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# Literacy Skills among Deaf and Hard of Hearing Students and Students with Cochlear Implants in Bilingual/ Bicultural Education

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Research has shown that many deaf students do not develop age-appropriate reading and writing abilities. This study evaluates the literacy skills of deaf students, hard of hearing students, and students with cochlear implants in bilingual/bicultural schools in Denmark. The results show that 45 per cent of the students did not have any reading and writing difficulties (i.e. they were no more than 1 year behind in school). Regression analysis models show that language abilities (either aural-oral or signed) and additional disabilities were explaining factors. Neither the level of hearing loss nor cochlear implantation was found to be significantly related to literacy skills. The results are discussed in relation to the Danish bilingual/bicultural approach in deaf education, an approach which appears to improve literacy skills among students with hearing impairment but does not eliminate all literacy difficulties.

KEYWORDS bilingual/bicultural, cochlear implant, deaf, deaf education, hearing impairment, literacy, reading, sign-language

## Introduction

The primary disadvantage of congenital deafness is that it inhibits the development of spoken language in terms of both production and comprehension. It is also well documented that many students with hearing impairment have academic difficulties (Mayberry, 2003; Lederberg et al., 2013). Research in the United States has shown that the median reading ability of deaf adolescents leaving secondary school is at the level of 4th grade and that only 10 per cent of students develop age-appropriate

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skills (Traxler, 2000). Similar results have been found in other countries (Wauters et al., 2006; Alvarado et al., 2008; Hermans et al., 2010).

Research on the many factors involved in the acquisition of literacy highlights the significance of two key areas of ability. These are (1) phonological ability, which includes skills relating to speech intelligibility, phonological coding and awareness, and speech reading; and (2) general language ability. In relation to phonological ability, studies of deaf students who sign or speak have found evidence that they use phonological skills in reading (Harris & Beech, 1998; Harris & Moreno, 2004). Colin et al. (2007) found that the phonological skills of deaf students in kindergarten were a significant predictor of their reading ability in first grade and accounted for 28 per cent of the variance in later reading scores. Phonological coding has been found to be a strong predictor of the reading success of deaf students (Dyer et al., 2003; Harris & Moreno, 2006) and both expressive vocabulary and letter-sound knowledge have been correlated with reading ability 9 months later among young deaf and hard of hearing students (Easterbrooks et al., 2008). Similarly, vocabulary knowledge and speech-reading skills have been shown to be predictors of later reading skills in 7- to 8-year-old deaf students from mixed language backgrounds (Kyle & Harris, 2011). Spencer and Oleson (2008) found speech production and perception skills among 7-year-old students with cochlear implants to be the strongest longitudinal predictors of reading skills 4 years later.

General language ability is also significant for the development of literacy skills. When individuals learn how to read and write, it is important that they know a language. In line with this, research suggests that the general language skills of deaf students are related to their acquisition of literacy. In a meta-analysis of the relation between reading ability and phonological skills in deaf students, Mayberry et al. (2011) found that 35 per cent of the variance was predicted by language ability whereas only 11 per cent was predicted by phonological coding and awareness. Research has documented that strong reading skills correlate with good sign-language skills (Chamberlain & Mayberry, 2008; Hermans et al., 2008). Strong and Prinz (1997) found that deaf students with good sign-language abilities have higher levels of English literacy than peers of similar IQ with a lower level of sign-language abilities. It has also been found that having early access to fluent sign language, for example through deaf parents, is associated with greater reading achievement (Chamberlain & Mayberry, 2000; Padden & Ramsey, 2000).

The impact of cochlear implantation (CI) on literacy skills has also been researched. Most studies have found that, due to better spoken-language skills, students with CI read and write better than students with hearing impairment without CI (Thoutenhoofd, 2006; Vermeulen et al., 2007; Archbold et al., 2008; Easterbrooks et al., 2008). However, other studies have not found that students with CI read and write any better than peers with hearing aids (Harris & Terlektsi, 2010). Harris and Terlektsi (2010) found an average delay of 3 years in reading among students with either CIs or hearing aids. Lederberg et al. (2013) conclude in their review that more research is needed to determine whether and how CIs improve literacy

rates for deaf students. Marschark et al. (2007) and Marschark et al. (2009) summarize that deaf students with pediatric CI seem to have many advantages in reading and other academic domains, but that it is not certain whether these advantages are related to improvements in phonological skills or general language abilities.

