Predicting the Academic Achievement of Deaf and Hard-of-Hearing Students From Individual, Household, Communication, and Educational Factors

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Abstract

Research suggests that the academic achievement of deaf and hard-of-hearing (DHH) students is the result of a complex interplay of many factors. These factors include characteristics of the students (e.g., hearing thresholds, language fluencies, mode of communication, and communication functioning), characteristics of their family environments (e.g., parent education level, socioeconomic status), and experiences inside and outside school (e.g., school placement, having been retained at grade level). This paper examines the relative importance of such characteristics to U.S. DHH secondary students' academic achievement as indicated by the Woodcock-Johnson III subtests in passage comprehension, mathematics calculation, science, and social studies. Data were obtained for approximately 500 DHH secondary students who had attended regular secondary schools and/or state-sponsored special schools designed for DHH students. Across all subject areas, having attended regular secondary schools and having better spoken language were associated with higher test scores. Significant negative predictors of achievement varied by type of subtest but included having an additional diagnosis of a learning disability, having a mild hearing loss, and being African American or Hispanic. The findings have important implications for policy and practice in educating DHH students as well for interpreting previous research. (Contains 7 tables).

Predicting the Academic Achievement of Deaf and Hard-of-Hearing Students from Individual, Household, Communication, and Educational Factors

Despite promising developments in the education of deaf and hard-of-hearing (DHH) students, their achievement continues to lag behind their hearing peers', and many do not acquire the knowledge and skills to reach their full potential (Qi & Mitchell, 2012). Research suggests several reasons for this troubling and longstanding underachievement. Many DHH students enter school lacking fluency in either a signed or a spoken language (Gregory, 1986; Singleton & Morgan, 2006), and service providers frequently struggle to adequately structure the language environments and to provide access and opportunities for DHH children to learn (Knoors & Marschark, 2012, 2014). There are also shortages of qualified teachers of the deaf and of research-based teaching methods and instructional materials for DHH students (Kelly, Lang, & Pagliaro, 2003; Marschark, Lang, & Albertini, 2002; Pagliaro & Ansell, 2002). Finally, research has revealed cognitive differences between DHH and hearing students that indicate the need for some different pedagogical techniques and instructional materials (Dye, Hauser, & Bavelier, 2008; Marschark & Knoors, 2012). Interestingly, an analysis of the characteristics of DHH students and the distinction between characteristics likely to affect academic achievement and those that are tangential is largely missing from these discussions (Stinson & Kluwin, 2011). This paper specifically addresses this issue by examining relationships among student characteristics and achievement in a nationally representative sample of DHH secondary school students.

Educating DHH Students

The history of efforts to educate DHH learners is a controversial one, particularly with regard to program placement and, relatedly, the language of instruction. The debates center on whether

DHH students are best served by regular schools with a wide variety of students, including those with and those without disabilities, or special schools or programs designed for DHH learners (e.g., Guralnick, 1999; Knoors & Hermans, 2010; Knoors & Marschark, 2014; Wang & Walberg, 1988) and whether sign language, spoken language, or both should be the language(s) of instruction (see Lang, 2011). Within each of these school placements, DHH students can experience a variety of instructional approaches, programs, assistance, and staffing. For example, in regular schools instruction for DHH students may be bilingual, with sign language support, or written/spoken language supported by assistive listening devices such as hearing aids and cochlear implants (multifrequency electrodes surgically implanted near the auditory nerve with an external microprocessor worn like a hearing aid that is mapped to the specific frequencies of an individual's hearing loss), real-time text, and attention to classroom acoustics. Although the debate about the most appropriate placement continues, the dramatic movement of DHH students in the United States from schools for the deaf to regular schools is unquestioned: 50 years ago, 80% of DHH children were educated in special settings where instruction typically was offered through some form of signed communication; today, more than 85% spend all or part of the school day in regular schools (United States Government Accountability Office, 2011).

Whatever the educational setting, the primary challenge in educating DHH student is meeting their communication needs. More than 95% of DHH children have speaking and hearing parents, but because of their hearing losses, DHH children's access to spoken language is limited. Thus, most DHH children arrive at school with significant delays in language development relative to hearing peers (Knoors & Marschark, 2012). DHH children of deaf parents, with access to a natural sign language from birth, and those who have greater (but not full) access to spoken language generally demonstrate somewhat better academic outcomes than DHH children without those characteristics. Nevertheless, neither group generally achieves at the level of their hearing peers (e.g., DeLana, Gentry, & Andrews, 2007; Geers, Tobey, Moog, & Brenner, 2008; Wauters, van Bon, Tellings, & Leeuwe, 2006). A possible explanation is that DHH children do not have full access to the language and environmental diversity of their hearing peers. This situation impacts not only language development, but also cognitive development, knowledge of the world, and social functioning, all of which influence each other cumulatively over time (Marschark & Knoors, 2012).

Despite DHH students' chronic difficulties in reading, recent studies have found that at least from middle school onward they learn just as much from text as they do from sign language or spoken language in the classroom (e.g., Borgna, Convertino, Marschark, Morrison, & Rizzolo, 2011; Marschark, Leigh, et al., 2006; Marschark et al., 2009; Stinson, Elliot, Kelly, & Liu, 2009). Those results suggest a limitation on the generality of findings indicating that early access to language via sign language or assistive listening devices is sufficient to provide DHH learners with age-appropriate reading abilities (e.g., Geers et al., 2008; Padden & Ramsey, 2000; see Holzinger & Fellinger, in press).

