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Deaf Students and Their Classroom Communication: An Evaluation of Higher Order Categorical Interactions Among School and Background Characteristics

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This article investigated to what extent age, use of a cochlear implant, parental hearing status, and use of sign in the home determine language of instruction for profoundly deaf children. Categorical data from 8,325 profoundly deaf students from the 2008 Annual Survey of Deaf and Hard-of-Hearing Children and Youth were analyzed using chi-square automated interaction detector, a stepwise analytic procedure that allows the assessment of higher order interactions among categorical variables. Results indicated that all characteristics were significantly related to classroom communication modality. Although younger and older students demonstrated a different distribution of communication modality, for both younger and older students, cochlear implantation had the greatest effect on differentiating students into communication modalities, yielding greater gains in the speech-only category for implanted students. For all subgroups defined by age and implantation status, the use of sign at home further segregated the sample into communication modality subgroups, reducing the likelihood of speech only and increasing the placement of students into signing classroom settings. Implications for future research in the field of deaf education are discussed.

The process of socialization, through which children acquire knowledge necessary to participate effectively in society, "is realized to a great extent through the use of language" (Garrett & Baquedano-Lopez, 2002, p. 339). This relationship between cognition and language has long been of interest to researchers, with a particular emphasis on the unique interaction of these constructs evidenced by deaf and hard-of-hearing individuals. Recent research has focused on cognitive and neuropsychological effects related to growing up utilizing a sign language rather than a spoken language (Marschark & Hauser, 2008). More importantly, recent research "indicates that findings previously viewed as reflecting cognitive, linguistic, or social–emotional deficiencies in deaf children now are more accurately seen as differences that are the product of early experiences" (Marschark & Hauser, 2008, p. 5). Indeed, the consideration of interactions among individual experience, language, and cognition provides additional insight into the cognitive processes of deaf individuals.

According to the language socialization approach, everyday routine and communicative experiences are the key to cognitive development (Garrett & Baquedano-Lopez, 2002). However, the nature of these communicative acts is determined by "preferences, orientations, and dispositions that are social in origin and culturally specific in nature, whereas at the same time they are interest-laden and are creatively and strategically deployed by individuals" (Garrett & Baquedano-Lopez, 2002, pp. 343–344). Especially for deaf children, the nature of everyday communicative acts is highly influenced by social and cultural background characteristics. One area of deaf children's everyday communication that is most impacted by background characteristics is school setting and the subsequent language of instruction. However, little is known about the relationship between language experience in the home and language experience in school.

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Understanding the home and school language experiences of deaf children is exceedingly complex, primarily because language (American Sign Language [ASL] vs. English) is often confounded with modality (spoken vs. signed vs. cued vs. written). Although a signing modality may imply the use of ASL, it cannot be assumed. Unfortunately, no comprehensive study of the use of ASL in the home and school has ever been undertaken. This article makes use of an existing data set, in which only the modality of instruction (signed vs. spoken vs. cued) is reported. Although this fact limits our ability to interpret the data in a linguistic or cultural framework, the analysis to be presented leads to intriguing questions about the effects of multiple languages and multiple modalities across home and school settings on the learning and cognitive development of deaf children.

School Setting and Mode of Language of Instruction

In the past 35 years, school composition for deaf students has undergone a major transformation. According to the Annual Survey for Deaf and Hard-of-Hearing Children and Youth of 1975–1976, 48% of deaf and hard-of-hearing students were enrolled in residential or day schools for deaf students (Karchmer & Mitchell, 2003). However, in the 2000–2001 Annual Survey, it was reported that 75.3% of students were educated in a mainstream facility, cutting the percentage of special school students in half (Karchmer & Mitchell, 2003). It is important to note that, although the Annual Survey collects individual student data from as many programs as are known to offer services to deaf and hard-of-hearing children in both mainstream and self-contained educational settings, there is a potential sampling bias toward programs who provide significant special education services to their deaf students. Programs in which students are fully mainstreamed with minimal or no special education support may be underrepresented in the Annual Survey database. Thus, the 75% figure cited above may actually underestimate the actual percentage of deaf and hard-of-hearing students who are being educated in a mainstream facility.

Major transformations in school composition have significant implications for the language of instruction for deaf students. Indeed, "the opportunity for a student to be placed in a signing classroom is likely to be constrained by the school setting in which the child has been placed" (Mitchell & Karchmer, 2004, p. 145). Separate schools for the deaf tend to emphasize sign communication, both with and without speech, whereas mainstream school settings tend to utilize speech for classroom instruction (Stinson & Kluwin, 2003). Confirming this tendency, the 2000–2001 Annual Survey results indicated that 80% of students in regular school settings and 75% of students in resource rooms receive instruction via speech (Karchmer & Mitchell, 2003). Conversely, 70% of students in self-contained classrooms and 90% of students in special schools receive at least some instruction via sign language. These studies provide evidence that "school settings and classroom use of sign for instruction covary" (Mitchell & Karchmer, 2004, p. 137). Although this previous investigation establishes the strong relationship between language use and educational setting, it did not examine the relationships among home communication variables and school instructional communication modes. The current investigation takes an in-depth look at these relationships.