The two key areas of ability identified, phonological ability, and general language ability, relate to different but not conflicting theories and educational approaches to deaf students' development of literacy. The first approach holds that deaf students learn to read in a similar way to hearing students and that forms of visual communication (e.g. visual phonetics and cued speech) should be used to support phonological skills (Wang et al., 2008). The second approach is a sign-bilingual educational approach based on the theory that supporting natural and fluent sign language improves general language abilities that in turn improve literacy skills.

In Scandinavia, the dominant model in education for deaf students since the early 1980s has been one which emphasises a bicultural (deaf and hearing) and bilingual (signed and oral) approach (Heiling, 1995; Svartholm, 2010). In 1981, Sweden was the first country to give sign language the status of a language and to introduce a bilingual curriculum in deaf schools (Svartholm, 2010). Norway and Denmark enrolled similar bilingual curriculum programmes in deaf schools a few years later. The change to a bilingual approach was made because of the discouraging results from educating deaf pupils only by speech with a focus on training phonological skills. These discouraging results had persisted despite the development of better hearing aids in line with extensive technical developments since the 1950s (Svartholm, 2010). Bilingual preschool and school programmes for deaf students established sign language as the natural first language. Danish Sign Language was used for all teaching and communication, and oral and written Danish was taught as a second language. Sign language became an independent subject in the curriculum where students learnt about sign-language linguistics, deaf culture, and deaf history (Ministry of Education, 1991). All teachers were trained teachers for the deaf and skilled sign-language users. Some of the teachers were deaf themselves and used Danish Sign Language as their first language. Owing to the introduction of CIs for all congenitally deaf students over the last decade, the number of students attending a bilingual/bicultural deaf school has decreased to a minimum. Most students are now mainstreamed (Percy-Smith et al., 2012).

The Scandinavian bilingual/bicultural educational approach experienced a period of growth during the 1980s and 1990s and inspired other countries to look to this model for guidance on developing bilingual/bicultural policy and practice (Swanwick, 2010). Despite this influence, the Scandinavian bilingual educational approach has not been systematically evaluated for its effects on educational outcomes.

The aim of this study is to provide an evaluation. First, it evaluates the literacy skills of a group of deaf/hard-of-hearing students with and without CI during a

period of bilingual/bicultural education. Second, it evaluates the factors that may explain the level of literacy skills.

## Method

This study involved 331 students from six different schools (three deaf schools and three hearing impaired units at mainstream schools). All schools used a bilingual curriculum programme. Data were collected in 2007. Another part of the data sample was used in a former study of psychosocial difficulties (Dammeyer, 2010). Informed consent was gained from all parents and legal guardians. All students ($N = 343$) at the six schools were invited to participate, but twelve of the students were not included. In two cases, the parents did not permit participation; in seven cases, either the parents did not respond or the teacher did not return the questionnaires; and in three cases, the students had completed 10th grade but were still enrolled at the school.

Information about each student was provided by their coordinating teacher who filled out a questionnaire form. The head of each school distributed the questionnaires and written instructions to the teachers. Information on the following variables was gathered through the questionnaires.

### Literacy skills

The literacy skills of deaf and hard-of-hearing students are usually determined in research through the use of either standardized tests or teacher ratings (Antia et al., 2009). At the time of this study, no national standardized test was available. Therefore, the study used teacher ratings. The student's reading and writing level in Danish was rated by their teacher according to the mainstream school grade it represented (level of the student's participation in the general education curriculum according to the national norms for hearing students; Ministry of Education, 2001), with a pre-school level rated as 0 and grade levels 1–10 rated 1–10. A similar method for evaluating academic levels was used by Power and Hyde (2002) in an Australian study of deaf and hard of hearing students. Data were collected during the second semester.