Research on the Achievement of DHH Students

The academic achievement of DHH students depends on the interaction of many factors, including those that are intrinsic to students themselves, such as expressive and receptive language abilities, family characteristics, and their experiences inside and outside school. Previous studies have been limited in their ability to identify predictors of achievement for DHH students largely because of the confounding of school placement, hearing thresholds, and language modality (e.g., Reich, Hambleton, & Houldin, 1977). Research on DHH students' academic achievement has also been limited by small samples (Cunningham & Cox, 2003), biased samples (Convertino, Marschark, Sapere, Sarchet, & Zupan, 2009), and other methodological issues. For example, normings of the Stanford Achievement Test (SAT) for DHH students (e.g., Holt, 1993; Traxler, 2000) are unlikely to be representative of DHH students in the general population because they are drawn from students represented in the Gallaudet Research Institute Annual Survey of Deaf and Hard-of-Hearing Children and Youth (henceforth Annual Survey), which is weighted toward students with greater hearing losses and those enrolled in schools for the deaf (Allen & Anderson, 2010; Holt, 1993; see Shaver, Marschark, Newman, & Marder, 2014, for a review).

Another limitation of prior research has been a narrow definition of academic achievement. Although DHH secondary school students appear to lag behind hearing peers across the curriculum (e.g., Roald, & Mikalsen, 2000; Spencer & Marschark, 2010; Chapter 8), previous studies have focused almost exclusively on reading and mathematics. Given the importance of other academic subjects such as science and social studies for postsecondary education and employment, it is important to examine achievement across a wider array of academic domains.

Taken together, complexities in predicting achievement and the limitations of prior research emphasize the importance of developing a stronger understanding of how various factors affect DHH students' learning and achievement across academic subject areas. Not only will this contribute to scientific understanding of cognitive and linguistic functioning among DHH learners, but it will also help researchers and educators design educational interventions and supports to improve their academic achievement and post-school outcomes.

Predictors of Achievement for DHH Students

The current study drew from the literature on DHH students' learning and academic achievement to identify factors that may predict achievement. Previous studies have addressed the relationship between achievement and characteristics such as hearing thresholds, the presence of additional disabilities, gender, and ethnicity, as well as school placement. With regard to hearing thresholds, reviews by Goldberg and Richburg (2004) and Moeller, Tomblin, Yoshinaga-Itano, Connor, and Jerger (2007) found that even minimal hearing losses, those as small as 15 dB (decibels), can significantly affect academic achievement and literacy, in particular.

Karchmer, Milone, and Wolk (1979) claimed that median SAT reading comprehension scores of students with less than severe hearing losses (i.e., < 71 dB) were higher than those of students with greater losses across the age range examined (8 to 18 years). Hearing thresholds among DHH students frequently are confounded with both school placement (students with greater hearing losses are more likely to be enrolled in special schools; Shaver et al., 2014) and preferred communication modality (those with greater losses being more likely to use sign language; Allen & Anderson, 2010). Comparisons between groups that vary on only one of these dimensions alone are rare. Antia, Reed, and Kreimeyer (2005) and Antia, Jones, Reed, and Kreimeyer (2009) examined writing scores of DHH 8- to 18-year-olds in regular classrooms. In both studies, gaps between the deaf learners and hearing norms narrowed with age, suggesting that the DHH students were catching up with hearing peers. In the 2005 study, students' use of signed or spoken communication was not related to their writing scores, although those who used sign language interpreters in the classroom scored lower than others. In the 2009 study, communication mode was significantly related to writing scores, favoring those students in programs emphasizing spoken language (see also, Musselman & Szanto, 1998).

Allen and Osborne (1984) found that SAT reading comprehension scores were significantly associated with hearing thresholds, ethnic status, additional disabilities, and school placement as well as gender (advantage females) for DHH students aged 8 years and older. Significant effects of ethnicity, additional disabilities, and school placement also were found for mathematics subtests. Importantly, especially with regard to significant relations with hearing thresholds, the Allen and Osborne data were drawn from students associated with the Annual Survey.

In a similar study, Holt (1993) reported that median SAT reading comprehension scores were higher for DHH students in general education classrooms than those in separate classrooms. Holt also reported that students with less than severe hearing losses scored higher than those with greater losses. She also found that White students scored significantly higher than minority students, although the latter also were more likely to be enrolled in regular schools with self-contained classrooms for DHH students. Students reported to have educationally relevant disabilities (e.g., learning disability, emotional/behavior problems) scored lower than DHH students without additional disabilities. They, too, however, were more likely to be enrolled in self-contained classrooms, leaving undetermined which of these factors might be considered the cause and which the effect of the observed findings.

As with hearing thresholds, the possible link between school placement and DHH students' academic achievement remains unclear. Stinson and Kluwin (2011) noted that previous studies had found school placement to account for less than 5% of the variability of DHH students' achievement scores. However, in addition to Allen and Osborne (1984) and Holt (1993), several others have reported higher academic achievement among DHH students in regular classrooms than those in special classrooms or special schools in both the United States (e.g., Kluwin, 1993; Kluwin & Moores, 1989; Kluwin & Stinson, 1993) and the United Kingdom (e.g., Powers, 1999). The question therefore has remained as to whether apparent links between school placement and achievement are the product of placement (i.e., curriculum, access, expectations) or a reflection of a priori differences among students in language or cognitive abilities, the likelihood of additional disabilities, or parental involvement (see Powers, 1999; Spencer & Marschark, 2010; Stinson & Kluwin, 2011, for reviews).

Finally, Morere (2013a, 2013b) studied DHH college students' achievement in reading, writing, mathematics, and general academic knowledge using the Woodcock-Johnson III (WJ III) reading fluency, writing fluency, academic knowledge, and math fluency subtests. Although the study involved Gallaudet University students, it used subtests from the WJ III Tests of Achievement, the instrument used in the present study with high school students. The mean scores (of 47–49 participants) were in the average range according to age-based norms, but the range of scores was very broad. This wide variability reflects the difficulty in assessing (and teaching) students in a population with such large individual differences. It also suggests caution in accepting mean scores as reflecting age-appropriate performance for any DHH group as a whole.

