



Oral communicating children using a cochlear implant: Good reading outcomes are linked to better language and phonological processing abilities



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ABSTRACT

Introduction/objective: Cochlear implantation provides children with a significant hearing loss the potential to engage in phonological processing via audition; however these children can still have poor or inadequately detailed mental (phonological) representations of speech and as such phonological awareness and reading difficulties. Heterogeneous participant profiles, particularly varying modes of communication have clouded the research regarding reading outcomes of children using a cochlear implant. The objective of this study was to explore the relationships between word reading and reading comprehension outcomes, and a range of variables of a relatively homogenous group of children using cochlear implants.

Method: Forty-seven oral communicating children using a cochlear implant and who had attended auditory-verbal therapy served as participants. They were administered a comprehensive battery of 10 different assessments covering 22 different tasks across the domains of speech perception, speech production, language, phonological processing and reading. Correlation and principal component analyses were used to examine the relationships between outcome areas.

Results: Audiologic and demographic variables were not significantly related to reading outcomes, with the exception of family size. Language and word reading were most strongly related to reading comprehension, while phonological awareness and language were most strongly related to word reading. It is proposed that the development of well-specified phonological representations might underlie these relationships.

Conclusion: For oral communicating children using a cochlear implant, good reading outcomes are linked to better language and phonological processing abilities.

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1. Introduction

It is well-established that children with a significant hearing loss have experienced difficulties in the area of reading (e.g., [1,2]). Several studies suggest that cochlear implantation is associated with the improved reading outcomes (e.g., [3,4]) but that as a group, even children using a cochlear implant continue to perform below their peers with normal hearing on reading tasks [4–6]. Additionally, research with this population has reported large ranges in reading outcomes below to above the average range, both within a group of participants and across studies [4,5,7].

1.1. What makes a child a good reader?

Throughout the reading outcome literature many factors have been associated with good reading skills. For instance, in children with normal hearing, oral language has been linked with reading comprehension [8,9]. Word reading has been associated with children's phonological processing abilities (e.g., [10,11]), speech production [12] and the quality of children's underlying phonological representations [13]. The better each of these abilities, the better a child's reading. What about children who use a cochlear implant? Why do they as a group, perform below their hearing peers? In children using a cochlear implant many factors have been implicated in discussions about comprised and/or variable outcomes, such as:

- communication approach used [14]
- therapy approach [15,16]

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- educational placement [5]
- audiologic factors [5,6,14]
- demographic factors (e.g., gender [5], socioeconomic status [5,14])
- individual children's skills [5].

For a family wanting to know whether their child with a severe/profound hearing loss will learn to read as their same-age hearing peers, clear interpretation of this literature is difficult, because of the heterogeneity of children with a severe/profound hearing loss included in outcome research [17]. What is needed is a comprehensive evaluation of the range of factors associated with improved reading outcomes for children exposed to the same type of therapy, using the same communication mode, in similar educational placements. To date, no study has examined a wide range of factors (audiologic and demographic factors and child-specific skills) that may be associated to word reading and reading comprehension outcomes in a homogeneous population of oral communicating children using a cochlear implant who have followed an auditory-verbal approach in aural habilitation. This study addresses that need.

What follows is an overview of factors associated with reading outcomes in children. We consider two different yet important measures of reading – reading comprehension and word reading. The literature on children with normal hearing is considered alongside literature documenting the abilities of children with a significant hearing loss using cochlear implant.

1.2. Demographic and audiologic factors and associated with reading

In children with normal hearing, demographic factors have been associated with reading including gender, socioeconomic status, and mother's education level [18,19]. In children using a cochlear implant, the role of demographic variables has been mixed. For example, Geers [5] found that girls performed better than boys in reading. Whereas, Dillon and Pisoni [20] found no significant difference in the performance of boys and girls on reading tasks. Children from families of higher socio-economic status (SES) have been reported to achieve higher reading scores than those from lower SES [5,14]. In a series of studies by Geers and colleagues, children from smaller families had better outcomes in speech perception, speech production and language [21], but not reading [5].

A range of audiologic factors have also been associated with reading outcomes including age at first hearing aid fitting, age at implantation, length of implant use, speech processor device and programming strategy (e.g., [5,6,14]). It is thought that the earlier a child is aided and implanted, the better the outcome [17]. More recent or advanced speech processor devices and programming strategies are also thought to be associated with improved outcomes [5].

1.3. Child-specific skills associated with reading comprehension

In children with normal hearing the research has established a strong relationship between reading comprehension and oral language skills (e.g., [8]). Reading outcomes have also been related to language ability for children using a cochlear implant (e.g., [4–6,14]). However, this body of research has included children who use total communication as well as children who use oral communication. In the few studies that have only included oral communicating children, reading has been related to language skills, however only vocabulary rather than broader language skills has been measured and the measure of reading comprehension was limited to sentence level rather than text level [7,22]. It is possible that the relationship between language and reading

comprehension is different for different populations of cochlear implant users; those that are oral communicators who are more dependent on the processing of spoken language and those that use more visual based communication systems. It is also possible that children's reading comprehension performance varies when the requirements of the task change (e.g. text level reading comprehension versus sentence reading comprehension). The ability to comprehend written information is of course predicated on an assumption that the reader has the ability to read individual words.

1.4. Child-specific skills associated with word reading

The ability to read a single word is a complex process. In children with normal hearing, research has established a strong relationship between word reading and phonological processing (e.g., [18,23]). Phonological processing refers to the ability to encode speech, create, store and retrieve phonological representations. Phonological representations are abstract mental stores of information about spoken words [13]. Phonological processing is typically assessed via measures of phonological working memory, phonological retrieval and phonological awareness [24]. We elaborate and define each of these measures of phonological processing later in the introduction to this paper.

The cochlear implant has provided many children with a significant hearing loss, improved access to the speech signal and as such the opportunity to engage in phonological processing. In suggesting that children using a cochlear implant have the potential to engage in phonological processing, it is important to note that these children do not have 'normal' auditory access to the speech signal. It is possible that they can still have poor or inadequately detailed phonological (mental) representations of speech and consequent difficulties with phonological awareness and word reading. This is thought to be associated with their lower level perceptual difficulties as well as reduced opportunity to make sense of the phonological structure of their language prior to receiving a cochlear implant during optimum period for auditory neural modification (the first few years of life) [25].

The following section provides an overview of this concept of the phonological representation of speech, and explores the literature on each of the three areas of phonological processing (phonological working memory, phonological awareness and phonological retrieval). Literature about the abilities of children with normal hearing is considered first, followed by literature on children who use a cochlear implant.

1.5. Phonological representations in the lexicon

Phonological representations are conceived to be a long-term mental store of the phonological aspects of spoken words [13]. When a child hears a word they are thought to implicitly create a temporary auditory-perceptual representation of that word [23]. With the assistance of working memory this information is transformed into an abstract phonological (mental) representation, stored in the lexicon. Children's phonological representations are thought to become increasingly detailed as their vocabulary grows, so as to distinguish one word from another [26]. Using the basic tenets of Walley and Mestala's lexical restructuring hypothesis, representations start out as holistic in nature, then transform and become segmental [26]. As representations become segmental, children have sufficient detail in their representations to engage in phonological awareness tasks such as segmenting and blending the individual speech sounds or phonemes that make up words (e.g., separating 'cat' into three speech segments and blending the three individual sounds that make up the word 'cat'). This ability to reflect upon and manipulate phonological

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