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Simultaneous Communication and Cochlear Implants in the Classroom?

Helen C. Blom¹ and Marc Marschark²

¹Radboud University Nijmegen and Royal Dutch Kentalis Academy, Research and Development, Sint-Michielsgestel, The Netherlands ²Center for Education Research Partnerships, National Technical Institute for the Deaf, Rochester, NY, USA

Abstract

This study was designed to evaluate the potential of simultaneous communication (sign and speech together) to support classroom learning by college students who use cochlear implants (CIs). Metacognitive awareness of learning also was evaluated. A within-subjects design involving 40 implant users indicated that the student participants learned significantly more when material was presented via simultaneous communication than spoken language overall, but a statistical interaction indicated that the difference held only with more difficult material. Learning in the speech-only condition was positively related to the students' spoken language skills, their confidence with spoken language, and their receptive simultaneous communication skills. Learning in that condition was negatively related to the age at which the participants learned to sign. Findings were interpreted to indicate that simultaneous communication can be beneficial for classroom learning by college students with CIs, at least with more complex material or when information redundancy is otherwise important. Further research is needed to determine who is likely to benefit in what settings.

Keywords

cochlear implants; deaf learners; simultaneous communication; sign supported speech; learning

Introduction

In their discussion of language planning for children who are deaf in the twenty-first century, Knoors and Marschark (2012) hypothesized that classroom use of *simultaneous communication* (SimCom or *sign-supported speech* as it is known outside of the United States) – producing speech and sign at the same time – might be particularly beneficial for

Correspondence to: Marc Marschark, Ph.D., Center for Education Research Partnerships, National Technical Institute for the Deaf, 52 Lomb Memorial Drive, Rochester, New York, 14623 USA, Marc.Marschark@rit.edu.

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students with cochlear implants (CIs). CIs do not provide 100 per cent ‘normal’ hearing but typically enable individuals who are profoundly deaf to hear as well as individuals with moderate hearing losses who use hearing aids (Dettman & Dowell, 2010). Such individuals frequently continue to display less than optimal speech perception skills despite substantial benefits of implantation, and they are especially sensitive to background noise such as often exists in classrooms. Knoors and Marschark (2012) therefore suggested that, for students with sufficient sign skills, words missed or misheard through audition or speechreading could be recoverable through linguistic redundancy on the hands. Further, extensive research in both cognitive psychology (e.g. Paivio, 1986) and educational psychology (Mayer & Moreno, 1998; Goolkasian & Foos, 2005) has indicated that simultaneous auditory and visual presentation of information leads to better learning and memory than presentation in either modality alone.

Knoors and Marschark’s (2012) suggestion that bimodal presentation of information might be helpful for students with CIs may seem straightforward, but the proposal is made more complex by (1) theoretical issues associated with SimCom not being a language (Johnson et al., 1989), (2) continuing debate concerning the appropriate language(s) of instruction in deaf education (e.g. speech alone, cued speech, speech+sign) (Leybaert & LaSasso, 2010), and (3) still-evolving approaches to developing the speech and auditory capacities of youth who are deaf and use CIs (Knoors & Marschark, 2012; Walker & Tomblin, 2014). This paper seeks to clarify some of the concerns at the intersection of these issues as well as providing an evaluation of the Knoors and Marschark (2012) hypothesis. The goal here is not to address broader issues associated with CIs and either language development in children who are deaf, sociocultural aspects of being deaf, or deaf education. Rather, we believe that a focus on SimCom in the classroom for secondary school and college students is particularly timely given the rapidly increasing prevalence of CIs, the relatively late age at implantation among most of these students, and the continuing move towards educating students who are deaf in regular classrooms.