### Hearing group

A non-aided hearing level of 80 dB in the better ear was used to divide between deaf and hard of hearing students. Information about age for first CI surgery was obtained.

### Aural-oral abilities

Two single-item scales were included to assess aural-oral abilities: Categories of Auditory Performance (CAP) (Archbold et al., 1995) and Speech Intelligibility Rating (SIR) (Allen et al., 2001). CAP is a reliable single-item scale with a range of 0–7 that assesses a student's functioning in everyday situations. Level 0 is 'no

awareness of environmental sounds' and Level 7 is 'uses a telephone with a known speaker'. SIR is also a reliable single-item scale with a range of 1–5. Level 1 is 'connected speech is unintelligible' and level 5 is 'connected speech is intelligible to all listeners'. Reliability was tested in this study for both CAP and SIR. Two different teachers rated forty-seven students and ordinal (quadratic) Kappa reached 0.79 for CAP and 0.85 for SIR. The sum of CAP and SIR scores was calculated for each student and labelled 'aural-oral score'.

#### Sign-language abilities

Two single-item ratings of sign-language production scale (SPS) and sign-language understanding scale (SUS) (Dammeyer, 2010) were included in the study. SPS is a single-item scale with a range of 1–5. Level 1 is 'the student does not produce signs' and level 5 is 'the student has a fluent and almost conventionally correct sign language'. SUS is a single-item scale with a range of 0–7. Level 0 is 'does not comprehend or attend to signs' and level 7 is 'able to take part in longstanding and complex conversation in sign-language'. Reliability was also tested for SUS and SPS. SUS and SPS were completed by two teachers independently for seventy-four students and ordinal (quadratic) Kappa reached 0.94 for SUS and 0.92 for SPS. Validity was evaluated for SUS by comparing ratings of twelve students with the score of the Danish translation of the Assessing British Sign Language Development: Receptive Skills Test (Herman et al., 1999). Correlation reached statistical significance (Spearman rank correlation coefficient = 0.91, $P < 0.00$). No corresponding test was available for sign-language production. The sum of SPS and SUS, labelled 'sign-language score', was calculated for each student.

#### Parental hearing loss

Information as to whether at least one of the parents had hearing loss was included in the study.

#### Additional disabilities

It has been reported that a number of deaf students face additional disabilities (e.g. intellectual impairment, cerebral palsy, autism, and severe visual impairment) (van Naarden et al., 1999; Bond, 2000; Hindley, 2005). Additional disabilities may affect the level of literacy skills. Information on diagnosed additional disabilities was included in the study.

#### Other variables

Information was obtained about age, gender, the educational level of parents, and the type of school (deaf school or hearing impaired unit).

### *Procedure*

The relationships between literacy skills and the explanatory variables, including all relevant interaction effects (Jaccard, 2001), were analysed using logistic regression.

The literacy skill score (the dependent variable) was dichotomized into no delay (no more than 1 year behind in school) and with delay (more than 1 year behind). Since information about literacy skills was collected in the second semester, it was decided that students in the first grade who demonstrated literacy skills of a pre-school level had a delay. The explanatory variables (the independent variables) were parents' education (sum of parents' education in years), aural-oral score (sum CAP and SIR, range 2–12), sign-language score (sum SUS and SPS, range 2–12), additional disabilities (no additional disabilities; one or more additional disabilities), age (year), hearing group (categorical variable: deaf; hard of hearing; CI), gender, and school type (deaf school; hearing impaired unit). The logistic regression model was found using forward selection (conditional). Odds ratios were used to explain the results. The statistical procedures were made in SPSS 17.0.

## Results

One hundred and seventeen students were deaf (35 per cent), 115 were hard of hearing (35 per cent), and 92 had CI (28 per cent). In seven cases, no information was given about hearing. The mean age of the deaf students was 13.8 years (SD = 2.1), of the hard of hearing students was 12.8 years (SD = 2.9), and of the cochlear implanted students was 11.0 years (SD = 2.4). The mean age of cochlear implant surgery was 6.1 (SD = 3.2), and the average number of years following implantation (age of hearing) was 4.8 (SD = 3.4). Out of all the students, 9 per cent had at least one parent with hearing loss.

