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Lexical Discrimination and Age of Cochlear Implantation: A First Report[1]

Karen I. Kirk[2] and David B. Pisoni

Speech Research Laboratory
Department of Psychology
Indiana University
Bloomington, Indiana 47405

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[2] Also Department of Otolaryngology-Head & Neck Surgery, Indiana University School of Medicine, Indianapolis, IN.

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Abstract. This paper examines the effects of age at time of implantation on word recognition and word discrimination by two groups of prelingually deafened pediatric cochlear implant (CI) users. An 'early' group consisted of children receiving implants at earlier than 6 years of age, while a 'late' group was implanted at 6 years or later. Both groups were tested on both lexical discrimination tasks (LNT, MLNT) and language measures (PPVT, Reynell). For monosyllabic words, significant age effects were found for both word and phoneme recognition, while significant effects of lexical difficulty were found for word recognition but not phoneme recognition. Similar results obtained for multisyllabic words, although there was no effect of lexical difficulty on either word or phoneme recognition. In addition, word recognition was moderately correlated with some measures of receptive and expressive language abilities in both the early CI and late CI groups. These preliminary findings suggest that early implantation produces better word recognition performance in young, prelingually-deafened children and that children who are better at making fine discriminations among phonetically similar words also exhibit better language skills.

Introduction

Recent research (e.g., Waltzman et al., 1994) suggests that prelingually-deafened children who receive a cochlear implant (CI) at an early age (i.e., before age 5-6 years) may obtain greater speech perception and language benefits than those children implanted at a later age. There are at least two accounts of this advantage. First, children implanted at an early age may still be within the critical period for the acquisition of spoken language skills. Second, because these children had briefer amounts of auditory deprivation, they have had more listening experience than their peers who were implanted at a later age. Both of these explanations would predict differences in the word recognition abilities of children implanted at earlier vs. later ages -- specifically improvements in lexical discrimination performance. That is, we predict that children who receive a CI prior to six years of age will demonstrate better word recognition performance, and will also be better at making fine lexical discriminations among phonetically similar words than children who are implanted at or after six years of age.

Purpose

The goals of the present investigation were:

1) To examine the effects of age at time of implantation on word recognition and lexical discrimination by pediatric cochlear implant users, and

2) To investigate the relationship between lexical discrimination and language skills in pediatric cochlear implant users.

Method

Subjects

Two groups of pediatric cochlear implant users participated as subjects in this investigation. All subjects were prelingually deafened (i.e., < 3 years) and received a cochlear implant because they essentially derived no benefit from conventional amplification. The *early group* consisted of 25 children who received their cochlear implant between the ages of 2.0 and 5.9 years. The *late group* consisted of 12 children who received their cochlear implant between the ages of 6.0 and 8.9 years. Subject characteristics are presented in Table 1 and device characteristics in Table 2.

Table 1

Subject Characteristics

	Early CI Group N=25		Late CI Group N=12	
	Mean	(SD)	Mean	(SD)
Age at Onset (yrs)	0.3	(0.7)	0.4	(0.6)
Age Fit with CI (yrs)	4.3	(0.9)	7.2	(1.1)
Length of Auditory Deprivation (yrs)	4.0	(1.2)	6.9	(1.1)
Age at Time of Testing (yrs)	7.9	(2.1)	9.9	(2.7)
Length of CI Use (yrs)	3.5	(1.9)	2.7	(2.1)
Unaided PTA (dB HL)	>110		>110	
Communication Mode	TC =13 Oral = 12		TC = 6 Oral = 6	

Stimulus Materials

Lexical Discrimination Tasks. The Lexical Neighborhood Test (LNT) and the Multisyllabic Lexical Neighborhood Test (MLNT) (Kirk, Pisoni & Osberger, 1995) are word lists constructed to allow systematic examination of the effects of word frequency (i.e., the frequency of occurrence of each word) and lexical difficulty (i.e., the number of phonemically similar words or neighbors to a target, as determined by counting the number of words that can be generated by adding, subtracting, or deleting a single phoneme) on spoken word recognition in children. The LNT contains two lists of 50 monosyllabic words, and the MLNT contains two lists of 30 two- and three-syllable words. Each test has an equal number of easy and hard words. Easy words have high word frequency and have few phonemically similar words with which they can be confused. Hard words have low word frequency and have more phonemically similar neighbors. The percent of words and phonemes correctly identified is determined separately for easy and hard words.

