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Cochlear Implants and Classroom Learning among Deaf College Students

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ABSTRACT

Previous studies have demonstrated that early academic benefits associated with cochlear implant (CI) use during the primary school years are attenuated or absent among secondary school and college students, at least when assessed via standardized testing. This study examined the extent to which CI use nevertheless provides deaf college students with advantages in classrooms that include both deaf and hearing learners. CIs users, deaf nonusers, and hearing students viewed two short lectures provided by a deaf, bilingual instructor, one in spoken language with sign language interpreting and one in sign language with voice interpreting. Content-specific pretests indicated that both CIs users and deaf nonusers came into the classroom with less content knowledge than their hearing peers, and both groups of deaf students scored lower than hearing peers on lecture-specific posttests. There was no advantage for CI users over non-CI users on either measure. The hearing status difference was eliminated, however, when prior knowledge was controlled. Participants' preferred communication modality did not affect performance. Performance also did not differ when instruction was provided directly by the instructor as compared to when it was mediated by a sign language/voice interpreter.

Cochlear Implants and Classroom Learning among Deaf College Students

Cochlear implants (CIs) are able to provide many deaf children with greater access to sound than ever before. By virtue of having greater access to sound, and to spoken language in particular, those children frequently also gain greater speech reception and speech intelligibility. When compared to peers with similar degrees of hearing loss who do not use CIs, the greater access to speech and environmental sounds possible with CIs is associated with childhood advantages in language Svirsky et al. [1], social functioning Punch et al. [2] access to information in the classroom Blom et al. [3] and academic achievement Vermeulen et al. [4]. Three important qualifications are necessary when describing such advantages for CI users. First is the wide variability among CI users in all of these domains, and particularly—for foundational purposes—in language development Archbold [5,6]. Second is the definitional point that CIs only increase access to sound, and it is that access—not the CI itself—that offers many users benefits in other domains Tomblin et al. [7]. Third, at least in the domains of social functioning Kushalnagar et al. [8,9] and academic achievement Convertino et al. [10-13] the early academic benefits of cochlear implantation are reduced or absent by high school and college age Marschark et al. [14] and are not particularly related to age at implantation Marschark et al. [15], The present study specifically examined the last of these issues.

Disappearing Academic Advantages?

Most of the research involving academic achievement among deaf learners (with or without CIs) has been focused on reading Luckner et al. [16-19]. There is a smaller body of research addressing mathematics Edwards et al. [20,21] and even less addressing science and other domains Marschark et al. [14,22] Yet, largely because of frequent lags in language development, many deaf learners (with or without CIs) exhibit academic challenges across the curriculum. Studies demonstrating CI use to be associated with better reading abilities almost exclusively have involved children younger than secondary school age Mayer et al. [19,12] however, found that

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scores on the Peabody Individual Achievement Test indicated that 60% of CI users who were reading at grade level when they were 7 to 8 years old had fallen behind hearing age-mates by the time they were 15 to 16 years old. In a sample of English CI users straddling the primary-secondary boundary, Mayer et al. [23] similarly found that 9- to 11-year-old CI users scored higher in literacy-related testing compared to 12- to 16-year-old CI users, even though the older group had used their implants longer Mayer et al. (Table 1).

Three studies provide convergent evidence from much larger samples of deaf learners. Marschark et al. [14] found that in a randomly selected national U.S. sample of approximately 500 deaf secondary school students, CI use was not a predictor of achievement in reading, mathematics, social studies, or science as measured by the Woodcock-Johnson III Tests of Achievement. Crowe et al. [24] found that among a sample of 980 college-bound secondary school students, CI use accounted for only 1% of the variance in American College Test (ACT) scores in English, and none of the variance for scores in reading, mathematics, or science. Finally, in a Danish national sample of 839 deaf adults, Dammeyer et al. [25] found CI use unrelated to level of degree attainment.