It was reported that 24 per cent of the students had additional disabilities.

Of the 331 students, 149 (45 per cent) demonstrated literacy skills no more than 1 year behind in school (no delay) and 182 student (55 per cent) demonstrated literacy skills more than 1 year behind (with delay). Of the students in 7th–10th grades (students aged 14–17 years of age), eighty-five (57 per cent) students demonstrated literacy skills above 4th grade level.

The logistic regression model of variables affecting literacy skills is presented in Table 1. Low aural-oral abilities and sign-language abilities were able to explain literacy delay. Odds ratio for scoring one point higher on SPS or SUS was 0.78,

TABLE 1

VARIABLES AFFECTING LITERACY DELAY AMONG 331 STUDENTS WITH HEARING IMPAIRMENT*

| Variable (scale/categories) | B | SE | Wald | df | *P* | Exp (B) |
|---|---|---|---|---|---|---|
| Aural-oral (range 1–12. 1 (reference) low abilities, 12 high abilities) | –0.254 | 0.038 | 45.567 | 1 | <0.001 | 0.78 |
| Sign-language (range 1–12. 1 (reference) low abilities, 12 high abilities) | –0.245 | 0.074 | 10.931 | 1 | 0.001 | 0.78 |
| Additional disabilities (no additional disabilities (reference), one or more additional disabilities) | 1.062 | 0.387 | 7.534 | 1 | 0.006 | 2.89 |

*Logistic regression model (model $x^2 = 88.0$; df = 3; $P < 0.001$).

indicating a decreased risk of 12 per cent for having literacy delays. For one higher point scored on CAP or SIR, odds ratio was also 0.78. The effect of sign-language and aural-oral abilities can be illustrated as follows: if scores on both SPS and SUS were at a maximum (7 and 5, respectively), then 68 per cent ($n = 73$) demonstrated literacy skills no more than 1 year behind in school. Similarly, if the scores on the CAP and SIR were at a maximum (7 and 5, respectively), then 90 per cent ($n = 36$) demonstrated literacy skills no more than 1 year behind in school.

Additional disabilities were also able to explain literacy delays. Odds ratio was 2.89, showing that students with additional disabilities had a language delay almost three times more often than students without additional disabilities.

Hearing groups (deaf, hard of hearing, or CI), parents' hearing status, gender, parents' education, and school type (deaf schools or hearing impaired unit) were not significantly related to language delay in the final logistic regression model. There were no significant interaction effects either.

## Discussion

In this study, 45 per cent of the students did not have literacy delays. It is difficult to compare this result to other studies due to different definitions and assessment procedures relating to literacy skills. However, the general level of literacy skills found in this study appear to be higher than those reported for the United States by Traxler (2000) who reported that only 10 per cent of students with hearing impairment developed age-appropriate reading skills by the end of secondary school. Similar results to Traxler's have been reported internationally (Wauters et al., 2006; Alvarado et al., 2008; Hermans et al., 2010). Although it may be the case that the bilingual/bicultural education in Denmark has resulted in higher levels of literacy skills, it has not ended reading and writing difficulties for deaf students. In this study, 55 per cent of the sample demonstrate delay in literacy skills development.

Sign-language score was associated with literacy skills. This result supports research emphasising the significance of sign-language abilities as an important cognitive and linguistic foundation for the development of literacy skills among deaf students (Strong & Prinz, 1997; Goldin-Meadow & Mayberry, 2001; Marschark et al., 2009; Mayberry et al., 2011).

That the aural-oral score was also associated with literacy skills supports the notion that aural-oral skills are important for the development of literacy skills. This study used only two single-item teacher-rated scales of aural-oral skills (the CAP and SIR scales) and cannot conclude what specific phonological skills are important.