The present study was designed to provide an extension of earlier studies that have involved achievement assessed using the SAT, WJ III tests, and tests of classroom learning. Examining relations among WJ III test scores in four academic subject areas and student characteristics in a nationally representative sample of DHH secondary school students, the present study sought to provide a more comprehensive understanding of DHH students' achievement than has been available previously. In particular, this study addressed the question of what individual, family, communication, and educational factors are associated with variations in the academic achievement among DHH secondary students.

Method

The findings in this paper come from secondary analyses of data from the National Longitudinal Transition Study 2 (NLTS2), funded by the U.S. Department of Education in 2000. The database and the methods used for analysis are described below.

Study Database

NLTS2 is a U.S. national database on the characteristics, experiences, and post-high school outcomes of secondary school-age students with disabilities. With an initial sample of more than 11,000 students, NLTS2 is nationally representative not only of students in the targeted age range as a whole, but also of those in each federal special education disability category, including DHH students. It is the largest data set available to examine the experiences and outcomes of secondary school DHH students and the only one that can address these topics for DHH students nationally. The NLTS2 database includes data collected from phone interviews and/or surveys of parents and youth across five waves of data collection (conducted every other year beginning in 2001 and ending in 2009), high school transcripts, surveys of students' high school teachers, and direct assessments of students' academic achievement.

Sample

The DHH students included in NLTS2 were ages 13–16, in grade 7 or above, and identified by their school district as receiving special education services for a primary disability of hearing impairment[1] as of December 1, 2000. NLTS2 sampling procedures involved first drawing a random sample of school districts that served students in the eligible age range, stratified by region, local education authority (LEA) size (student enrollment), and wealth. The second sampling stage entailed randomly selecting students receiving special education in each of the 12 special education disability categories, from the rosters of participating LEAs or special schools. Weights were computed taking into account various youth and school characteristics used as stratifying variables in the sampling and nonresponse in those strata. Results are weighted so that findings are nationally representative of students in the hearing impairment category in the NLTS2 age range and time frame.

The analysis sample for the present study included approximately 500 DHH students for whom data were available for the variables used in the analyses.[2] The sample did not include DHH students who were identified for special education services for a primary federal disability category other than "hearing impairment" or DHH students not identified for special education services. The variables and their measures are described below.

Measures

Data for this study came primarily from the direct assessments of academic achievement and wave 1 and wave 2 parent/youth structured phone interviews and/or mail surveys.[3]

Academic outcome measures. Direct assessments of DHH students' academic achievement involved the research edition of the WJ III (Woodcock, McGrew, & Mather, 2001) administered in the data collection wave sample when members were 16 to 18 years old (2002 or 2004). The WJ III is a comprehensive, norm-referenced, individually administered assessment of academic skills and knowledge. Assessors were recruited and trained for the NLTS2 direct assessments. Students were allowed to use any testing accommodations (e.g., use of an American Sign Language [ASL] interpreter, additional time) specified in their Individualized Education Program.[4]

Scores on the WJ III are reported as standard scores, ranging from 0 to 200, with a mean of 100 and a standard deviation of 15. In the general population, the distribution of test scores on each subtest is equally divided above and below the mean (i.e., 50% score above and 50% below). The present study used four direct assessment subtests described below: passage comprehension, mathematics calculations, social studies, and science (Mather & Woodcock, 2001).

Passage comprehension. This subtest presents items that range in difficulty. The least difficult items present a phrase with pictures. Students point to the picture that matches the phrase (e.g., two trees). The more difficult items are entirely text based, address more technical topics, and require greater vocabulary and the ability to make inferences from context.

Mathematics calculation. This subtest assesses computation skills, ranging in difficulty from elementary (e.g., simple addition) to advanced (e.g., integrating a function). Students are required to perform basic operations as well as some geometric, trigonometric, logarithmic, and calculus operations.

Social studies. This subtest assesses knowledge of history, geography, government, economics, and other aspects of social studies. Early items require a pointing response and later ones require students to respond orally or to an ASL interpreter.

Science. This subtest assesses knowledge of various areas of biological and physical sciences. Early items require a pointing response and later ones require students to respond orally or to an ASL interpreter.

Demographic and family predictors. Parent interviews provided information on student gender and race/ethnicity, as well as head of household's education level and household income.

Disability-related predictors. Parents were asked the age at which their child's hearing loss was first identified and whether the child had secondary disabilities. Three variables indicating additional diagnosed disabilities were created for analyses: dyslexia or other type of learning disability (LD), attention deficit disorder or attention deficit hyperactivity disorder (ADD/ADHD), and a secondary disability that was not dyslexia/LD or ADD/ADHD.

Hearing and communication predictors. School district rosters categorized DHH students in a single "hearing impairment" category. To better distinguish the range of hearing and communication abilities, parents were asked whether their child's hearing losses were mild, moderate, or severe/profound.[5] Parents also were asked how their child communicated, their child's clarity of speech, and their child's ability to understand what other people say in his or her primary language (including sign language). Parents were asked to indicate whether the child was *not at all* able, had *a lot of trouble, a little trouble*, or *no trouble* with these aspects of communication.

Educational predictors. Secondary school and educational history factors included the type of school a student attended, whether he or she had ever been held back a grade, and whether he or she had ever been expelled or suspended from school, according to parental report. To examine types of schools, students were grouped into two categories: (a) those who attended regular secondary schools only (i.e., those serving a wide variety of students, including students with and those without disabilities) and (b) those who attended special secondary schools only, such as schools for the deaf, or a mix of both regular and special secondary schools across NLTS2 data collection waves.[6] Categorizing students' school settings and experiences beyond these broadly defined placement categories was beyond the scope of this study.

Data Analysis

All analyses were weighted using a cross-wave, cross-instrument weight appropriate for multiple waves of NLTS2 data and multiple instruments (Valdes et al., 2013) to accommodate for design effects and the complex nature of the data set. Standard errors are presented for means and percentages, and the sample sizes are rounded to the nearest tens (as required by the U.S. Department of Education). No imputation of missing values was conducted.