Table 2

Device Characteristics

	Early CI Group N=25	Late CI Group N=25
Processor Type	WSP = 0 MSP = 10 Spectra = 15	WSP = 1 MSP = 5 Spectra = 6
Processing Strategy	F0F1F2 = 0 MPEAK = 10 SPEAK = 15	F0F1F2 = 1 MPEAK = 5 SPEAK = 6
Stimulation Mode	CG[a] = 10 BP [b] = 3 BP+1[c] = 7 BP+2[d] = 3 BP+3[e] = 2	CG[a] = 8 BP [b] = 0 BP+1[c] = 3 BP+2[d] = 1 BP+3[e] = 0
Number of Active Electrodes	13-22	5-22

[a] Common Ground, [b] Bipolar, [c] Bipolar + 1, [d] Bipolar + 2, [e] Bipolar + 3

Language Measures. The *Peabody Picture Vocabulary Test* (Dunn, 1965) was used to assess receptive vocabulary skills in both groups. The single-word stimuli were presented in the child's communication mode, along with a written and/or signed representation, as appropriate. Children responded by pointing to one of four words pictured on a single plate, and a receptive vocabulary age was determined for each child.

The *Reynell Developmental Language Scales - Revised* (Reynell & Huntley, 1985) is a measure designed for normally-hearing children ages 1-7 years. The test is organized in a hierarchy of difficulty, utilizing a variety of question forms, and yields both a receptive and expressive language quotient (language age/chronological age).

Procedures

All subjects were tested in a quiet room, seated across a table from the examiner. Stimuli were presented via live voice at approximately 70-75 dB SPL by one of five experienced audiologists or speech-language pathologists. Language assessments were carried out in the childs communication mode, either Total Communication using Signed English, or orally; written cues also were provided during vocabulary assessment. Word recognition/lexical discrimination was assessed in the auditory-only modality. Children responded by repeating the word they heard. If the child's verbal response could not be understood, it was phonemically transcribed and scored; no credit was given for word recognition.

Results

Spoken Word Recognition / Lexical Discrimination

Figures 1 and 2 present the percent of words and phonemes correctly identified on the LNT and MLNT. Separate two-way analyses of variance were performed for each test, with word and phoneme scores as the dependent measures and age at implantation and lexical difficulty as the independent variables. Because of the relatively small number of subjects in the Late implantation group, alpha levels between .05-.1 were considered marginally significant.

Insert Figures 1 and 2 about here

Monosyllabic Stimuli (LNT). Results from administration of the Lexical Neighborhood Test were as follows:

- Significant effects of age at time of implantation were found for both monosyllabic word and phoneme recognition. The average scores for the Early and Late groups were 40% vs. 29% for word identification ($p < .06$), and 60% vs. 48% for phoneme identification ($p < .07$).

- Significant effects of lexical difficulty were found for word recognition ($p < .02$) but not for phoneme recognition. On average, 40% of the Easy words and 30% of the hard words were correctly identified. The percent of phonemes correctly identified in the Easy and Hard words was 56% vs. 52%, respectively.

- The interactions between age at implantation and lexical difficulty for word or phoneme recognition were not significant.

Multisyllabic Stimuli (MLNT). Results from administration of the Multisyllabic Lexical Neighborhood Test were as follows:

- The effects of age at implantation were significant for both multisyllabic word ($p < .02$) and phoneme ($p < .007$) recognition. Average scores for the Early and Late groups respectively were 56% vs. 40% for word identification, and 70% vs. 53% for the phoneme identification.

- There was no effect of lexical difficulty on multisyllabic word or phoneme recognition, and no interaction between age at implantation and lexical difficulty.