Background Characteristics and Mode Language of Instruction

As stated previously, mode language of instruction is likely determined by deaf children's background characteristics. In this article, we focus on four such characteristics, each of which is predicted to significantly impact classroom communication choice: (a) *Age*, in order to determine whether patterns of classroom communication and its relationships with other background characteristics change as students move from elementary and middle school into high school; (b) *Use of a cochlear implant*, which we predict will have a large effect on classroom communication modality directing implant users to classes where speech is emphasized as the mode of instruction; (c) *Coming from a family in which one or both parents are deaf*, which is also predicted to direct students to classes where sign language is used as the mode of classroom instruction; and (d) *Regular use of sign language in the home*, which we predict will direct students to classrooms where sign language is also used as the mode of instruction. Additionally, we limit our investigation to only those students with hearing loss in the profound range (average hearing thresholds of 90 dB or greater in the better ear). This will eliminate confounding effects due to variability in the degree of hearing loss and limit the generalizability of our results to students whose hearing loss is in the profound range. A brief discussion of each of these variables follows.

Age. Some research suggests that communication needs and preferences of deaf students adjust as they grow older. For example, as children begin the process of identity development, their preferences for communication may differ from communication decisions previously made for them by their parents. Results from the 2000–2001 Annual Survey indicated that, compared to other school settings, special schools for the deaf enroll a large proportion of older students (Karchmer & Mitchell, 2003), suggesting that a larger percentage of older deaf students receive instruction in sign language. Consequently, younger students more often receive their education in regular schools, resource rooms, or self-contained settings, with a greater likelihood of receiving education via speech.

Use of a cochlear implant. As cochlear implants are intended to "give the child an awareness of sound" (Easterbrooks & Baker, 2002, p. 86), it seems logical that a large percentage of deaf children with cochlear implants would receive their education via speech. Moreover, research investigating the influence of school placement on successful cochlear implant use has indicated accelerated performance of children in auditory–oral programs (Osberger et al., 1991; Tyler, 1990). Although results from the 2000–2001 Annual Survey did not find differences in cochlear implant use across school settings (Karchmer & Mitchell, 2003), other researchers have identified patterns in the school setting for cochlear implant users. After cochlear implantation, there tends to be a "movement from deaf-only to more integrated or mainstreamed school placements" (Spencer & Marschark, 2003, p. 441), also suggesting a movement from sign to speech in the classroom. Interestingly, the interaction between implantation and age of implantation also helps determine school placement. A study conducted by Archbold, Nikolopoulos, O'Donoghue, and Lutman (1998) found that of the 121 deaf children in their sample, those who received cochlear implants early, before an educational decision had been made, were more likely to attend mainstream schools than those given implants when already placed in an educational setting. Within 2 years of implant use, approximately half of the younger students had been placed in mainstream school settings and were likely receiving instruction in speech.

Coming from a family in which one or both parents are deaf. As young deaf children interact with their caregivers, they acquire linguistic and social skills necessary for later cognitive and emotional tasks (Garrett & Baquedano-Lopez, 2002). Deaf children of deaf parents often grow up in a rich signing environment and arrive at school with a strong sign language foundation (Easterbrooks & Baker, 2002). However, deaf children of hearing parents often have more complicated language experiences before arriving at school. These hearing parents with deaf children often struggle with a variety of language modes before pinpointing an appropriate and effective pathway for communication and learning (Easterbrooks & Baker, 2002). Because the pathway to language acquisition is so complicated for deaf children of hearing parents, "it is no wonder that many parents have difficulty instilling a native, or first, language system in their children" (Easterbrooks & Baker, 2002, p. 84).

In their analysis of the 1999–2000 Annual Survey, Mitchell and Karchmer (2004) investigated school placement and patterns of sign use in deaf children of deaf parents and deaf children of hard-of-hearing parents. It was found that parental hearing status helped predict placement within a special school or center, with deaf children of deaf parents attending special schools at a higher rate than deaf children of hard-of-hearing parents. With respect to predicting if a child would be exposed to signed or spoken language for instruction, no difference was found to be associated with having a deaf parent versus having a hard-of-hearing parent. As stated before, placement in a special school for the deaf is associated with a greater chance of using sign in the classroom. This trend suggests that the deaf children of deaf parents investigated in the study by Mitchell and Karchmer are more likely to attend special schools and consequently receive classroom instruction in sign. Indeed, deaf parents "provide homes where sign is used regularly (93% of the cases with at least one deaf parent) and who see their children enrolled in schools with classrooms that use sign for instruction (91% of these cases)" (Mitchell & Karchmer, 2004, p. 148).

Regular use of sign language in the home. Regardless of parental hearing status, parents may espouse different philosophies or preferences with regard to the language development of their deaf children. Revisiting the 2004 study by Mitchell and Karchmer, it was found that "the most powerful predictors of the use of signing for classroom instruction are the school setting, *regular use of sign at home* [italics added], and child's degree of hearing loss" (p. 145). According to the 1999–2000 Annual Survey, deaf students from signing homes were 18 times more likely to be enrolled in a signing classroom than deaf students from homes where sign was not used regularly.

Research Questions and Hypotheses

This article sought to investigate to what extent age, use of a cochlear implant, parental hearing status, and use of sign in the home determine the mode of language of instruction for profoundly deaf children. Additionally, this study explored to what degree higher order categorical interactions between these background characteristics accounted for the mode of language of instruction in school.