A four-step multilevel linear regression analysis was used to predict scores on each of the four WJ III subtests. In the first step, measures of individual and household characteristics were included. In the second step, we included variables related to disability identifications. In the third step, we added variables related to hearing and communication. Last, we added variables related to educational experiences.

The objective of this four-step approach was to examine the relative contribution of these four clusters of factors to the explained variance. We were particularly interested in the relative contribution of the last two groups of variables, hearing/communication and educational experiences, factors that may be more readily addressed by educational practices and policies than factors in the first two groups. A likelihood ratio test was conducted for each step to determine whether the addition of each group of variables yielded a statistically significant change in the model's predictive ability.

The selection of variables occurred in several stages. First, variables available in the NLTS2 database that previous research has shown to be associated with academic achievement for DHH or all youth (e.g., hearing thresholds, socioeconomic status) were identified. Second, bivariate analyses were conducted to identify variables associated with the WJ III subtests. Variables that were not associated with any of the four outcome measures were eliminated (including having cochlear implants, the use of hearing aids or devices, the youth's age at the time of the assessment, and whether the youth had general health problems). Finally, bivariate correlations were examined, resulting in the elimination of several variables that were highly correlated ($r > .60$) with other similar variables (including overall ability to communicate and ability to carry on a conversation).

Regression diagnostic tests revealed that, overall, the data met regression assumptions. For example, residuals were approximately normally distributed for all regressions except for the first model (with only the demographic and household variables) for the math calculation subtest, which was slightly negatively skewed. In addition, tests for multicollinearity revealed low variance inflation factors (VIFs) for the independent variables (VIFs were less than 2.0 in all cases).

The resulting descriptive and multivariate analyses are presented below. Statistical significance levels have been adjusted using the Benjamini-Hochberg (Benjamini & Hochberg, 1995) method to control for false discoveries due to multiple comparisons.[7]

Results

The demographic and household characteristics of DHH students represented by the full analysis sample are presented in Table 1, and their disability, communication, and educational characteristics are presented in Table 2.

Insert Tables 1 & 2 about here

The mean WJ III standard scores for DHH students represented by the analysis sample are shown in Table 3. DHH students scored highest, on average, on the mathematics calculation subtest (92.0) and lowest on the passage comprehension and science subtests (77.1 and 76.9, respectively). Mean scores on all four subtests were significantly below the mean for the general population (100, $p < .001$ for all comparisons). Tables 4 through 7 present the regression model results predicting DHH students' academic achievement in the four academic domains.

Insert Table 3 about here

Predicting Achievement in Passage Comprehension. The demographic characteristics entered in the first model accounted for 9% of the variance in passage comprehension scores. Adding disability characteristics (model 2) accounted for an additional 9%, adding hearing and communication factors (model 3) accounted for an additional 13%, and adding educational factors (model 4) accounted for an additional 7% of the variance in scores ($p < .001$ for the F change statistics from each model to the next). The final model accounted for 38% of the explained variance and revealed that, controlling for other factors, having better speaking abilities and attending regular schools only were positively related to passage comprehension scores ($\beta = 6.1$ and 16.5, respectively; $p < .001$). Factors that were negative predictors for this subtest included identification as Hispanic ($\beta = -10.9$, $p < .05$), having a diagnosis of dyslexia or LD ($\beta = -11.5$, $p < .001$), and having been held back a grade ($\beta = -6.1$, $p < .05$).

Insert Table 4 about here

Predicting Achievement in Mathematics Calculations. Demographic characteristics alone accounted for 6% of the variance in mathematics calculation scores. Adding disability characteristics accounted for an additional 11%, adding hearing and communication factors accounted for an additional 13%, and adding educational factors accounted for an additional 6% of the explained variance ($p < .001$ for the F change statistics). The final model accounted for 36% of the variance in scores. Like the results for the passage comprehension subtest, better speaking abilities and attending only regular schools were positively related to mathematics achievement ($\beta = 4.2$ and 9.4, respectively; $p < .05$ and $p < .01$); whereas having been held back a grade or ever having been expelled or suspended were negatively related to mathematics calculation ($\beta = -7.1$ for both; $p < .01$ for grade retention and $p < .05$ for suspensions/expulsions). Other significant negative predictors included having a diagnosis of dyslexia/LD ($\beta = -11.0$, $p < .01$), having a secondary disability other than dyslexia/LD or ADD/ADHD ($\beta = -6.6$; $p < .05$), and having a mild hearing loss (β = -16.8, $p < .001$).

Insert Table 5 about here

Predicting Achievement in Social Studies. Demographic factors alone accounted for 16% of the variance, disability and health problems accounted for an additional 10%, hearing and communication factors accounted for another 13%, and educational factors accounted for an additional 1% of the explained variance ($p < .001$ for the F change statistics from model 1 to model 2 and model 2 to model 3; $p < .01$ for the F change statistic from model 3 to model 4). The final model accounted for 40% of the variance in social studies achievement scores and showed that after controlling for other factors, having better speaking abilities and attending only regular schools were positively related to social studies scores (β = 4.4 and 8.1, respectively; $p < .01$). Other significant predictors were negatively associated with social studies scores, including identification as African American or Hispanic (β = -9.3 and -10.3, $p < .001$), diagnosis of dyslexia/LD (β = -8.0, $p < .01$), and diagnosis of a secondary disability not including dyslexia/LD or ADD/ADHD (β = -5.0, $p < .05$).

Insert Table 6 about here

Predicting Achievement in Science. Demographic factors alone accounted for 16% of the variance in science scores. Adding disability factors accounted for an additional 11%, hearing and communication factors accounted for an additional 15%, and educational factors increased the explained variance of science scores by another 4% ($p < .001$ for the F change statistics from each model to the next). The final model accounted for 46% of the variance in science achievement scores. In the full model, better speaking abilities (β = 6.3, $p < .001$) and having attended regular schools only (β = 13.8, $p < .001$) positively predicted science scores. Negative predictors included identification as African American or Hispanic (β = -9.9 and -16.4, respectively; $p < .001$), and having a diagnosis of dyslexia/LD ($\beta = -8.8$, $p < .05$).

