Phonological awareness and early reading skills in children with cochlear implants

ARTICLE *in* COCHLEAR IMPLANTS INTERNATIONAL · MAY 2014

DOI: 10.1179/1467010014Z.000000000172 · Source: PubMed

3 AUTHORS, INCLUDING:

Teresa YC Ching
Australian Hearing
96 PUBLICATIONS **1,542** CITATIONS
SEE PROFILE

Linda Cupples
Macquarie University
38 PUBLICATIONS **634** CITATIONS
SEE PROFILE

Phonological awareness and early reading skills in children with cochlear implants

Teresa YC Ching[1,2], Julia Day[1,2], Linda Cupples[3]

[1]National Acoustic Laboratories, Sydney, Australia
[2]HEARing CRC, Australia
[3]Macquarie University, Australia

Corresponding author:
Teresa YC Ching, PhD
National Acoustic Laboratories
Australian Hearing Hub
16 University Avenue
Macquarie University
Sydney NSW 2109
Australia
Email: Teresa.Ching@nal.gov.au
Phone: +612 9412 6832
Fax: +612 9411 8273

Conflicts of interest

None were declared.

Acknowledgement:

This paper was presented at Panel C, Academic Achievements of Cochlear Implantees, 11th European Symposium on Paediatric Cochlear Implantation, May23-26, 2013, Istanbul, Turkey.

Abstract:

This paper summarises findings from a population study on outcomes of children with hearing loss in Australia, the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI, www.outcomes.nal.gov.au) study. Children were evaluated at several intervals using standardised tests, and the relationship between a range of predictors and the outcomes was examined. This paper reports the performance of children with cochlear implants at 5 years of age together with factors predicting word reading ability. Earlier age at cochlear implantation was significantly associated with better word reading ability, after controlling for the effects of language, receptive vocabulary, nonverbal cognitive ability and device configuration.

Key words: Children, cochlear implants, language, reading, phonological awareness

Introduction

About 1 in every thousand live births has permanent childhood hearing loss. This condition has major negative impacts on children's development of language, literacy, and hence their academic achievement. In 2001, the US Preventive Services Task Force noted that "the average deaf student graduates from high school with language and academic achievement levels below those of the average fourth-grade student with normal hearing. Average reading scores for hard-of-hearing students graduating from high school are at the fifth-grade level. The lag in reading performance has remained virtually unchanged since it was first carefully measured in the early 1960s."

With widespread implementation of universal newborn hearing screening (UNHS), it has become possible to detect hearing loss soon after birth so that early treatment, including amplification and cochlear implantation, can be provided. The goal of UNHS is to improve language and literacy outcomes at a population level. For children detected with severe or profound hearing loss through UNHS, cochlear implantation may be provided early in life to support early development before delay occurs.

Some recent reports on children who received a cochlear implant (CI) before 2 or 4 years of age showed benefits for language acquisition when compared to those who received later implantation (Archbold et al, 2008), whereas other reports did not find a difference between groups (Geers & Hayes, 2010; Dillon et al, 2012). Across studies, reading ability at 8-9 years was on average below 1SD of normative mean; and for children who were measured again at 16 years, a decline in development was evident (Geers et al, 2008; Archbold et al, 2008). With widespread implementation of UNHS, it

may reasonably be expected that children who need cochlear implants should get them earlier than 2 years. Indeed, benefits are likely to be greater for devices to be provided earlier so that the effect of auditory deprivation could be minimized. There were no population studies that included large numbers of children who received a cochlear implant before 12 months of age, nor any direct comparison of outcomes of early and later-implanted children in a prospective manner.

As cochlear implants provide auditory access to sounds, it may be hypothesized that children who received a CI earlier would have better awareness of sound structures of language, or phonological awareness (PA), than those who received later implantation. If PA is positively related to reading ability as for typically developing children (for a review, see Melby-Lervåg et al., 2012), early reading ability may well be better for children who received a CI earlier in life. On the other hand, if language ability and variables other than PA were more important for development of reading in hearing-impaired children (for a review, see Mayberry et al, 2011), there would be no difference in reading ability between children who received early or later implantation.