It was hypothesized that a greater proportion of students of age 13 and older (approximately middle school level and above) would receive instruction in sign compared to students below the age of 13 years (approximately elementary school level and below). Additionally, it was hypothesized that students with cochlear implants would receive instruction in speech to a far greater extent than those without cochlear implants. With respect to parental hearing status, it was hypothesized that deaf children of deaf parents would receive instruction in sign to a far greater extent than deaf children of hearing parents. Similarly, it was hypothesized that a greater proportion of students from signing homes would be enrolled in sign programs than students from homes without sign. Regarding higher order interactions, the analysis was exploratory and sought to answer questions such as, *Is the relationship between cochlear implant use and classroom communication the same for younger versus older children?*

Methods

Participants

The aforementioned research questions were investigated by conducting a secondary analysis of data from the 2007–2008 Annual Survey of Deaf and Hard-of-Hearing Children and Youth (Annual Survey), which is a large national database focused on deaf and hard-of-hearing children in educational placements throughout the United States. Through this analysis, it was possible to define population segments of students with unique classroom and background communication profiles. The 2007–2008 Survey contains individual student data on 36,710 deaf and hard-of-hearing children. Among those were 8,325 respondents with profound levels of hearing loss (actual or estimated average hearing thresholds across the speech range of 90 dB or greater), who were selected for the current analysis. Our purpose was to investigate the interactions among school and background characteristics for students with little or no unaided access to auditory information across the speech range. One of the tremendous benefits of the Annual Survey is that it permits the use of statistical analysis on segments of a population with sufficient power due to the large sample size to evaluate complex interactions.

Measures

As stated above, data from the 2007–2008 Annual Survey were analyzed for this article. The Annual Survey has been conducted by the Gallaudet Research

Institute since 1968, soliciting information on educationally relevant characteristics from as many programs as are known to serve deaf and hard-of-hearing children in the United States. The independent variables used in this analysis were age, cochlear implant use, hearing status of the students' parents, and family communication and language. The dependent variable used was the mode language of instruction, which was divided into four language outcomes: (a) speech only (where all instruction is presented orally with no sign language), (b) sign only (where all instruction is presented using sign language), (c) sign and speech (where a combination of sign and speech is employed), and (d) cued speech (a system for representing the phonemes of spoken language visually with hand cues).

Procedure

The categorical independent and dependent variables were analyzed using the chi-square automatic interaction detector (CHAID, Kass, 1980). This statistical technique evaluates complex interactions among categorical variables and displays its results in a decision tree that allows the visualization of coherent segments of the population under study vis-à-vis a target-dependent variable (in this case, mode of language in instruction) and a group of independent variables (age, cochlear implant use, parental hearing status, and family use of signs in the home). In the present analysis, each independent variable was dichotomized to simplify the interpretation of the resulting tree: *Age* (below 13 years old vs. 13 and older), *Cochlear implant use* (has had an implant vs. has never had an implant), *Parental hearing status* (one or both parents deaf or hard of hearing vs. both parents hearing), and *Use of signs in the home* (signs regularly used in the home vs. signs not used in the home).

CHAID is an exploratory stepwise technique often used in market research to identify homogeneous subgroups of a population. At each step, CHAID evaluates all possible chi-squares for a set of independent variables relative to a set of parent nodes derived on the previous step. The independent variable, not yet included in past analyses, that demonstrates the greatest chi-square relationship with the dependent variable for the subgroup defined by the parent node is selected for displaying on the tree. These "children" nodes then become the parent nodes for the subsequent step. Rules for terminating the stepwise procedure (e.g., when the resulting node contains fewer than 50 respondents) are specified in the analysis. The results help guide the understanding of the interactions among a set of interrelated categorical independent variables with a target-dependent variable. The tree provides a visual representation of the obtained relationships. A classification analysis allows the assessment of how well the overall tree predicts dependent variable categorization for each value of the dependent variable.

CHAID allows one to force a variable into the model on the first step. In the current design, the independent variable of Age was forced into the model on the first step as we were interested in comparing the patterns of interactions among the other independent variables separately for younger versus older students in the database. This decision allowed comparison of nodes in the tree for younger versus older children that are identical with respect to each of the remaining independent variables.

Results

Bivariate Relationships of Each Independent Variable With the Target Variable

Prior to running the CHAID analysis, each independent variable was cross-tabulated with the target-dependent variable to determine its degree of association with the target.

Table 1 displays the distributions of classroom communication modes separately for younger (under 13) versus older (13 and older) children. Contingency analysis indicated a high degree of association between the mode of classroom communication and age, $\chi^2(3) = 433.7, p < .001$. Younger children were far more likely than older children to be receiving instruction in speech-only classrooms (19.5% compared to 6.7%). Conversely, older children were far more likely than younger children to be receiving instruction in sign-only classrooms (37.2% compared to 22.0%). At the same time, the percentages in the dual-modality sign and speech category were similar for the younger and

Table 1 Age × primary mode of communication used in teaching

	Primary mode of communication used in teaching				
Age	Speech only	Sign only	Sign only	Cued speech	Total
Under 13	724 (19.5%)	2,146 (57.9%)	817 (22.0%)	19 (0.5%)	3,706 (100.0%)
13 and older	311 (6.7%)	2,581 (55.9%)	1,718 (37.2%)	9 (0.2%)	4,619 (100.0%)
Total	1,035 (12.4%)	4,727 (56.8%)	2,535 (30.5%)	28 (0.3%)	8,325 (100.0%)

older children (57.9% and 55.9%, respectively). Overall, there were only 28 children (19 younger and 9 older) reported in cued speech classes among the 8,325 in the current data set.[1] This represented less than 0.3% of the sample.