Insert Table 7 about here

Discussion

The present study examined relationships between characteristics of DHH secondary school students identified for special education services and their achievement in reading, mathematics, social studies, and science as measured by WJ III subtests. Overall, the findings reinforce the fact that academic achievement of DHH students across the curriculum is related to a complex array of factors relating to the students themselves, their family environments, and their school experiences.

The analysis approach used illuminates the predictive power of clusters of variables and reveals that the hearing and communication variables explained a large proportion of the variance across the four subtests relative to the other clusters. Demographic and household characteristics most powerfully predicted achievement on the social studies and science subtests. The educational factors included in the models made the smallest contribution to the explained variance, particularly for the social studies subtest. Analyses also suggest that multiple individual factors are powerful in differentiating students on the basis of their academic achievement including race/ethnicity, presence of additional disabilities, hearing thresholds, communication functioning, a history of grade retention or school suspensions/expulsions, and type of school attended. Several of these are particularly noteworthy given prior research.

Studies of DHH students' achievement typically have been unable to separate out the effects of race/ethnicity, socioeconomic status (SES), and parents' education, although the three are frequently found to be intertwined in studies of achievement among hearing students (Davis-Kean, 2005). In the present study, White students performed higher than African American and

Hispanic students in passage comprehension, social science, and science, but race/ethnicity did not predict mathematics calculation scores. Coefficients for family income variables were not statistically significant after adjustments for multiple comparisons; however, they approached significance for the mathematics and social studies subsets, suggesting a possible association with achievement after controlling for race/ethnicity and other factors.

Various studies have indicated that up to 40% of DHH students have other conditions or disabilities that might affect learning (see Knoors & Marschark, 2014, for discussion of their impact in various domains). In the present study, having a diagnosis of dyslexia/LD was negatively related to achievement across all four subtests, but having a diagnosis of ADD/ADHD was not related to achievement in any of the subtests when controlling for other factors. A diagnosis of a secondary disability other than dyslexia/LD or ADD/ADHD was negatively associated with achievement in mathematics and social studies. Van Dijk, Nelson, Postma, and van Dijk (2010) and others have argued that the combined effects of multiple disabilities among DHH individuals tend to be multiplicative and not merely additive. With regard to school achievement, strategies or interventions (including the use of sign language) intended to support a DHH student could be limited by or disrupted by some other disability or vice versa.

One of the most consistent findings from the NLTS2 data was that better speaking ability was positively related to achievement scores across all the WJ III subtests, whereas having a mild hearing loss was negatively associated with performance on the mathematics subtest and approached significance on the passage comprehension and social studies subtests. This latter finding is consistent with findings of Goldberg and Richburg (2004) and Moeller et al. (2007) indicating that students with lesser hearing losses typically are assumed to be functioning effectively in the classroom and thus receive fewer support services than students with greater hearing losses. Marschark and Hauser (2012, Chapter 2) suggested that hard-of-hearing students frequently “fall into the cracks” and perform less well than would be expected on the basis of their hearing thresholds alone and argued that whether or not they need less support than peers with greater hearing losses, they may need different support. Among other issues, students with minimal to mild hearing losses may not be aware of how much communication they are missing in the classroom (Borgna et al., 2011). Regarding communication mode, students’ use of sign language was not statistically associated with achievement on any of the subtests, although this factor approached significance for the social studies subtest (negatively) after adjustments for multiple comparisons.

Finally, some of the present results indicate that school experiences of DHH students are important in differentiating achievement. Being held back a grade was negatively related to scores on reading comprehension and mathematics subtests, and ever having been expelled from school was negatively related to the latter. DHH students who attended only regular schools (including those in self-contained classrooms within regular schools) performed higher across all achievement measures than DHH students who attended only special schools or a mix of regular and special schools, even after other factors were controlled. We noted earlier that placement in a special setting for DHH students frequently is assumed more likely to be the product of prior developmental and academic progress rather than a precursor of them (Allen & Osborne, 1984; Powers, 1999; Stinson & Kluwin, 2011). Although many of the factors that would contribute to such a priori differences were controlled in the present study, real-world interactions among them during development and other factors beyond statistical control may well account for the present finding. For example, research has indicated that teachers in mainstream settings may have higher expectations for DHH students than those in schools for the deaf (Kelly et al., 2003) and that DHH students in special school settings may not have strong emotional links with their teachers or be satisfied with teachers' classroom management (e.g., time on task, instructional organization; Hermans, Wauters, de Klerk, & Knoors, in press). Neither of these factors was tapped by NLTS2, but factors such as these may explain the differences in achievement between DHH students in special schools and those in regular schools.

In summary, a better understanding of the factors contributing to DHH students' academic achievement across subject areas is important for both theoretical and practical reasons. Not only will this contribute to scientific understanding of cognitive, social, and linguistic functioning among DHH learners, but it also will help us design educational materials, methods, and interventions to support their academic achievement. Findings emerging from analyses of the NLTS2 dataset emphasize that it is only by recognizing the diverse strengths and needs of DHH students that teachers can appropriately target their instruction. These findings are of interest to parents, teachers, school administrators, and researchers who want to improve instruction to help DHH students reach their full potential as students and life-long learners. In terms of policy and practice, findings indicating that youth with mild hearing losses may have somewhat lower achievement scores than those with moderate or severe/profound losses are consistent with recent suggestions that even minimal hearing loss can interfere with achievement outcomes and that these students may not receive appropriate or sufficient support services.