Some researchers argue that the bilingual model, according to which sign-language skills directly transfer to reading and writing skills, should be modified (Mayer & Akamatsu, 1999; Hermans et al., 2010; Mayer & Leigh, 2010). It may be that good language abilities are a necessary but not sufficient foundation to learn to read and write. Therefore, good sign-language skills can serve as a mediator

but explicit literacy instruction in the written language may also be needed (Hermans et al., 2010). This study was not able to explore more specific relations between sign language and literacy skills.

For a student with hearing impairment, learning to read and write may draw on different skills. The deaf student may simultaneously use different pathways involving semantic, orthographic, and phonological information (Mayberry et al., 2011). In a study of four good deaf readers, Harris and Beech (1998) reported that two had good English-speaking abilities and phonological awareness, and two were good signers with poor phonological skills.

The effect of CI was also considered in this study. Whether the student was deaf, hard of hearing, or cochlear implanted had no significant impact on the delay in literacy skills. This result was in line with some studies (Harris & Terlektsi, 2010) but contradicts other studies that have found that CI improves deaf students' literacy abilities (Thoutenhoofd, 2006; Vermeulen et al., 2007). Age of implant surgery was high among the students included in this study ($M = 6.1$ years, SD = 3.2), and age of hearing (years of CI use) was low ($M = 4.8$ years, SD = 3.4). This may be important since early CI (i.e. before 5 years of age) has been shown to improve oral communication outcome (Stacey et al., 2006) and reading abilities (Archbold et al., 2008).

Several studies have found that late first-language acquisition, due to late age of CI or late exposure to sign language, are significant for deaf students' social, cognitive, and language development in general (for review, see Mayberry, 2007; Lederberg et al., 2013). Early or late first-language acquisition may be part of the explanation for why some of the students in this study had delayed literacy skills and others did not, but this issue was not investigated in this study.

Additional disabilities explained part of the delay in literacy skills found among students with hearing impairment in this study. Additional disabilities, such as intellectual impairment, may affect a student's ability to learn to read and write. The relatively large number of students with additional disabilities (24 per cent) suggests that this is a variable that cannot be ignored when evaluating levels of literacy skills among students with hearing impairment. If additional disabilities are ignored, literacy skills difficulties may incorrectly be associated with hearing loss. Development of literacy skills among students with hearing impairment and additional disabilities is an issue that needs attention in deaf education. Special educational support should be developed to help these students.

### *Limitations*

No standardized tests were used to evaluate the level of literacy skills of the students. The information gathered was based on teachers' reports. Similarly, data describing the sign-language and aural-oral abilities were obtained by single-item rating scales that were also completed by teachers. The results from this study need to be confirmed by using standardized assessment tests. They should also be evaluated in

light of further studies exploring different aspects of phonological, sign-language, and literacy abilities.

A control group of students with hearing impairment who have not been involved in a bilingual programme should be included in future research to investigate the effects of a bilingual/bicultural education programme.

Late age of CI may have impacted on results and may therefore be a significant limitation of this study. Another limitation is that students with CI attending mainstream schools were not included in the study. The results of this study cannot be generalized to students with cochlear implants in general. A study including students implanted at a younger age and attending mainstream schools may have given a different conclusion.

### *Conclusion*

Around half of the students with hearing impairment had literacy difficulties. The study found three significant variables: (1) aural-oral abilities, (2) sign-language abilities, and (3) additional disabilities. The results in relation to the first two show that if communication was good (as determined by high scores on SPS and SUS or CAP and SIR) the risk of literacy delay decreased substantially. Neither the level of hearing impairment nor CI was found to be significantly related to literacy delay. It appears that it is not deafness *per se* that causes literacy deficiency among students with congenital deafness but rather delay in language development. The presence of additional disabilities was shown to be significantly related to the delay of literacy skills. Given the high percentage of students with additional disabilities, this is an issue that cannot be ignored either in research or in educational practice with students with hearing impairment.

The bilingual/bicultural approach to the education of deaf and hearing-impaired students with or without CI in Denmark may have improved the general level of literacy skills but it has not eliminated the difficulties for all students. One half of the students in this study attained a literacy level equivalent to their hearing peers, but the other half did not.

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