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Nonword repetition and reading in deaf children with cochlear implants

Caitlin M. Dillon^{*} and David B. Pisoni

Speech Research laboratory, Department of Psychology, Indiana University, Bloomington, IN, 47405, USA

Abstract

In this study, we report analyses of nonword repetition responses from 76 experienced pediatric cochlear implants users. Nonword repetition performance reflects the participants' reliance on their phonological system, which has been found to be related to phonological awareness skills and reading in normal-hearing children. We found that nonword repetition performance was strongly correlated with several measures of reading readiness and reading in deaf children with cochlear implants. Correlations between nonword repetition performance and reading indicate that the children relied on their knowledge of phonology to complete the reading tasks.

Keywords

Nonword repetition; Reading; Phonological processing; Phonological awareness

1. Introduction

Studies of children in prereading and early reading stages often discuss “phonological awareness”, the extent to which the child is aware that individual words are composed of sequences of speech sounds (i.e., phonemes, syllables; [1]). Children who have developed phonological representations of the sounds of their ambient language can take greater advantage of such processes as “inner speech” [2] and verbal rehearsal processes in working memory [3] when learning to read. The extent to which deaf readers use phonological processing skills in visual word recognition and reading is not known [4]. In this study, we investigated the relationship between the children's performance on traditional reading readiness, single-word reading, and reading comprehension measures and an auditory-only task that measured their ability to perceive, encode, rehearse, and reproduce novel phonological patterns.

2. Method

2.1. Participants

The 76 children in this study participated in the Central Institute for the Deaf “Education and the Deaf Child” program in 1999 or 2000 [5,6]. Thirty-six were male and 40 were female. Seventy-four children used a Nucleus 22 and the SPEAK coding strategy. One child used a Nucleus 24, and one child used a Clarion CI. The children's demographic characteristics are shown in Table 1. Higher communication mode scores indicate an emphasis on Oral Communication. Lower scores indicate Total Communication.

2.2. Materials and procedure

The 20 target nonwords used in this study were balanced in terms of syllable number. The targets included 112 target consonants and 68 target vowels (see Table 2).

The children were asked to listen to and repeat aloud recordings of the nonwords spoken by a female native speaker of American English, played via loudspeaker at approximately 70 dB SPL. The target nonwords and children's attempted nonword repetitions were recorded and played back to normal-hearing adult listeners. On each trial, the listener heard the target nonword followed by a child's repetition. Listeners provided ratings of the child's response on a scale of 1 (poor) to 7 (perfectly accurate), which were used to calculate a mean accuracy rating per child [9].

Several measures of reading were administered to all children. The Word Attack subtest of the Woodcock Reading Mastery Tests—Revised (WRMT-R; [10]) includes 45 nonwords. Each child was asked to read aloud the nonwords one at a time. The Word Attack measured the child's "ability to apply phonic structural analysis skills to pronouncing words that are not recognizable by sight" [10]. The reading recognition subtest of the Peabody Individual Achievement Test—Revised (PIAT-R; [11]) includes four alternative forced choice questions with a pointing response designed to test reading readiness skills and single-word reading [12]. The reading comprehension subtest of the PIAT-R includes 82 meaningful narrative sentences designed to test literal reading comprehension. For each item, the child was asked to silently read a sentence and point to one of four pictures that best represented the sentence. Lastly, the children participated in a Rhyming Task [6], in which they were asked to state whether or not a pair of words rhymed.

Grade Equivalent Scores were determined for Word Attack [13], the reading recognition, and reading comprehension tasks [12]. A Total Reading standard score was also calculated for each child; the child's raw scores on the two PIAT-R reading subtests were summed and converted to a standard score [12]. The Rhyming task was scored by the percentage of word pairs for which the child responded incorrectly [6].

3. Results

In the nonword repetition task, all of the children in this study provided a response to at least 15 of the 20 nonword stimuli. The children's responses varied in terms of mean perceptual accuracy rating (range=1.1 to 5.7, mean=3.1, S.D.=1.1; [9]).

A summary of the children's scores on the reading measures is given in Table 3. Seventeen children (22%) scored above the fourth-grade level on the Word Attack, two children (3%) on reading recognition, and eight children (11%) on reading comprehension. Ten children (13%) scored below the first-grade level on at least one of the Word Attack, reading recognition, and reading comprehension tasks. Fifty-three children (70%) had Total Reading standard scores within the normal range for children their age. The remaining 23 children (30%) had Total Reading standard scores below the normal range for children their age (based on norms from Markwardt [12]).

In addition, we found that the children's nonword repetition performance was correlated with scores on the reading tasks (Table 3), even after potentially confounding demographic factors were partialled out (age at onset of deafness, communication mode, and performance IQ [14]; see Refs. [6,9]).

4. Discussion and conclusions

In summary, most of the deaf children with cochlear implants could successfully complete the nonword repetition task, which requires immediate and rapid phonological processing. The deaf children with cochlear implants in this study demonstrated higher-level reading skills than have traditionally been reported in deaf children [15]. Nonword repetition performance was correlated with measures of reading readiness (such as letter–sound correspondences and rhyme recognition), single-word reading, nonword reading, and written-sentence comprehension.

The correlation between the children's nonword repetition performance and their performance on PIAT-R reading comprehension suggests that the children who were better able to decompose and reassemble an auditorily-presented nonword for spoken reproduction were also better able to comprehend meaningful written sentences. The correlations found in this study indicate that the children were utilizing phonological processing skills in order to complete these reading tasks. The children's ability to use abstract phonological representations contributed to their reading readiness and reading skills, perhaps due to their use of processes such as inner speech [2] and verbal rehearsal [3,9].

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Table 1

Summary of the demographic makeup of the 76 children

Demographic variable	Range	Mean	Standard deviation
Age at onset of deafness (months)	0–36	2.3	6.4
Duration of deafness (months)	7–65	37.2	13.1
Age at implantation (years)	1.9–5.4	3.3	1.0
Duration of implant use (years)	3.8–7.5	5.6	0.8
Chronological age (years)	7.8–9.9	8.9	0.6
Number of active electrodes	8–22	18.4	2.3
Communication mode score	6–30	19.8	7.7

Table 2

The 20 nonwords used in this study (adapted from Gathercole et al [7]; see also Ref. [8])

Number of syllables			
2	3	4	5
Ballop	Dannifer	Comisitac	Altupatory
Prindle	Bernzen	Contramponist	Detratapillic
Rubid	Doppolate	Emplifervent	Pristeractional
Sladding	Glistering	Fennerizer	Versatrational
Tafflist	Skiticull	penneriful.	Voltularity

Table 3

Reading measure scores; simple bivariate correlations with nonword repetition mean accuracy ratings, and partial correlations with nonword repetition accuracy ratings in which age at onset of deafness, communication mode, and performance IQ have been partialled out

Reading measure	Mean (S.D.)	Range	Bivariate r	Partial r
WRMT Word Attack	3.3 (2.8)	0.0–12.6	+0.61 ***	+0.49 ***
PIAT recognition	2.9 (1.0)	0.4–6.1	+0.57 ***	+0.50 ***
PIAT comprehension	2.9 (1.5)	0.0–8.7	+0.43 ***	+0.41 ***
PIAT total reading	87.6 (6.5)	72–106	+0.59 ***	+0.55 ***
Rhyme errors	12.4(7.2)	0–37	−0.37 **	−0.29 *

*
 $p < 0.05$.

*
 $p < 0.01$

 $p < 0.001$.