Simultaneous communication, cochlear implants, and deaf education

Despite high expectations, CIs have not proved to be a uniform solution to the academic challenges of students who are deaf over the long term. Geers et al. (2008), for example, reported a follow-up study of children with CIs who had demonstrated reading levels in advance of peers with comparable levels of hearing loss, at or near grade level, when they were in primary school. By secondary school, the sample was reading an average of almost 2 years behind grade level, but that figure masks the large individual differences among children with CIs in academic achievement (Spencer et al., 2011) as well as spoken language (Niparko et al., 2010). In the Geers et al. study, for example, 20 per cent of the children were reported to be reading in advance of hearing peers as teens, 20 per cent were at the same level, and 60 per cent had fallen behind. Archbold et al. (2008) found a strong positive relation between earlier ages of implantation and reading ability in their study of outcomes 7 years after implantation. Nevertheless, even among children who had received their implants the earliest (1–3 years), approximately 40 per cent showed at least a 1-year delay in reading achievement 7 years later (far better than those who received CIs at 6–7 years of age, 100 per cent of whom were at least 1 year delayed).

In contrast to studies with children, a number of studies have found CI use unrelated to academic performance by secondary school students (e.g. Harris & Terlektsi, 2011; Fitzpatrick et al., 2012; Marschark et al., in press) and college students (e.g. Convertino et al., 2009). Vocabulary knowledge, for example, appears to parallel the situation with regard to reading. Studies by Connor et al. (2006) and Hayes et al. (2009), utilizing the Peabody Picture Vocabulary Test (PPVT), found rapid growth in deaf children's vocabularies following cochlear implantation, suggesting that children with CIs might eventually catch up to hearing peers. Convertino et al. (2014), however, found that this had not occurred in a sample of 93 college-age CI users. Even the subgroup that had received their CIs by age 3.5 years did not differ significantly from 92 deaf peers without CIs, and both groups had PPVT scores significantly below a sample of 89 hearing peers (see also Sarchet et al., 2014).

Beyond the large individual differences observed in spoken language among deaf children following cochlear implantation (Niparko et al., 2010), the observed lessening of early gains in reading with age might have its source in any of several possibilities. These include such individuals' receiving their CIs relatively late (3–12 years of age) (e.g. Archbold et al., 2008), pre-implant language and cognitive abilities (e.g. Miyamoto et al., 1994), concomitant neurological or psychological conditions (e.g. Dettman et al., 2004), post-implantation educational methodologies (Marschark et al., 2010), the greater complexity and abstractness of reading materials for older students (Archbold, in press), or the fact that the degraded signals provided by CIs do not give them full access to spoken language (Most & Aviner, 2009; Dettman & Dowell, 2010). The focus here is on the last of those possibilities and what we can do about it in the classroom.

A number of studies have found that deaf children with CIs who are enrolled in programmes that utilize spoken language develop better speech than those in programmes using both spoken and signed language (e.g. Archbold et al., 2000; Svirsky et al., 2000; Geers et al., 2003; Nicholas & Geers, 2006). Belzner and Seal (2009) and Spencer and Marschark (2010), however, noted that the differences tended to be small. The Belzner and Seal review further found the trend to be diminishing over time. Spencer and Marschark suggested that the differences likely resulted in part from characteristics of the CI users, such as placement in an oral programme because of better spoken language skills, and were not solely a product of post-implant communication modalities. Walker and Tomblin (2014) concluded that no evidence has been offered that sign language *interferes* with the development of spoken language in children who are deaf without CIs, even if reliance on spoken language often is associated with advantages in that regard. Further, there is considerable evidence that early sign language can support the development and perception of spoken language by children with CIs (Tomblin et al., 1999; Connor et al., 2000; Spencer & Tomblin, 2006; Yoshinaga-Itano, 2006; Seal et al., 2011; Giezen et al., 2014).