Not coincidentally perhaps, several published and unpublished studies have indicated a parallel between deaf learners who use CIs and those who are early sign language users, either by virtue of having deaf parents or having attended bilingual education programs. That is, although deaf children immersed early on in sign language environments have been found to demonstrate better reading achievement during the primary school years relative to deaf children who are not, the benefits of early sign language appear to be reduced or absent by high school and college age. Crowe et al. [5,14,15,24,26-29], suggested several possible explanations for such findings. Specifically, with regard to CI users, Archbold [5] noted that the materials and goals of reading at the secondary school level are very different than those at the primary school level. Addressing both populations of deaf learners, Marschark et al. [15] additionally noted that the language used at the primary school level (e.g., basic interpersonal communication skills) are very different than those needed at the secondary school level (e.g., cognitive-academic language proficiency). Unfortunately, at least in the United States, deaf children who demonstrate grade-level appropriate language and academic skills at the primary level—frequently including young CI users and native signers—typically lose their academic support services as they move into secondary education. This likely is another contributor to the attenuation of academic benefits gained from early language exposure.

The Present Study

To date, most studies that have demonstrated the reduced academic benefits of CIs at the secondary level have measured those benefits in terms of standardized testing. Still to be determined is whether the ongoing benefits of CI use to deaf learners' access to spoken language might have significant benefits to classroom learning, even if they are not reflected in achievement scores. That question was addressed in the present study by comparing classroom learning of college-aged CI users, deaf nonusers, and hearing peers. One potential difficulty in making such comparisons is the challenge of ensuring that materials and their presentation are comparable. In particular, presentations typically will be mediated by a sign language interpreter (1) if the teacher is hearing and sign language-oriented deaf students are involved or (2) if the teacher is deaf and spoken language-oriented deaf students (or hearing students) are involved. In such research, different instructors can lead to different results. This potential difficulty was eliminated in the present study by involving only a single instructor, a deaf college professor with fluent sign language and spoken language skills. This allowed for a research design that provided direct instruction to both deaf sign language-oriented students (in sign language) and deaf spoken language-oriented students and hearing students (in spoken language). The involvement of a highly-regarded and popular deaf instructor also eliminated potential concerns that might be raised about the appropriateness and skills of a hearing instructor teaching deaf students in such a study.

A second potential difficulty in a study of this sort is the fact that previous research involving deaf and hearing university students have found that the former frequently enter the classroom with less content knowledge than their hearing peers Marschark et al. [30] Administration of content-specific pretests and controlling for prior knowledge through the use of gain scores (posttest scores minus pretest scores) allowed for the consideration of that possibility in the present study.

Method

Participants

A total of 81 college students were paid for their participation in the study. These included 32 hearing students, 16 deaf students who were current CI users, and 33 deaf students who did not use CIs (henceforth "nonusers"). Participants were recruited through campus advertising and were paid for their participation. The CI users reported receiving their first implants between the ages of 3 and 21 years with a mean of 10.78 years (SD = 4.80 years). These ages indicate relatively late cochlear implantation by current standards, but they are representative of contemporary CI users in postsecondary education and the workplace, what Spencer et al. [31] referred to as late Cohort 1 and early Cohort 2 CI recipients. Three individuals reported receiving a second implant 8 to 14 years after their first. Among the deaf participants, 25 nonusers and five CI users reported also using hearing aids. The only other information available about the participants from institutional records was unaided pure-tone hearing thresholds (PTAs) averaged over both ears for 13 of the CI users (mean = 105.88, SD = 12.57) and 26 of the nonusers (mean = 93.90 dB, SD = 17.39).

Materials and Procedure

A (highly skilled and popular) deaf, bilingual college professor of computer science created two short lectures appropriate for college students who are not computer science majors, one on HTML/XHTML (13:10) and the other on computer networks (14:00). Each lecture was video recorded twice, in a professional television studio, once in which he signed the lecture without voice and the second in which he spoke the lecture without signs or gestures (i.e., direct instruction). A single, highly-skilled and nationally-certified interpreter provided spoken language interpreting for the instructor's signed lectures and sign language interpreting for his spoken lectures (i.e., mediated instruction). The instructor worked with the researchers to create a 16-item multiple-choice test for each lecture to assess learning. From each test, eight questions were chosen randomly for use on a pretest, allowing assessment of prior content knowledge. Participants were tested in small groups in a mock classroom. Lectures were presented using two LCD projectors so as to depict life-size, side-by-side images of the instructor and the interpreter as they would appear in an interpreter-supported classroom. Prior to each lecture, the relevant eight-item pretest was administered; immediately following each lecture, the relevant 16-item posttest was administered. The two lectures were separated by a short distractor task. Ordering of lecture content and lecture modality (signed or spoken) was counterbalanced across groups.