Table 2 displays the instructional communication mode distributions for children with and without cochlear implants. As hypothesized, a high degree of association was observed between communication mode and cochlear implant usage, χ^2 (3) = 1670.7, $p < .001$. Although 32.5% of the implanted children received instruction in speech-only classrooms, only 3.8% of the non-implanted children attended speech-only classes. The reverse was true for the sign-only setting: 10.2% of the implanted children attended sign-only programs, whereas 39.1% of the non-implanted children were in sign-only settings. Although these differences are in the predicted direction, the percentage of implanted children who receive at least some of their instruction in sign is noteworthy. Again, similar to the age analysis above, the dual-modality sign and speech category did not significantly differ for the two subgroups under study.

Table 3 shows the communication distributions for children whose families do and do not regularly use sign in the home. The two groups defined by this characteristic showed markedly different patterns of classroom communication mode, χ^2 (3) = 1082.5, $p < .001$. Although more than one-quarter of the children coming from families who do not regularly use sign in the home attended classes where speech is the only mode of communication, only 1.6% of the children coming from signing families did so. The opposite was true for the sign-only category, though the differences were not as pronounced (37.2% of the children from signing families attended sign-only classes; 20.6% of the children from non-signing families received sign-only instruction).

Table 4 shows the communication distributions for children with both hearing parents and those with one or both deaf parents. Again, the relationship of this characteristic with the target was strong, χ^2 (3) = 226.6, $p < .001$. Nearly one-half of the children with one or both deaf parents received sign-only instruction, whereas 27.5% of the children with both hearing parents were reported in this category. At the same time, only 3.7% of the children with one or both deaf parents received speech-only instruction, compared to 13.5% for the children with both hearing parents.

Decision Tree

Given the strong relationships noted between each independent variable and the target-dependent variable, and the large sample sizes reported in each subgroup, a CHAID decision tree procedure was performed. This decision tree allowed further examination of the higher order interactions among the independent variables in segregating the classroom communication groups into more homogeneous subgroups, defined by unique combinations of categories defined by the four independent variables. A schematic representing the results of this analysis is presented in Figure 1.

Table 2 Cochlear implant × primary mode of communication used in teaching

	Primary mode of communication used in teaching				
Ever had cochlear implant	Speech only	Sign and speech	Sign only	Cued speech	Total
No	217 (3.8%)	3,295 (57.0%)	2,259 (39.1%)	7 (0.1%)	5,778 (100.0%)
Yes	816 (32.5%)	1,417 (56.5%)	255 (10.2%)	21 (0.8%)	2,509 (100.0%)
Total	1,033 (12.5%)	4,712 (56.9%)	2,514 (30.3%)	28 (0.3%)	8,287 (100.0%)

Table 3 Family sign use × primary mode of communication used in teaching

Family regularly uses sign in the home	Primary mode of communication used in teaching: Speech only	Sign and speech	Sign only	Cued speech	Total
No	932 (26.9%)	1,797 (51.8%)	713 (20.6%)	24 (0.7%)	3,466 (100.0%)
Yes	63 (1.6%)	2,378 (61.1%)	1,447 (37.2%)	4 (0.1%)	3,892 (100.0%)
Total	995 (13.5%)	4,175 (56.7%)	2,160 (29.4%)	28 (0.4%)	7,358 (100.0%)

As noted above, we instructed the analysis to force our age variable into the tree model on the first step in order to allow the assessment of interactions among the remaining three variables separately for younger versus older students. As shown in Table 1, age significantly divided the sample into two groups with distinct patterns of classroom communication modality.

Each node represented in Figure 1 constitutes a proportional distribution for a subgroup that is significantly distinct from a "sibling" node pulled from an antecedent "parent node." Each of the reported sets of sibling nodes represents a significant chi-square. Although these are not reported, all the node comparisons represented by the tree were significant beyond the .001 level. CHAID employs a Bonferroni technique to ensure an overall experiment-wise alpha of .05.

Figure 1 shows that, for both younger and older children, the order of entry of the remaining three independent variables into the model was identical. Cochlear implant use exerted the strongest influence on communication modality. Then, given age and cochlear implant use, the regular use of sign in the child's family further segregated the sample significantly. Finally, given age, cochlear implant use, and family sign use, parental hearing status further segregated the sample for some (though not all) of the antecedent subgroups. Younger deaf students who have implants and whose families regularly use sign were further segregated by parental hearing status, younger deaf students who do not have implants and whose families regularly use sign were further segregated by parental hearing status, older deaf students with no cochlear implants whose families do not regularly use sign were further segregated by parental hearing status, and older deaf students with no cochlear implants whose families regularly use sign were further segregated by parental hearing status.

CHAID analyses retain and report distinct nodes for groups defined with missing values on any of the independent variables if those groups result in distinct patterns. In the current analysis, three nodes displayed distinct patterns of communication mode for students with missing data on whether families regularly use sign in the home. Looking at the total *N* in Table 3 reveals that there were roughly 1,000 students for whom data on family sign use were not reported. Subgroups showing distinct patterns of classroom communication with missing data on family use of sign in the home included: under 13 no implant; under 13 implant; and 13 and older implant.

The complete set of distributions for all the nodes on the tree are presented in Figure 2 for the younger deaf students and in Figure 3 for the older deaf students. Although a myriad of comparisons are possible through an examination of the distributions of subpopulations reported in Figures 2 and 3, we will limit the discussion here to those we consider to be of greatest significance.

