired students (Moores, 1978) appears to be supported in the present study.

Further, it should be noted that between 28% (for mathematics applications) and 47% (for reading comprehension) of the variability in performance in the five areas was explained by the eight variables examined in this study. Yet, as reflected by the internal consistency measures reported earlier, there is considerably more explainable variance. The failure of these often cited "predictors" of academic achievement of hearing impaired students reveals that, as with hearing students, the task of identifying the salient factors related to achievement is a complex and difficult one. While there are a number of provocative explanations available for understanding the differences in psychoeducational processes between hearing and deaf (Moores, 1978, pp. 121-137), there are few research studies which concern the differences among hearing impaired students themselves (Scholes et al., 1978). In the present study, when the presence of intercorrelated, personal, non-manipulable variables was statistically controlled, only one of the manipulable variables considered was associated with academic performance, and that was restricted to reading. However, the influence of other potentially manipulable variables merits further investigation. The relationship between teaching strategy, curriculum content, and early communicative environment (Brasel & Quigley, 1977), for example, and academic performance should be the subject of future research if more effective solutions for the educational treatment of hearing impaired students are to be formulated.

NOTES

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[1] The age deviation score for each student was computed by subtracting the mean score for his/her age group and then dividing this difference by the standard deviation of the test for that age group (Jensema, 1975, p. 3).

[2] Although computational ability was tested at Level 1, only one-half of the computation test was used. It was not possible to combine the scores of the students administered the Level 1 "half-test" with the scores of the students at the remaining levels since the score conversion procedure employed for analysis purposes required use of the full test.

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