Results and Discussion

All and only those results significant at or beyond the .05 level are reported below. A preliminary analysis of variance in which group (CI users, nonusers, hearing) was a between-subjects variable, and lecture content (HTML, Networks) was a within-subjects variable, indicated no overall difference in participants' prior knowledge concerning the two topics, $F(1, 78) = 1.81$, but there was a main effect of group, $F(2, 78) = 8.40$, $p < .001$. Bonferroni-corrected post hoc tests indicated that the hearing participants had higher pretest scores for both lectures than either group of deaf participants, which did not differ from each other (Table 1).

Table 1: Mean test scores (proportions) for CI users, deaf nonusers, and hearing participants.

	Deaf Nonusers		Hearing		CI Users	
Score	**Mean**	**SD**	**Mean**	**S.D.**	**Mean**	**SD**
HTML Pretest	0.50	0.19	0.53	0.17	0.45	0.18
Networks Pretest	0.51	0.22	0.65	0.20	0.43	0.19
HTML Posttest	0.62	0.17	0.72	0.14	0.58	0.20
Networks Posttest	0.64	0.17	0.82	0.14	0.65	0.13
Signed Posttest	0.65	0.20	0.72	0.19	0.57	0.18
Spoken Posttest	0.62	0.16	0.80	0.12	0.62	0.16
HTML Gain	0.12	0.17	0.20	0.18	0.14	0.16
Networks Gain	0.13	0.18	0.18	0.24	0.22	0.21
Signed Gain	0.14	0.18	0.19	0.22	0.12	0.18
Spoken Gain	0.11	0.15	0.16	0.15	0.19	0.18

A similar analysis of variance using participants' test scores, as the dependent variable again yielded a main effect of group, $F(2, 78) = 12.23$, $p < .001$, as hearing participants had higher posttest scores for both lectures than either group of deaf participants, which did not differ from each other according to Bonferroni-corrected post hoc tests. A significant main effect of lecture content, $F(1, 78) = 11.65$, $p < .001$, reflected the fact that all three groups scored somewhat higher on the HTML test than on the Networks test. Counterbalancing of the materials, however, resulted in there being no main effect of lecture modality, $F(1, 78) = 1.47$, when lecture modality rather than lecture content was the within-subjects variable. The latter analysis did yield a main effect of group, $F(2, 78) = 13.11$, $p < .001$, as hearing participants scored higher than both groups of deaf participants, which did not differ from each other. These main effects and the lack of significant statistical interactions when lecture content was the within-subjects variable, $F(2, 78) = 1.27$, and when lecture modality was the within-subjects variable, $F(2, 78) = 1.36$, reflect two key findings. First, deaf students with and without CIs did not differ significantly in their performance on the instructor's tests (Table 1). Second, direct versus mediated (interpreted) instruction did not have a significant effect on performance for any of the groups.

As noted earlier, and consistent with previous findings, both CI users and nonusers in the present study demonstrated less prior knowledge about the two lecture topics than their hearing peers. In order to obtain a measure of classroom learning separate from test performance per se, gain scores were calculated by subtracting each participant's pretest scores from the appropriate posttest scores. A group by lecture modality analysis of variance in which gain scores were the dependent variable yielded no main effect for either group, $F(2, 78) = 0.77$, nor modality, $F(2, 78) = 0.00$ (Table 1). In the broadest terms, these results replicate previous findings indicating that when taught by a skilled teacher of the deaf, deaf students can learn as much as hearing students in the same classroom, given their own starting points. More specifically, these results are consistent with previous findings involving achievement testing in reading and mathematics indicating that by college age, CI users do not have an advantage over deaf nonusers either in academic content knowledge or in academic performance. Although

CI users in the present study represented had only a limited range of ages of implantation, bivariate correlations of lecture posttest scores, gain scores, and age of implantation yielded no significant coefficients, -.31 < rs (14) < -.23.