Gain

When evaluating the decision trees produced in CHAID analysis, it is instructive to identify which

Table 4 Parent hearing status × primary mode of communication used in teaching

Parent hearing status	Primary mode of communication used in teaching: Speech only	Sign and speech	Sign only	Cued speech	Total
Both parents hearing	934 (13.5%)	4,051 (58.6%)	1,901 (27.5%)	28 (.4%)	6,914 (100.0%)
One or both parents deaf	35 (3.7%)	439 (46.5%)	470 (49.8%)	0 (0.0%)	944 (100.0%)
Total	969 (12.3%)	4,490 (57.1%)	2,371 (30.2%)	28 (0.4%)	7858 (100.0%)

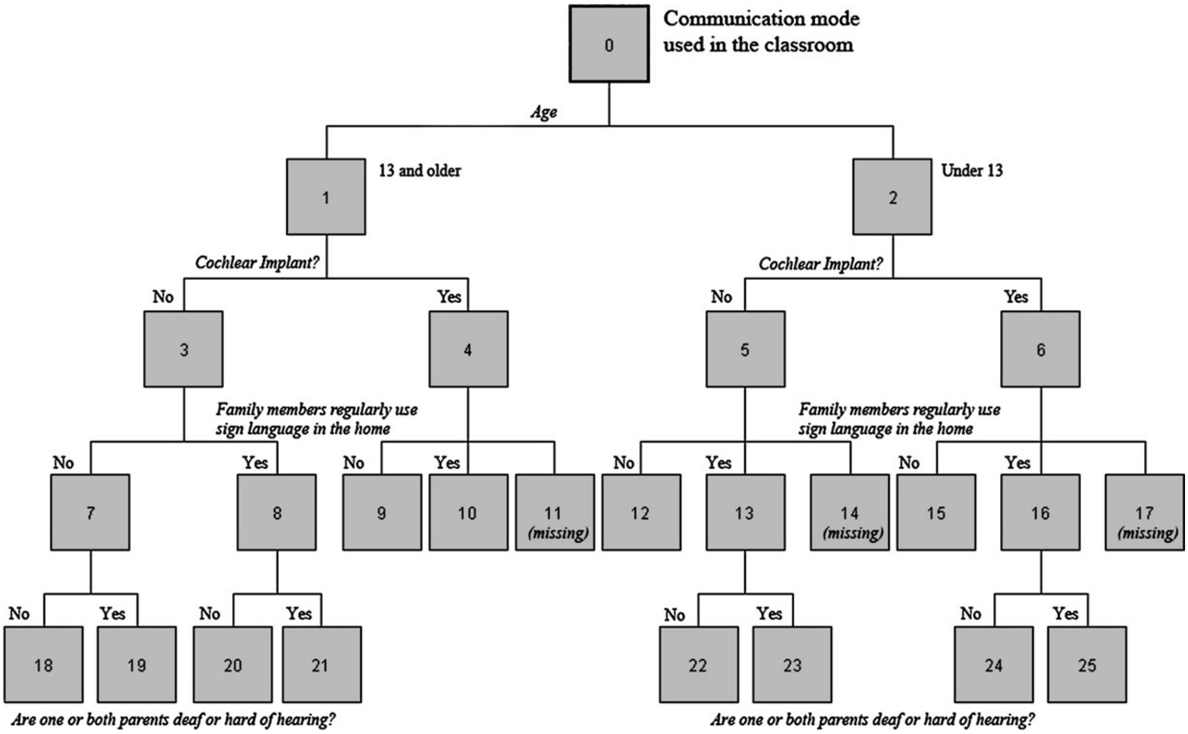

Figure 1 Schematic of results of chi-square automatic interaction detector decision tree analysis: DV—communication mode used in the classroom (numbers 0–25 refer to node numbers in Figures 2 and 3).

nodes resulted in the greatest gains for a particular target category. For example, when we specify "speech only" as a target category, we can examine the tree and identify the nodes that resulted in the greatest gains in the prevalence of children in speech-only instruction over their parent nodes. Across the entire tree, Node 9 resulted in the greatest gain in the speech-only category. This node is defined as: 13 and older, has a cochlear implant, and family does not sign in the home. In this subgroup, 44.1% were reported in the speech-only instructional category. This represents an increase of 20.7 percentage points over the parent Node 4 (defined as 13 and older, has a cochlear implant), in which 23.4% were reported in the speech-only category.

Node 15 (defined as: under 13, has a cochlear implant, and family does not sign in the home) also produced a large gain in the speech-only category over its parent Node 6 (defined as: under 13 and has a cochlear implant). In this subgroup, 55.9% of the sample is reported as receiving instruction in speech-only classes, representing an 18.5 percentage point gain over the parent Node 6, in which 37.4% were reported in the speech-only category. Significantly, only 8.4% of the subgroup defined as: under 13, cochlear implant, and family does sign in the home (Node 16) attends classes where they receive speech-only instruction. Thus, family not signing in the home has a large effect on whether both younger and older implanted children are enrolled in speech-only classes.

When we compare Node 15 (defined as: under 13, has a cochlear implant, and family does not sign in the home) with Node 9 (13 and older, has a cochlear implant, and family does not sign in the home), we can see the effect of age on the likelihood of speech-only instruction for implanted children from families who do not sign. Older implanted children from non-signing families have a decreased likelihood of attending speech-only classes (44.1%) compared to their younger counterparts (55.9%).