Certainly, there are issues associated with the use of sign language by youth with CIs beyond the empirical question of the extent to which it affects their use of spoken language. However, whether or not one supports sign language for younger deaf children with CIs, it appears that many 'oral' students who are deaf, with or without CIs, eventually use signed communication to some extent, at least as young adults if not as children (e.g. Cormier et al., 2012). For example, according to institutional records, the 282 students at Rochester

Institute of Technology (RIT) who were using CIs in the spring of 2014 obtained a mean self-rating of their sign language skills of 3.4 on a 5-point scale from 'Don't know sign' to 'Excellent', 59 per cent of them rated their sign language skills as good to excellent, and only 14 per cent said they did not know sign language (see Belzner & Seal, 2009, with regard to children). Asked to rate their receptive SimCom skills, the CI students obtained a mean rating 4.25 on a 5-point scale from 'Understanding nothing' to 'Understanding everything'. Some students who primarily rely on spoken language as children eventually will acquire a natural sign language like American Sign Language (ASL) or Sign Language of the Netherlands (Cormier et al., 2012). Others will use signs with the word order of the spoken/written vernacular (e.g. signed English or signed Dutch) with or without accompanying speech (Marschark et al., 2005).

The signed and spoken language of a country do not share the same phonology or grammar, so signing and speaking at the same time while preserving the linguistic features of both languages is not possible. SimCom (e.g. signed English with spoken English), in contrast, allows an individual to communicate effectively with deaf or hearing individuals. With regard to classroom learning, research evidence clearly indicates that at least from 10 years of age onward, students who are deaf (without CIs) learn as much or more from SimCom as they do from other forms of communication when teachers are skilled users (e.g. Caccamise et al., 1977; Newell, 1978; Hyde & Power, 1992; Marschark et al., 2008).

There is less research involving SimCom and learning by children who are deaf and use CIs. Spencer et al. (2003) examined the reading, writing, and language abilities of 16 children with an average age of 9.8 years who had received their CIs at an average age of 3.9 years and had used them for an average of 5.9 years. All were enrolled in public school classrooms with sign language interpreting support and were reported to use SimCom at least some of the time. Grade equivalent scores indicated that the children with CIs were reading at an average grade level of 3.3 years compared to 3.8 years for the hearing children, considerably better than the national norms for deaf and hard-of-hearing children at that age (Qi & Mitchell, 2012). Although the Spencer et al. study did not include a comparison group of children who did not have sign language or SimCom in school, the similarity of these results to the large-scale study of Geers et al. (2008) suggests that, at the very least, use of sign language did not impair long-term reading outcomes.

Spencer et al. (2004) obtained results similar to those of Spencer et al. (2003) in a study involving 27 high school students who had been consecutively implanted at a single centre. All had prelingual hearing losses, had received their CIs at an average age of 6.4 years (range 2.4–12.7 years), and had between 3 and 14 years' experience with their CIs (mean=9.9 years). As in the Spencer et al. (2003) study, the students all were in regular school classrooms supported by sign language interpreters and used SimCom to some extent. Despite the relatively late average and wide range in age of implantation, the 24 consistent CI users were reading on par with hearing peers. The group as a whole scored within the normal range, a high level of performance for late-implanted users (cf. Archbold et al., 2008; Geers et al., 2008). Marschark et al. (in press) examined achievement scores among a nationally representative sample of approximately 500 deaf and hard-of-hearing 16- to 18-year-olds in the United States. Across Woodcock-Johnson III Tests of

Achievement in passage comprehension, mathematics calculation, science, and social studies, CI use never accounted for a significant proportion of variability in scores.

The present study

Long-term academic achievement of students who are deaf and use CIs will be affected by a host of variables in addition to the primary mode of communication following implantation. Convertino et al. (2009) examined over 30 language, family, audiological, and academic factors in a re-analysis of 10 experiments from previous studies examining learning by deaf students in mainstream college classrooms supported by sign language interpreters. CI use was found not to be significantly related to classroom learning. When other factors were controlled, the only language variable that significantly predicted learning was their SimCom receptive skills. Because none of the experiments evaluated by their study involved SimCom, Convertino et al. (2009) concluded that SimCom receptive skills more broadly reflected language flexibility, an important factor in mainstream college classrooms. That conclusion was seen to be consistent with findings of Spencer et al. (2003, 2004) demonstrating that high school students with CIs benefitted from the availability of both spoken language and sign language in the classroom.