The present findings are informative with regard to secondary school students' academic achievement, but more research is needed to understand how such achievement is related to various school interventions and support services as well as to various home and school environments. For example, parent reports of hearing loss and communication abilities may not fully reflect their DHH children's experiences (Marschark, Bull, et al., 2012). Although parent reports are important and valuable, they cannot be equated with the results of assessments conducted by individuals trained to evaluate or diagnose disabilities, health conditions, or communication skills. Further, with the broad implementation of universal newborn hearing screening, the increasing popularity of digital hearing aids and prevalence of pediatric cochlear implantation, and changing methodologies in deaf education, the extent to which the NLTS2 population of DHH secondary school students is representative of later (and future) cohorts is constantly changing. It should be noted again that this study focused only on DHH students identified for special education services under the primary federal disability category of “hearing impairment” and therefore did not provide information on DHH students who may have benefited from supports or services but who did not qualify for them, qualified under another primary disability category, or chose not to be identified for services. Finally, this study examined school types broadly defined; however, within each type of school environment, DHH students experience a wide range of instruction and services. Further research on the language of instruction, the extent to which DHH students interact with hearing peers, the accommodations and supports provided, and the training and support given to teachers to teach DHH students is warranted to better understand how to improve DHH students’ academic achievement. Together with earlier and ongoing studies on language and communication, the effects of early diagnosis and early intervention, and the influence of assistive hearing devices on child development and academic functioning, studies of this sort serve an important role in improving educational opportunities and outcomes for DHH students.

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Table 1. Demographic Characteristics of Secondary School-age DHH Youth Represented by Analysis Sample

Characteristics	Percentage	*SE*
Gender		
Female	52	3.53
Male	49	3.53
Ethnicity		
White	64	2.46
African American	12	1.65
Hispanic	21	1.86
Other	3	1.29
Head of household's level of education		
Less than high school	19	3.63
HS grad or GED	36	4.87
Some college	25	3.24
B.A. or higher degree	20	3.27
Household income		
$25,000 or less	30	2.76
$25,001–$50,000	33	2.81
More than $50,000	37	3.04

Note. Percentages are weighted population estimates based on an analysis sample of approximately 480 youth. Unweighted sample size was rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education. The analysis sample includes youth with values for all the variables in the full regression models, model 4 in tables 4–7.

Source: NLTS2 Wave 1 and 2 Parent Interview/Survey, 2001 and 2003.

Table 2. Disability, Communication, and Educational Characteristics of Secondary School-age DHH Youth Represented by Analysis Sample

Characteristics	Mean	Percentage	*SE*
Disability Issues			
Mean age when disability identified (years)	2.5		0.25
Diagnosed with ADD/ ADHD		16	2.9
Diagnosed with dyslexia/LD		12	1.78
Has a secondary disability other than ADD/ADHD or dyslexia/LD		21	3.48
Hearing and Communication			
Level of hearing loss			
Mild		8	2.00
Moderate		26	4.48
Profound		64	5.04
Uses sign language		61	4.85
Ability to speak clearly			
Has no trouble		31	4.67
A little trouble		42	4.74
A lot of trouble		15	2.16
Not at all able		11	2.20
Ability to understand others			
Has no trouble		52	4.18
A little trouble		41	4.54
A lot of trouble		7	2.03
Not at all able		0	
Educational Factors			
Type of school			
Regular school only		79	3.01
Special school only or mix of regular and special schools		21	3.01
Youth was ever held back a grade		27	3.05
Youth was ever suspended or expelled		16	2.46

Note. Mean/percentages are weighted population estimates based on an analysis sample of approximately 480 youth. Unweighted sample size was rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education. The analysis sample includes youth with values for all the variables in the full regression models, model 4 in tables 4-7.

Source: NLTS2 Wave 1 and 2 Parent Interview/Survey, 2001 and 2003 (type of school variable uses data from the waves in which youth were in secondary school through wave 4).

Table 3. Mean Standard Scores on WJ III Subtests for Youth Represented by Analysis Sample

WJ-III Subtest	Mean Standard Score	*SE*
Passage comprehension	77.1	2.32
Mathematics calculation	92.0	1.79
Social studies	81.7	1.70
Science	76.9	1.96

Note. Means are weighted population estimates based on an analysis sample of approximately 480 youth. Unweighted sample size was rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education. The analysis sample includes youth with values for all the variables in the full regression models, model 4 in tables 4–7.

Source: NLTS2 direct assessments, 2002 and 2004.

Table 4. Regression Model Results Predicting Achievement on the WJ III Passage Comprehension Subtest

	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3	Model 4	Model 4
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Intercept	77.98***	4.35	72.32***	4.67	53.58***	9.12	46.08***	8.28
Demographic Characteristics								
Male	-1.54	3.21	-1.54	3.35	-0.96	2.88	1.50	2.82
African American	-8.06†	3.62	-10.01*	3.49	-6.69†	3.04	-6.40†	2.70
Hispanic	-11.23*	4.39	-11.29*	4.07	-9.04†	4.19	-10.86*	4.15
Head of household's level of education	2.35	1.71	3.56†	1.69	2.92†	1.43	2.38	1.39
Household income $25,000 or less	-5.10	4.87	-4.60	4.81	-3.25	4.51	-3.00	4.11
Household income $25,001–$50,000	-3.66	3.64	-4.83	3.18	-5.67†	2.81	-5.20	2.72
Disability Issues								
Age when disability identified			1.94***	0.45	0.73	0.45	0.51	0.40
Diagnosed with ADD/ADHD			-1.39	3.35	1.48	3.06	3.06	2.66
Diagnosed with dyslexia/LD			-13.43***	3.02	-13.62***	2.92	-11.46***	2.59
Has a secondary disability other than ADD/ADHD or dyslexia/LD			1.12	2.85	2.02	2.52	-0.43	2.66
Hearing and Communication								
Hearing loss is mild					-8.38†	3.67	-7.60†	3.36
Hearing loss is moderate					-1.18	3.68	0.22	3.30
Uses sign language					-4.24	3.34	-2.33	3.66
Ability to speak					9.12***	1.43	6.09***	1.48
Ability to understand					-0.52	1.92	0.91	1.78
Educational Factors								
Attended regular schools only							16.54***	3.31
Ever held back a grade							-6.07*	1.97
Ever suspended or expelled							-3.67	2.75
Model summary								
F	5.12***		7.90***		8.47***		14.02***	
(Degrees of freedom)	(6, 132)		(10, 130)		(15, 130)		(18, 126)	
F change			7.70***		10.32***		12.14***	
(Degrees of freedom)			(4, 130)		(5, 130)		(3, 126)	
R^2	0.09		0.18		0.31		0.38	
R^2 change			.09		0.13		0.07	
N	510		490		490		480	

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$ after adjustments for multiple comparisons.