When "sign only" is specified as the target category, three nodes show gains of 10 percentage points or more over their parent nodes. Node 5 (defined as: under 13 and no cochlear implant) shows the greatest gain over the parent Node 2 (defined as: under 13). Among the younger children with no implants, Under 13

Node 2 Category	%	n
Speech only	19.5	724
Sign & speech	57.9	2146
Sign only	22.0	817
Cued Speech	0.5	19
Total	44.5	3706

Under 13
No CI

Node 5 Category	%	n
Speech only	5.5	113
Sign & speech	60.4	1251
Sign only	34.0	704
Cued Speech	0.2	4
Total	24.9	2072

Under 13
CI

Node 6 Category	%	n
Speech only	37.4	611
Sign & speech	54.8	895
Sign only	6.9	113
Cued Speech	0.9	15
Total	19.6	1634

Under 13
No CI
Fam. does not sign

Node 12 Category	%	n
Speech only	13.8	105
Sign & speech	64.1	487
Sign only	21.7	165
Cued Speech	0.4	3
Total	9.1	760

Under 13
No CI
Family signs

Node 13 Category	%	n
Speech only	0.3	3
Sign & speech	57.8	650
Sign only	41.8	470
Cued Speech	0.1	1
Total	13.5	1124

Under 13
CI
Fam. does not sign

Node 15 Category	%	n
Speech only	55.9	539
Sign & speech	38.2	368
Sign only	4.7	45
Cued Speech	1.2	12
Total	11.6	964

Under 13
CI
Family signs

Node 16 Category	%	n
Speech only	8.4	47
Sign & speech	80.6	453
Sign only	10.5	59
Cued Speech	0.5	3
Total	6.8	562

Under 13
CI
Fam. sign missing

Node 17 Category	%	n
Speech only	23.1	25
Sign & speech	68.5	74
Sign only	8.3	9
Cued Speech	0.0	0
Total	1.3	108

Under 13
No CI
Family signs
Both parents hear

Node 22 Category	%	n
Speech only	0.4	3
Sign & speech	64.5	434
Sign only	34.9	235
Cued Speech	0.1	1
Total	8.1	673

Under 13
No CI
Family signs
One or both par. deaf

Node 23 Category	%	n
Speech only	0.0	0
Sign & speech	47.9	216
Sign only	52.1	235
Cued Speech	0.0	0
Total	5.4	451

Under 13
CI
Family signs
Both parents hear

Node 24 Category	%	n
Speech only	6.2	31
Sign & speech	83.0	416
Sign only	10.2	51
Cued Speech	0.6	3
Total	6.0	501

Under 13
CI
Family signs
One or both par. deaf

Node 25 Category	%	n
Speech only	26.2	16
Sign & speech	60.7	37
Sign only	13.1	8
Cued Speech	0.0	0
Total	0.7	61

Figure 2 Node tabulations for children under 13.

34.0% were reported as receiving sign-only instruction, compared to 22.0% for younger children overall, representing a 12 percentage point gain. For both younger children and older children (Nodes 23 and 21, respectively), having a deaf or hard-of-hearing parent resulted in gains of 10 percentage points over parent nodes consisting of those children who were not implanted and whose family regularly used sign in the home. Specifically, among the younger non-implanted children whose families regularly used sign language in the home, 52.1% of those with one or both deaf parents attended sign-only instruction (compared to 41.8% in the parent node—a gain of 10.3 percentage points). Among the older

13 and older

Node 1		
Category	%	n
Speech only	6.7	311
Sign & speech	55.9	2581
Sign only	37.2	1718
Cued Speech	0.2	9
Total	55.5	4619

13 and older; No CI

Node 3		
Category	%	n
Speech only	2.8	106
Sign & speech	55.0	2059
Sign only	42.1	1576
Cued Speech	0.1	3
Total	45.0	3744

13 and older; CI

Node 4		
Category	%	n
Speech only	23.4	205
Sign & speech	59.7	522
Sign only	16.2	142
Cued Speech	0.7	6
Total	10.5	875

13 and older; No CI; Fam. does not sign

Node 7		
Category	%	n
Speech only	7.3	95
Sign & speech	57.7	752
Sign only	34.8	454
Cued Speech	0.2	3
Total	15.7	1304

13 and older; No CI; Family signs

Node 8		
Category	%	n
Speech only	0.5	11
Sign & speech	53.6	1307
Sign only	46.0	1122
Cued Speech	0.0	0
Total	29.3	2440

13 and older; CI; Fam. does not sign

Node 9		
Category	%	n
Speech only	44.1	193
Sign & speech	43.4	190
Sign only	11.2	49
Cued Speech	1.4	6
Total	5.3	438

13 and older; CI; Family signs

Node 10		
Category	%	n
Speech only	1.9	7
Sign & speech	78.0	283
Sign only	20.1	73
Cued Speech	0.0	0
Total	4.4	363

13 and older; CI; Fam. sign missing

Node 11		
Category	%	n
Speech only	6.8	5
Sign & speech	66.2	49
Sign only	27.0	20
Cued Speech	0.0	0
Total	0.9	74

13 and older; No CI; Fam. does not sign; Both parents hear

Node 18		
Category	%	n
Speech only	6.5	81
Sign & speech	58.4	725
Sign only	34.9	433
Cued Speech	0.2	3
Total	14.9	1242

13 and older; No CI; Fam. does not sign; One or both par. deaf

Node 19		
Category	%	n
Speech only	22.6	14
Sign & speech	43.5	27
Sign only	33.9	21
Cued Speech	0.0	0
Total	0.7	62