The present investigation can be seen as an extension of the Spencer et al. studies, focusing specifically on the extent to which SimCom might be beneficial for learning in the classroom by students who are deaf and use CIs. It asked simply whether deaf college students with CIs would learn more from a classroom lecture communicated via speech and sign together (SimCom) than one presented via spoken language alone, and whether the potential benefits of SimCom might be related to material difficulty (i.e. the need for communication redundancy). In addition, we examined students' awareness of their learning (i.e. metacognition). Previous studies have demonstrated that students who are deaf tend to be significantly less accurate than hearing peers in predicting how much they understand or learn from text, sign language, or spoken language (e.g. Marschark et al., 2007; Borgna et al., 2011). This issue apparently has not been investigated with regard to students with CIs. Pisoni et al. (2010) reported that relative to hearing peers, children with CIs lag behind in the development of several aspects of metacognition, but metacognitive awareness with respect to comprehension and learning was not considered.

Method

Participants

A total of 40 deaf CI users (21 females) enrolled at RIT volunteered to participate in the study for \$15 each. They reported using their CIs an average of 93 per cent of the time in school and 90 per cent of the time out of school. All but one reported using their CIs in both settings, and 80 per cent of them reported having their CIs 'tuned up' at least once a year. All used their CIs during the experiment. The undergraduate students were between 19 and 28 years of age with a mean of 21 years ($SD = 1.99$). The mean age of first implantation was 6.39 years ($SD = 5.34$), with a range of 1–22 years. Thirteen students had received a second CI between 13 and 21 years of age, at a mean age of 16.08 years ($SD = 2.29$).

Materials

Two passages were drawn from the Marschark et al. (2009) study of learning from text and sign language among deaf college students. The selected passages were written at two levels of difficulty according to the Dale-Chall readability formula (Chall & Dale, 1995).

Missouri's Water Snakes... A Closer Look (henceforth 'Snakes') contained 364 words and was written at an eighth to ninth grade reading level. *The Sea around Us* (henceforth 'Sea'), which contained 261 words, was written at a ninth to tenth grade reading level. Two versions of each passage were videotaped in a professional television studio. The presenter was an RIT professor accustomed to communicating with deaf and hard-of-hearing individuals with a wide range of communication skills and preferences. She also was a highly skilled, senior interpreter/interpreter trainer experienced as an oral transliterator. For one version of each passage, she simply read them from a Teleprompter as though she was lecturing to a class. In the other, she read the passages while simultaneously producing manually coded English (i.e. SimCom). The presenter had practiced the material prior to recording in order to ensure accuracy and natural delivery in both presentation modes, and she was fully aware that the presentations would be for a class of college students who used CIs.

Eight multiple-choice questions for each passage were drawn from the Marschark et al. (2009) study that used the same materials. Each question had four alternative answers designed to tap learning of the most important information in the passages. The tests were compared to the signed versions of the passages to ensure that the information necessary to answer all the questions was available. Four of the questions for each passage were used on a pre-test to evaluate whether the groups and materials were comparable in terms of students' content knowledge prior to the study.

Each student participant completed a version of the Language and Communication Background Questionnaire (LCBQ) used by RIT to evaluate the communication needs of students who are deaf for the purpose of service provision. The LCBQ is a pencil-and-paper self-report measure that is faster than interview assessments and correlates around 0.80 with them (McKee et al., 1984; Metz et al., 1997). The LCBQ asks students about their CI and hearing aid use as well as about their spoken language and sign language use and skills. Among other dimensions, they rated on 5-point scales their skills in understanding and producing ASL, signed English (without speech), simultaneous communication, understanding spoken language (without sign), and their comfort using spoken language. They also provided estimates of the proportion of time they used their CIs in school and out of school, using visual analogue scales.

Procedure

The study was conducted so as to be as similar to a classroom presentation as possible. Rather than using an audiometric testing suite, student participants were tested in small groups in a quiet laboratory setting designed as a mock classroom. They viewed the recorded lectures on a large-screen LCD television with speakers located on either side of the screen. The volume was set to be as close as possible to that experienced in a regular

classroom and was the same for all testing sessions. None of the participants asked for any volume adjustment.