Conclusions and Limitations

Previous studies of academic achievement among CI users have demonstrated significant benefits among primary school-aged children, but those benefits consistently have been found attenuated or absent among CI users in secondary and postsecondary education Convertino et al. [4,10,12,13,24,26]. Among those studies that included consideration of age of implantation Crowe et al. [12,13,24] none found significant effects of age of implantation among older CI users Marschark et al. [15]. Tests typically used in such studies assess current abilities in targeted domains such as reading or mathematics. Such abilities, however, are cumulative, depending on knowledge and skills acquired formally and informally throughout the individual's developmental and educational histories. The present study addressed the academic benefits of CI use in the classroom using measures that both included the influence of such cumulative, prior knowledge (posttest scores) and controlled for it (gain scores). As a single instructor-interpreter team presented signed and spoken lectures to groups of CI users, deaf nonusers, and hearing college students, yielding three key findings.

First, hearing students demonstrated both significantly greater prior knowledge of lecture content and significantly higher post-lecture test scores than the deaf students. The latter difference was eliminated when prior knowledge was controlled through the use of gain scores. Those results replicate prior findings indicating that although deaf students frequently come into the classroom with less background content knowledge compared to hearing peers, under appropriate conditions, they can learn as much given their own starting points. Second, the present results replicated prior findings indicating that deaf students can learn as much when information is mediated by a skilled sign language interpreter as when it is conveyed directly by a skilled-signing instructor. Third, extending previous studies indicating that the early academic benefits of cochlear implantation are attenuated or absent among older deaf learners when assessed in terms of standardized tests, CI users in the present study scored no higher than deaf nonusers on pretests tapping prior content knowledge, post-lecture tests, or measures of gain.

As noted earlier, findings indicating the attenuation of early academic advantages among CI users with age are paralleled by similar findings among deaf children of deaf parents Marschark et al. [13,27] and those enrolled in bilingual education programs Lange et al. [27-29]. The similarity of such findings suggests a common cause or causes. Among the likely contributors to the observed attenuation are the withdrawal of academic support/ access services for deaf children who demonstrate age-appropriate language and academic skills, greater linguistic and cognitive complexity of secondary school materials relative to primary school materials, and lesser similarity in home language in school language at the secondary level than the primary level Marschark et al. [14]. All of these suggest the importance of maintaining support services and attention to deaf children's language and learning beyond primary school, even if they are demonstrating age-appropriate language and grade level-appropriate academic functioning.

Although the present results are consistent with a pattern of findings in the literature pertaining to cochlear implantation and academic achievement, they admittedly raise some troubling questions in need of further investigation. Among the limitations of the present study are the relatively late ages of implantation among participants and the fact that they were all academically advanced enough to have gained entrance to university. Further studies need to include CI users with a broader range of age of implantation and academic ability. Individuals who received CIs during the first year or two of life, (spencer's [31] Cohort 3 CI recipients, are not yet of college age in the United States), but comparisons of users at primary, secondary, and postsecondary levels in the same study would be informative. At the same time, given the large variability in language outcomes among deaf learners with and without CIs, examination of receptive language skills (both in sign language and spoken language) also would be useful. Finally, it will be important to determine which support and access services available to primary school CI users need to be maintained, and to what extent, for older learners with varying language and academic histories. Spencer et al. [31] described a sample of CI users who were functioning academically (and in reading, specifically) at grade level when they were 16 years of age or older. All of those individuals, however, had received sign language interpreting throughout their academic careers, and thus the source(s) of their academic benefits is unclear.

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Ethics Approval

Ethical approval from the Rochester Institute of Technology IRB.

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