13 and older; No CI; Family signs; Both parents hear

Node 20		
Category	%	n
Speech only	0.5	10
Sign & speech	55.8	1125
Sign only	43.7	882
Cued Speech	0.0	0
Total	24.2	2017

13 and older; No CI; Family signs; One or both par. deaf

Node 21		
Category	%	n
Speech only	0.2	1
Sign & speech	43.0	182
Sign only	56.7	240
Cued Speech	0.0	0
Total	5.1	423

Figure 3 Node tabulations for children 13 and older.

non-implanted children whose families regularly used sign language in the home, 56.7% of those with one or both deaf or hard-of-hearing parents attended sign-only instruction (compared to 46.0% in the parent node—a gain of 10.7 percentage points). Coming from a family in which one or both parents are deaf or hard of hearing impacts the likelihood that a child (who is not implanted and whose family uses sign) will attend a school in which sign only is the mode of classroom instruction.

Classification Analysis

CHAID analysis permits the assessment of the accuracy of making predictions regarding the target variable, based on an individual's traits defined by the independent variables. The results of this analysis appear in Table 5.

Overall, 59.8% of the deaf students reported here could be correctly classified based on their independent variable characteristics. However, predictability was not evenly distributed across categories; 79.8% of the students in the mixed mode sign and speech category were correctly predicted, and 70.7% of the students in the speech-only category were correctly classified. Only 18.7% of the students in the sign-only category were correctly predicted, indicating that the factors investigated here giving rise to placements in sign-only instruction are not as strong as those giving rise to placements in speech-only instruction. Indeed, there were 94 students who were predicted to have speech-only placements who were actually placed in sign-only instruction, but only one student predicted to be in sign only instruction who actually received instruction in a speech-only setting.

Terminal Nodes

In a CHAID decision tree, it is instructive to evaluate the distribution of respondents in the nodes that have no children, that is, the terminal nodes. These nodes describe groups of respondents that are segregated, to the extent permitted by the model, into homogeneous groupings. Table 6 presents the distributions of respondents in the terminal nodes for children in the under 13 age group. Table 7 presents the distributions for children 13 and older.

Comparing the terminal nodes for younger and older children revealed some striking differences. Most importantly, younger children were more segregated into communication categories than their older counterparts. For younger children, the modal category (Node 15, representing 26% of the younger cohort) contained implanted children whose family does not sign. This group was followed in size by nonimplanted children whose family does not sign (Node 12, representing 20.5%). Among the older cohort, implanted children in non-signing families dropped to third in rank, with only 9.5% in this group. The modal category for older students contained nonimplanted students who have both hearing parents and whose families sign (Node 20, representing 43.7% of the cohort). The group containing nonimplanted students, with both hearing parents, who do not sign, ranked second among the older students (Node 18, 26.9%). These top two ranked groups accounted for over 70% of the older cohort, whereas the top two ranked groups for the younger students accounted for 46.5%, indicating less segmentation among older students regarding their classroom communication.

Summary and Discussion

The CHAID analysis presented in this article presents a visualization of the interactions among a set of characteristics for a large sample of profoundly deaf students that can predict the modality of their classroom communication. Clearly, all the background characteristics examined in this study were significantly related to classroom communication modality. Younger students demonstrated a different distribution of communication modality than older students, with a greater percentage of younger students in speech-only classrooms and a smaller percentage in sign-only classrooms. For both younger and older students, cochlear implantation had the greatest effect on differentiating students into different communication modalities, yielding greater gains in the speech-only category for implanted students. For all subgroups defined by age and implantation status, the use of sign in the home further segregated the sample into communication

Table 5 Classification analysis: predicted and observed classroom language modality

	Predicted				
Observed	Speech only	Sign and speech	Sign only	Cued speech	% Correct
Speech only	732	302	1	0	70.7
Sign and speech	558	3771	398	0	79.8
Sign only	94	1966	475	0	18.7
Cued speech	18	10	0	0	0.0
Overall %	16.8	72.7	10.5	0.0	59.8

Table 6 Terminal nodes for children under 13, sorted by frequency

Node	Description	*N*	% Within age group	% Overall
15	Under 13, CI, family does not sign	964	26.0	11.6
12	Under 13, no CI, family does not sign	760	20.5	9.1
22	Under 13, no CI, family signs, both parents hearing	673	18.2	8.1
24	Under 13, CI, family signs, both parents hearing	501	13.5	6.0
23	Under 13, no CI, family signs, one or both parents deaf	451	12.2	5.4
14	Under 13, no CI, family sign data missing	188	5.1	2.3
17	Under 13, CI, family sign data missing	108	2.9	1.3
25	Under 13, CI, family signs, one or both parents deaf	61	1.6	0.7

Note. CI = cochlear implant.

modality subgroups, reducing the likelihood of speech only and increasing the placement of students into signing classroom settings. For some of these resulting groupings, parental hearing status further segregated the sample. Having one or both deaf parents resulted in the greatest gain in sign-only instruction for older non-implanted students whose families regularly used sign in the home. The absence of signing in the home resulted in the greatest gain in speech-only instruction for younger implanted students.