Each participant received both of the passages, one presented via spoken language and one presented via SimCom. The order in which the two passages were presented and the mode of presentation was balanced as evenly as possible across groups. All participants indicated that they were comfortable with the session being conducted in spoken language and were tested by the first author. Multiple-choice tests were administered after each passage. When students had finished the multiple-choice test, they were asked to indicate which questions they thought they likely got wrong. The communication questionnaire was administered at the end of the testing session.

Results

The alpha level in this experiment was set at 0.05. All and only those results significant at that level are reported. A preliminary one-way ANOVA examined whether the four (passage order by presentation mode order) groups differed significantly in their prior knowledge. Neither the Sea passage, $F(3, 36) < 1$, $MSE = 2.66$, nor the Snakes passage, $F(3, 36) < 1$, $MSE = 2.34$, revealed any group differences in content knowledge related to the passages. With no need to control for prior knowledge, subsequent analyses collapsed across order, and involved the proportions of post-test questions correct as the dependent variable.

Overall, SimCom resulted in higher test scores than speech only, $t(39) = 2.39$, $P < 0.03$, and scores for the Snakes passage were higher than the Sea passage, $t(39) = 2.35$, $P < 0.03$, (see Table 1). Because of the incomplete blocks design, the 2 (presentation mode condition) by 2 (passage) design was examined using independent-sample, one-way t -tests for each passage. Those analyses indicated that, as predicted, scores for the easier Snakes passage did not differ in the two presentation conditions, $t(39) = 1.34$, whereas for the more difficult Sea passage, scores were significantly lower in the speech only condition relative to the SimCom condition, $t(39) = 1.77$. Although the differences were not large, 18 of 20 student participants scored higher on the Snakes passage when they received it via SimCom rather than speech only; only 12 of 20 scored higher on the Sea passage when they received it via SimCom.

Participants' metacognitive awareness of the accuracy of their answers was determined by subtracting their actual post-test (proportion) scores from their expected post-test (proportion) scores as indicated by their post-test judgments. An ANOVA similar to that used for correct scores indicated that, overall, participants were significantly more accurate in their judgments following passages presented via SimCom than via speech only, overestimating by just 1 per cent on the former and by 8 per cent on the latter, $F(1, 38) = 4.84$, $MSE = 0.02$. The interaction with passage was not significant, $F(1, 38) = 1.96$.

Pearson's correlations were used to examine relations between test scores obtained with the two presentation modes, metacognitive judgments, and the communication variables assessed by the self-report questionnaire. As can be seen in Table 2, scores in the speech condition were positively related to speech production skills, confidence in speech skills,

and SimCom receptive skills. Scores in the speech condition were negatively related to the age at which participants reported learning to sign (i.e. those who learned to sign earlier scored higher). Scores were not related to either the age at which they received their CIs or their use of CIs in or out of school. Scores in the SimCom condition were not significantly related to any of the communication variables. Participants who overestimated their performance in the speech condition reported using their CIs a lesser proportion of time when they were out of school, but there were no significant correlations between overestimates in the SimCom condition and any of the communication variables. Correlational analyses for the separate passages indicated that scores for the Sea passage were significantly related only to the age at which student participants reported learning to sign ($r = -0.34$) and their SimCom receptive skills ($r = 0.34$). Scores for the Snakes passage were related only to the amount of time that participants reported using their CIs outside of school ($r = 0.35$).

Discussion

The present study explicitly asked whether SimCom could provide added value to classroom learning for college students with CIs. A within-subjects design provided an affirmative answer to the above question in the case of more difficult material, but not easier material. Knoors and Marschark (2012) hypothesized that for students with CIs who have sufficient sign skills, SimCom could provide communication support in the classroom because it provides redundant information. Information that is missed by the ears can be captured by the eyes from the hands. That redundancy is not available when a teacher depends on a sign language interpreter, because their productions are out of synchrony. Results also indicated that participants' self-rated spoken language skills and their confidence in those skills were related to their learning in the speech only condition. SimCom receptive skills also were significantly related to learning in that condition.