This paper draws on a population study that investigated the effectiveness of UNHS for improving child outcomes, the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study (www.outcomes.nal.gov.au). About 460 children were enrolled from three states in Australia in which UNHS was at different stages of implementation. Across states, children received consistent hearing service provision from the national service provider, Australian Hearing (Ching et al, 2013). Of these children, 53% received their first hearing aids before 6 months of age. Of the 165

children who use a CI at 5 years of age, 32% of them first received it before 12 months of age.

This paper reports the reading ability and phonological awareness of children with cochlear implants at 5 years of age; and examines the factors affecting reading development.

Method

Participants: This is a prospective cohort study. Participants were 165 children enrolled in the LOCHI study who were using CIs at 5 years of age - 14 used a CI in one ear only (unilateral CI), 56 children had a CI in one ear and a hearing aid in the other ear (CI+HA), and 95 had bilateral CIs.

Procedure: Soon after a child turned 5 years of age, a team of trained research speech pathologists conducted assessments using standardized tests. Measures of language ability included the Pre-school Language Scale 4th ed. (PLS-4) to evaluate receptive and expressive language, and the Peabody Picture Vocabulary Test, 4th ed. (PPVT) to evaluate receptive vocabulary. Phonological awareness was assessed by using the elision, sound matching and blending word subtests of the Comprehensive Test of Phonological Processing (CTOPP). Reading ability was assessed by using a letter name knowledge test and the word identification and word attack subtests of the Woodcock Johnson III® Diagnostic Reading Battery (WDRB). The Wechsler Nonverbal Scale of Ability (WNV) was used to assess nonverbal cognitive ability. Custom-designed questionnaires were used to collect demographic information.

Statistical analysis: The Statistica software was used for analysis. The primary outcome measures were summarized in terms of means and standard deviations. To determine factors affecting reading ability, multiple linear regression analysis using word identification standard scores as a dependent variable and age at CI activation, nonverbal cognitive ability, PLS-4 total language scores, PPVT scores, and device configuration (unilateral CI, CI+HA, bilateral CI) as predictor variables was performed.

Results and Discussion

Table 1 shows the outcomes data for children at 5 years of age. The nonverbal cognitive ability of the children was within normal range, but the language ability was below normative populations: mean scores for receptive language (-1.3 SD), expressive language (-1.6 SD), receptive vocabulary (-1.1 SD. In regard to reading, children knew the names or sounds associated with some letters of the alphabet (mean = 15, SD = 8); and their overall pattern of performance was approximately in line with published norms for the word identification and word attack subtests of the WDRB. It is noteworthy that even though the mean scores for phonological awareness were between -0.5 and -0.8 SD of the normative mean, these scores overestimated the abilities of children with cochlear implants, given that more than half of the children were unable to cope with the CTOPP test.

Table 1 about here

Multiple regression analysis of data from 62 children with the full set of scores revealed that earlier age at cochlear implant activation was associated with better word reading ability ($F = 4.09$, $p = 0.048$). There were no other significant factors at the 5% probability level.

By design of this prospective study, children will be evaluated again at 9 years of age. To date, 29 children who use CIs have completed their 9-year assessments. Preliminary results from 22 children with nonverbal cognitive ability scores within the normal range (mean score: 99.95; SD: 13.1) had language scores below normal levels (Receptive language: -1.7 SD; Expressive language: -1.9 SD; Language memory: -1.9 SD). Deficits in vocabulary were also indicated (Receptive vocabulary: -1.7 SD; Expressive vocabulary: -1.5 SD). Their word and non-word reading ability was at -0.8 SD, but their passage comprehension ability was at -1.1 SD. Of these 22 children, 4 received their first CI by 12 months of age, and were using bilateral CIs by 5 years of age. These 4 children had language and reading scores within the normal range at 9 years of age.

When all data become available, it will be possible to quantify the effect of age of cochlear implantation and other factors on children's development of phonological skills, language and reading ability. It will also be possible to examine whether early phonological skills at 5 years predict reading abilities at 9 years. This longitudinal study will allow development trajectories to be quantified, and factors affecting growth rate, including age at early intervention, to be determined at different stages of education.

Conclusion

This population-based study found that earlier age at cochlear implant activation was significantly associated with better reading ability at 5 years of age, after controlling for language ability, receptive vocabulary, nonverbal cognitive ability, and device configuration.