† $p < .05$ before adjustments for multiple comparisons and $p > .05$ after adjustments.

Note. Scaled scores from the WJ III Research Edition were used in analysis (Mather & Woodcock, 2001) using weighted data. Unweighted sample size numbers reported here are rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education.

Source: NLTS2 Direct Assessment of Student Achievement (2002 and 2004); Wave 1 and 2 Parent Interview/Survey, 2001 and 2003 (type of school variable uses data from all waves in which youth were in secondary school through wave 4).

Table 5. Regression Model Results Predicting Achievement on the WJ III Mathematics Subtest

	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3	Model 4	Model 4
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Intercept	94.44***	3.59	95.76***	3.79	74.68***	8.17	76.14***	8.40
Demographic Characteristics								
Male	-1.09	2.74	1.21	2.69	1.92	2.15	3.58	2.25
African American	-4.50	2.72	-5.76†	2.47	-2.86	2.04	-1.07	2.06
Hispanic	-5.08	3.22	-3.55	3.06	-1.80	2.57	-3.55	2.42
Head of household's level of education	1.33	1.42	1.14	1.32	0.93	1.01	0.19	1.03
Household income $25,000 or less	-6.41	3.37	-5.39	3.23	-3.59	2.78	-3.50	2.48
Household income $25,001–$50,000	-4.48	2.63	-3.86	2.42	-4.60†	2.14	-4.44†	2.21
Disability Issues								
Age when disability identified			0.57	0.47	-0.04	0.40	-0.06	0.37
Diagnosed with ADD/ADHD			-7.61†	3.27	-5.00	2.71	-3.72	2.48
Diagnosed with dyslexia/LD			-14.42***	2.92	-12.79***	2.92	-10.95**	2.90
Has a secondary disability other than ADD/ADHD or dyslexia/LD			-6.73†	2.91	-5.18†	2.49	-6.58*	2.44
Hearing and Communication								
Hearing loss is mild					-17.24***	3.19	-16.81***	2.94
Hearing loss is moderate					-3.56	2.22	-3.55	2.20
Uses sign language					-3.83	2.71	-3.78	2.78
Ability to speak					6.21**	1.35	4.16*	1.43
Ability to understand					2.18	1.57	2.50	1.57
Educational Factors								
Attended regular schools only							9.38**	2.82
Ever held back a grade							-7.08**	1.99
Ever suspended or expelled							-7.11*	2.53
Model summary								
F	3.88**		9.03***		9.80***		11.75***	
(Degrees of freedom)	(6, 130)		(10, 128)		(15, 128)		(18, 125)	
F change			14.05***		8.87***		10.00***	
(Degrees of freedom)			(4, 128)		(5, 128)		(3, 125)	
R^2	0.06		0.17		0.30		0.36	
R^2 change			0.11		0.13		0.06	
N	510		490		490		470	

$*p < .05$, $**p < .01$, $***p < .001$ after adjustments for multiple comparisons.

† $p < .05$ before adjustments for multiple comparisons and $p > .05$ after adjustments.

Note. Scaled scores from the WJ III Research Edition were used in analysis (Mather & Woodcock, 2001) using weighted data. Unweighted sample size numbers reported here are rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education.

Source: NLTS2 Direct Assessment of Student Achievement (2002 and 2004); Wave 1 and 2 Parent Interview/Survey, 2001 and 2003 (type of school variable uses data from all waves in which youth were in secondary school through wave 4).

Table 6. Regression Model Results Predicting Achievement on the WJ III Social Studies Subtest

	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3	Model 4	Model 4
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Intercept	81.07***	3.97	79.19***	2.89	58.65***	7.66	55.41***	8.47
Demographic Characteristics								
Male	2.14	2.57	2.79	2.45	3.18	1.93	3.91	2.03
African American	-10.26**	2.85	-12.08***	2.28	-9.35***	2.02	-9.34***	2.00
Hispanic	-10.58**	3.13	-11.33***	2.01	-9.33***	1.84	-10.27***	1.95
Head of household's level of education	2.86	1.58	3.25*	1.33	2.85*	1.05	2.27†	1.05
Household income $25,000 or less	-7.05	3.57	-4.69	2.61	-2.53	2.02	-2.28	1.89
Household income $25,001–$50,000	-5.48†	2.61	-5.38†	2.47	-5.36*	2.23	-4.95†	2.16
Disability Issues								
Age when disability identified			1.40***	0.25	0.24	0.28	0.15	0.28
Diagnosed with ADD/ADHD			-5.66**	1.85	-2.84	1.65	-2.04	1.68
Diagnosed with dyslexia/LD			-9.23***	2.30	-9.19***	2.18	-8.00**	2.12
Has a secondary disability other than ADD/ADHD or dyslexia/LD			-5.01	2.65	-3.72	2.06	-5.04*	2.01
Hearing and Communication								
Hearing loss is mild					-6.87†	3.01	-6.31†	3.09
Hearing loss is moderate					-0.91	2.01	-0.99	1.98
Uses sign language					-7.46**	2.43	-5.87†	2.64
Ability to speak					5.99***	1.37	4.36**	1.31
Ability to understand					2.84	1.49	3.42†	1.55
Educational Factors								
Attended regular schools only							8.81**	2.80
Ever held back a grade							-1.62	1.77
Ever suspended or expelled							-2.28	2.28
Model summary								
F	10.12***		12.00***		19.86***		16.91***	
(Degrees of freedom)	(6, 132)		(10, 130)		(15, 130)		(18, 126)	
F change			13.38***		7.76***		4.10**	
(Degrees of freedom)			(4, 130)		(5, 130)		(3, 126)	
R^2	0.16		0.26		0.39		0.40	
R^2 change			0.10		0.13		0.01	
N	510		490		490		480	

**p* < .05, ***p* < .01, ****p* < .001 after adjustments for multiple comparisons.

† *p* < .05 before adjustments for multiple comparisons and *p* > .05 after adjustments.