The use of spoken language and sign language together in educating deaf learners has a controversial history. Nevertheless, as described earlier, the evidence base is consistent in indicating that in the hands of a good user of SimCom, deaf students in secondary school through college learn as much from instruction in that mode as they do when highly skilled sign language interpreters are involved. A possible role for SimCom in the education of students with CIs had not been explicitly explored previously, although studies by Spencer et al. (2003, 2004) found that high school students with CIs who received support from sign language interpreters in school and used SimCom themselves to some extent were reading at or near grade level.

Taken together with the present results, the previous findings suggest the potential of the simultaneous use of signing to support learning by deaf students who use CIs. When auditory information is missed, misheard, or is novel, SimCom can provide such students with redundant verbal signals that can either compensate for what is missed or provide implicit reassurance that information was heard correctly. It therefore is not surprising that the addition of signs to a spoken presentation is most beneficial with more difficult information; the same would be expected for information presented in noise.

The present study also has some limitations and needs to be replicated with students in a wider age range, longer retention intervals, and materials of more diverse complexity and difficulty in order to determine who is likely to benefit, with what materials, under what conditions. The average age of implantation in the present sample, for example, was quite late, although neither that variable nor the reported frequency of using of implants in or out of school was related to scores in the speech only condition. Still, the value added for individuals who get their CIs earlier or later and have greater or lesser fluencies in spoken and sign language remains unclear. The study sample also was composed entirely of college students who may not be representative of the broader population of deaf young people in terms of their language skills or their content knowledge, which would have facilitated comprehension and learning of the passages (Rawson & Kintsch, 2002).

Finally, while the present findings suggest a potentially useful instructional strategy for deaf learners with CIs who are in schools or programmes for the deaf, it is unclear to what extent they might influence instruction and academic outcomes for the majority of those students, those in regular classrooms. For them, SimCom might be beneficial during tutoring, instruction from an itinerant (peripatetic) teacher, or other learning situations with individuals who may be competent in signed communication, but not fluent in the national sign language. It also may be that, in addition to other support services (e.g. real-time text, interpreters, improved classroom acoustics), SimCom can provide younger learners with sufficient additional access to the vernacular and academic content that they can close the gaps in those domains before they reach secondary and post-secondary settings. The present study does not offer answers to these worthwhile questions, but it does indicate that SimCom can have a place in the education of CIs users and deserves empirical and *in situ* evaluation.

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Table 1

Means and standard deviations (SD) of test scores for two passages under speech only and speech plus sign (SimCom) conditions

	<u>Speech only</u>		<u>Speech+sign</u>	
	Mean	SD	Mean	SD
Sea passage	0.69	0.19	0.79	0.15
Snakes passage	0.79	0.24	0.88	0.16

Table 2

Pearson correlation coefficients for communication ratings with scores and metacognitive accuracy judgments in speech only and simcom conditions

Communication variable	Speech score	SimCom score	Speech overestimate	SimCom overestimate
Age learned to sign	−0.39*	−0.13	0.27	0.07
Sign vs. speech preference	0.06	−0.01	−0.06	0.003
ASL or signed English preference	−0.04	−0.001	0.11	−0.004
ASL receptive skill	−0.01	0.01	−0.02	0.06
SimCom receptive skill	0.33*	0.10	−0.22	−0.12
Signed English receptive skill	0.16	0.23	−0.02	−0.23
Speech receptive skill	0.17	0.18	−0.01	−0.07
ASL expressive skill	−0.07	0.12	−0.06	−0.04
Signed English expressive skill	−0.001	0.08	0.05	−0.08
SimCom expressive skill	0.07	−0.08	−0.12	0.08
Speech expressive skill	0.37*	0.12	−0.14	−0.05
Speech confidence	0.38*	0.15	−0.10	−0.15
% time CI use in school	0.20	0.03	−0.17	−0.02
% time CI use out of school	0.24	0.17	−0.44*	−0.26
Age of implantation	0.10	0.14	−0.28	0.08

* $P < 0.05$.