Acknowledgements, Grants

We are grateful to all families and their children for participating in the LOCHI study. Data collection and project administration are supported by the LOCHI team.

The project described was partly supported by Award Number R01DC008080 from the National Institute On Deafness And Other Communication Disorders. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute On Deafness And Other Communication Disorders or the National Institutes of Health.

Funding support was also provided by the Office of Hearing Services in Australia, Department of Health in New South Wales, Phonak Ltd., and the Oticon Foundation.

We also acknowledge the financial support of the Commonwealth of Australia through the establishment of the HEARing CRC and the Cooperative Research Centres.

References

Archbold, S.M., Harris, M., O'Donoghue, G., Nikolopoulos, T., White, A., Richmond, H.L. (2008). Reading abilities after cochlear implantation: the effect of age at implnatation on outcomes at 5 and 7 years after implantation. *International Journal of Pediatric Otorhinolaryngology*, 72(10), 1471-1478.

Ching, T.Y.C., Dillon, H., Marnane, V., Hou, S., Day, J., Seeto, M., Crowe, K., Street, L., Thomson, J., Van Buynder, P., Zhang, V., Wong, A., Burns, L., Flynn, C., Cupples, L., Cowan, R.S.C., Leigh, G., Sjahalam-King, J., Yeh, A. (2013). Outcomes of early- and late-identified children at 3 years: findings from a population study. *Ear and Hearing*: Published online ahead of print.

Dillon, C. M., de Jong, K., Pisoni, D. B. (2012). Phonological awareness, reading skills, and vocabulary knowledge in children who use cochlear implants. *Journal of Deaf Studies and Deaf Education*, 17(2), 205-226.

Geers, A. (2003). Predictors of reading skill development in children with early cochlear implantation. *Ear and Hearing,* 24(1), 59S-68S.

Geers, A., Tobey, E., Moog, J., Brenner, C. (2008). Long-term outcomes of cochlear implantation in the preschool years: from elementary grades to high school. *International Journal of Audiology*, 47(S2), S21-S30

Geers, A., & Hayes, H. (2010). Reading, writing, and phonological processing skills of adolescents with 10 or more years of cochlear implant experience. *Ear and Hearing*, 32, 49S-59S.

Mayberry, R. I., del Giudice, A. A., & Lieberman, A. M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *Journal of Deaf Studies and Deaf Education,* 16(2), 164-188.

Melby-Lervåg, M., Lyster, S-A. H., & Hulme, C. (2012). Phonological Skills and Their Role in Learning to Read: A Meta-Analytic Review. *Psychological Bulletin,* 138(2), 322-352.

Table 1. Mean standard scores, standard deviation (SD), and range for assessments of children at 5 years of age. Cognitive ability was measured by the Wechsler Nonverbal Test of Ability (WNV), Receptive and Expressive language ability by the Pre-school Language Scale (PLS-4), receptive vocabulary by the Peabody Picture Vocabulary Test (PPVT), names or sounds of the 26 alphabets, Reading was assessed by the Woodcock-Johnson Diagnostic Reading Battery (WDRB word identification and word attack subtests), and phonological awareness was assessed by using the Comprehensive Test of Phonological Processing (CTOPP, elision, sound matching and blending words subtests). The CTOPP scores have a normative mean of 10 and a standard deviation of 3. All other tests have a normative mean of 100 and a standard deviation of 15.

Test	**n**	**Mean**	**SD**	**Median**	**25th percentile**	**75th percentile**
Cognitive ability (WNV)	110	101.1	101.5	101.5	91	111
Receptive language: PLS-4	112	81.0	82.0	82.0	64	95
Expressive language: PLS-4	110	76.5	76	76.0	52	94
Receptive vocabulary: PPVT	105	84.1	83	83.0	71	97
Letter name knowledge	99	13.3	15	15.0	5	21
Real Word reading: WDRB_Word Identification)	76	103.4	103.5	103.5	91	111
Non-word reading:	48	115.5	110.5	110.5	101	123

WDRB_Word Attack						
Elision: CTOPP	34	7.6	7	7.0	7	8
Sound matching: CTOPP	35	8.1	8	8.0	6	9
Blending words: CTOPP	34	8.0	7	7.0	7	9