Note. Scaled scores from the WJ III Research Edition were used in analysis (Mather & Woodcock, 2001) using weighted data. Unweighted sample size numbers reported here are rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education.

Source: NLTS2 Direct Assessment of Student Achievement (2002 and 2004); Wave 1 and 2 Parent Interview/Survey, 2001 and 2003 (type of school variable uses data from all waves in which youth were in secondary school through wave 4).

Table 7. Regression Model Results Predicting Achievement on the WJ III Science Subtest

	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3	Model 4	Model 4
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Intercept	80.18***	4.59	73.48***	3.85	52.27***	9.53	45.42***	9.72
Demographic Characteristics								
Male	-1.23	3.05	-0.90	2.97	-0.25	2.41	1.33	2.43
African American	-10.46**	3.21	-12.85***	2.83	-9.47**	2.67	-9.90***	2.43
Hispanic	-16.90***	3.70	-17.46***	2.93	-15.09***	2.93	-16.40***	2.91
Head of household's level of education	2.10	1.60	3.32†	1.44	2.61†	1.23	1.98	1.10
Household income $25,000 or less	-6.42	4.38	-5.46	3.54	-3.51	3.17	-3.31	2.87
Household income $25,001–$50,000	-3.10	2.94	-3.68	2.64	-3.86	2.32	-3.34	2.16
Disability Issues								
Age when disability identified			2.33***	0.31	0.73†	0.34	0.52	0.32
Diagnosed with ADD/ADHD			-6.75*	2.37	-3.40	2.26	-2.12	2.11
Diagnosed with dyslexia/LD			-9.92*	3.73	-10.61*	3.71	-8.81*	3.26
Has a secondary disability other than ADD/ADHD or dyslexia/LD			1.31	3.11	2.31	2.37	0.20	2.36
Hearing and Communication								
Hearing loss is mild					-3.68	2.99	-3.05	2.94
Hearing loss is moderate					1.60	3.09	2.44	2.80
Uses sign language					-7.07*	2.48	-4.90	2.69
Ability to speak					8.75***	1.54	6.27***	1.56
Ability to understand					0.84	1.92	2.06	1.92
Educational Factors								
Attended regular schools only							13.83***	3.42
Ever held back a grade							-2.45	1.97
Ever suspended or expelled							-3.40	2.48
Model summary								
F	13.66***		17.41***		20.89***		22.23***	
(Degrees of freedom)	(6, 132)		(10, 130)		(15, 130)		(18, 126)	
F change			15.61***		10.55***		7.21**	
(Degrees of freedom)			(4, 130)		(5, 130)		(3, 126)	
R^2	0.16		0.27		0.42		0.46	
R^2 change			0.11		0.15		0.04	
N	510		490		490		480	

*$p < .05$, **$p < .01$, ***$p < .001$ after adjustments for multiple comparisons.

† $p < .05$ before adjustments for multiple comparisons and $p > .05$ after adjustments.

Note. Scaled scores from the WJ III Research Edition were used in analysis (Mather & Woodcock, 2001) using weighted data. Unweighted sample size numbers reported here are rounded to the nearest 10 as required by the restricted data use agreement with the U.S. Department of Education.

Source: NLTS2 Direct Assessment of Student Achievement (2002 and 2004); Wave 1 and 2 Parent Interview/Survey, 2001 and 2003 (type of school variable uses data from all waves in which youth were in secondary school through wave 4).

[1] Students were sampled under the federal disability category of "hearing impairment." In this paper, we refer to this population as "deaf and hard-of-hearing" (DHH) students, the convention used in deaf education and related research after the 1991 joint statement by the World Federation of the Deaf and the International Federation of Hard of Hearing People, rejecting "hearing impairment" in favor of "deaf and hard of hearing."

[2] Because the analyses conducted for this paper were part of a larger study of school-based interventions for DHH students, the 0.2% of DHH secondary school-age youth nationally who were in non-school settings such as home schooling, juvenile justice facilities, or medical facilities were not included in analyses.

[3] Structured phone interviews were conducted by trained interviewers using computer-assisted telephone interviewing technology. TTY and mail survey options were available for DHH parents. Parents and youth who did not or could not participate in phone interviews were sent a self-administered mail survey. NLTS2 instruments are available at www.nlts2.org.

[4] Overall, 61% of youth represented by NLTS2 received no accommodations, 28% received one accommodation, and 11% received two or more. Those who participated in the NLTS2 direct assessment with one or more accommodations did not differ significantly from those who did not in disability-related factors, demographics, or mean standard scores on any direct assessment subtest.

[5] Although they already had been identified as having a hearing loss, when asked about the level of hearing loss, the parents of a small number of DHH children indicated that they had "normal-hearing," presumably a description of their aided hearing. Those individuals were included in the mild hearing loss category for these analyses.

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[6] The NLTS2 database does not contain information about school type for every year of students' enrollment in secondary school. This information is available only for years of data collection waves (every other year) for which there was a completed parent or youth interview or survey for youth who were still enrolled in secondary school (up through wave 4, although most youth had exited school by wave 3).

[7] To control for false discovery, the *p* values for all the regression coefficients from models 1 to 4 for a specific subtest (e.g., passage comprehension) were adjusted for multiple comparisons. A less conservative approach (e.g., including only the coefficients for the final model, model 4) would have yielded more statistically significant findings at the $p < .05$ level.