Although the noted splits in the CHAID analysis were in the predicted directions, the results are by no means indicative of perfect predictions. For example, many students with cochlear implants were in programs that use sign for instruction, whereas some deaf parents chose oral programs for their children. It is important to note that "even in a seemingly homogenous group such as Deaf children of Deaf parents, individual differences emerge" (Easterbrooks & Baker, 2002, p. 83). In this article, the classification analysis demonstrated a near 70% correct classification of communication modality, based on the students' characteristics. However, classification was not equally accurate among the different communication mode categories. Students in speech-only settings were far more predictable than students in sign-only settings. That is, being in a speech-only class was far more tied to the independent variables under study than being in a sign-only class. Specifically, age, implant status, and communication in the home can more accurately predict whether a student is enrolled in a speech-only class than any combination of these independent variables can predict placement in a sign-only class. This difference implies that factors other than the ones studied are necessary to predict placement of deaf students in sign classrooms. One possibility is that students who do not succeed in speech-only classrooms are placed in sign classrooms when they get older, regardless of their background characteristics. Future longitudinal research should examine whether academic success or failure in the early years predicts later placements and communication strategies.

Younger students were more evenly dispersed over categories of independent variables than older

Table 7 Terminal nodes for children 13 and older, sorted by frequency

Node	Description	*N*	% Within age group	% Overall
20	13 and older, no CI, family signs, both parents hearing	2,017	43.7	24.2
18	13 and older, no CI, does not sign, both parents hearing	1,242	26.9	14.9
9	13 and older, CI, family does not sign	438	9.5	5.3
21	13 and older, no CI, family signs, one or both parents deaf	423	9.2	5.1
10	13 and older, CI, family signs	363	7.9	4.4
11	13 and older, CI, family sign data missing	74	1.6	0.9
19	13 and older, no CI, family does not sign, one or both parents deaf	62	1.3	0.7

Note. CI = cochlear implant.

students. Among the older students, 70% were either non-implanted children of hearing parents who signed in the home or non-implanted children of hearing parents who did not sign in the home. Clearly, the population dynamics regarding both the prevalence of different communication backgrounds and the interactions of these characteristics was different among younger and older students.

Reasons for these shifts among younger and older deaf students deserve further study. Given the cross-sectional design of the Annual Survey and a sampling strategy that emphasizes the collection of data from special education programs that will yield underestimates for students in mainstream settings, it is not possible to draw longitudinal conclusions, for example, that students migrate to more signing programs as they get older. Rather, the data may be an artifact of the Survey's sampling design. If more highly successful deaf students integrate into regular education, they may be less likely to be identified by the Survey's sampling strategies.

This caveat is particularly important for interpreting the data on cochlear-implanted students. Have successful cochlear implant students disappeared from the Annual Survey database because they have migrated to mainstream programs less likely to be covered by the Survey? An answer to this question is critical for a better understanding of the role of classroom and home communication strategies for implanted students. Another possible interpretation of the current findings pertains to the relatively recent approval of implantation for very young students. This fact alone might account for the increased prevalence of implantation among younger students. Additionally, the older implanted students are not likely to have received their implants at the same young ages as the younger implanted students. One would imagine that age of implantation might impact the manner in which communication practices at home and school interact.

Despite Survey limitations, the current analysis documents a significant number of implanted students at older ages in families who regularly use sign and who attend classes where sign is used, either alone or in combination with speech. This heterogeneity in implanted students has also been noted by Easterbrooks and Baker (2002), who found that children with cochlear implants display a wide array of uses of the technology, ranging from "no use, to use for environmental awareness, to use as a primary means of understanding communication" (Easterbrooks & Baker, 2002, p. 87). Are these students cochlear implant "failures" or are there effective bilingual approaches for cochlear-implanted students that employ signs in combination with speech? The use of signing with implanted students is a sensitive issue in deaf education. The question of whether signing facilitates or inhibits the effectiveness of the implant is one that should receive considerable attention among researchers and educators.

One other methodological issue deserves mention. The dependent variable in this article consisted of a question that was ambiguous with regards to the distinction between language and modality. This article began with the observation that language and culture impact cognitive development. The current analysis documented the considerable diversity with respect to language choices in both school and home for children who are profoundly deaf. If language and culture impact cognition, then diversity of language in home and school cannot help but impact the cognitive development of deaf children. As noted by Marschark and Hauser (2008), Deaf students "tend to come to the classroom with experiences that vary more widely than their hearing peers, and, partly as a consequence of those experiences, they have developed different problem-solving and learning strategies" (p. 7).

Unfortunately, the Annual Survey data employed in the current analysis cannot fully articulate the range of language diversity because its question on classroom communication focuses on modality and not on language. "Speech only" most certainly designates an English-only education, and "sign only" probably designates an ASL setting (though with somewhat less certainty). However, the "sign plus speech" category (which is the modal category overall) is ambiguous. It fails to differentiate bilingual ASL/English programs from those that employ simultaneous communication or interpreter-mediated programs. Future large-scale surveys of school language and communication strategies should consider a broader set of communication options. Several studies strongly suggest that student background characteristics that result in school placement differences are the "largest factor in the achievement of deaf students" (Stinson & Kluwin, 2003, p. 56). Unfortunately, few early interventionists possess adequate knowledge regarding the heterogeneity of the deaf student population (Easterbrooks & Baker, 2002). Therefore, future studies should incorporate measures of cognition and literacy and incorporate longitudinal designs so that the impacts of classroom communication strategies for students with different cultural and communication backgrounds can be more fully understood.

Note

1. Because of its low prevalence in the data, cued speech will not be discussed in the remainder of this article, although we have chosen to leave the numbers in the tables and figures.

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Conflict of Interest

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