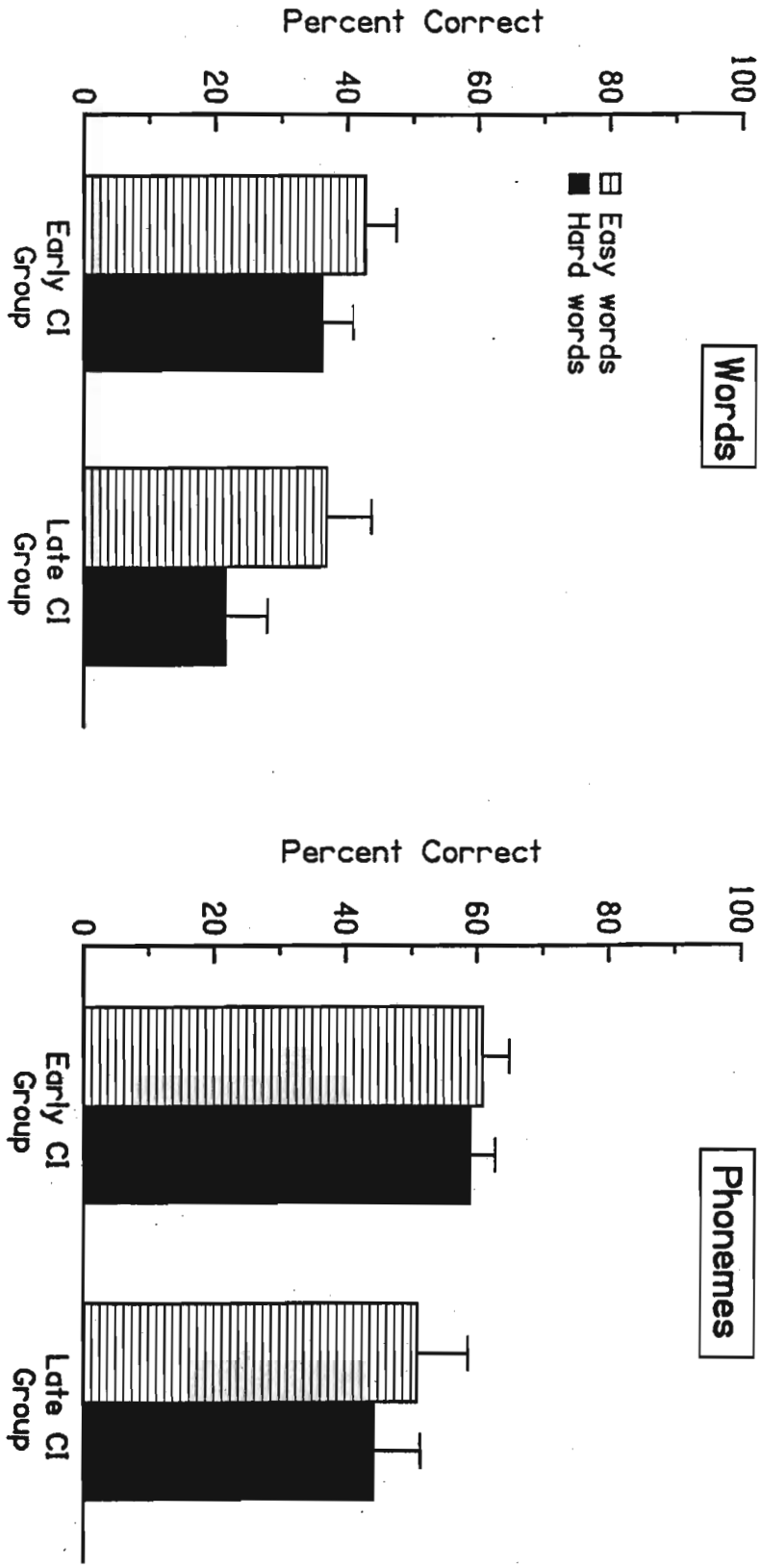

Figure 1. The percent of monosyllabic words and phonemes correctly identified as a function of age at time of implantation and lexical difficulty.

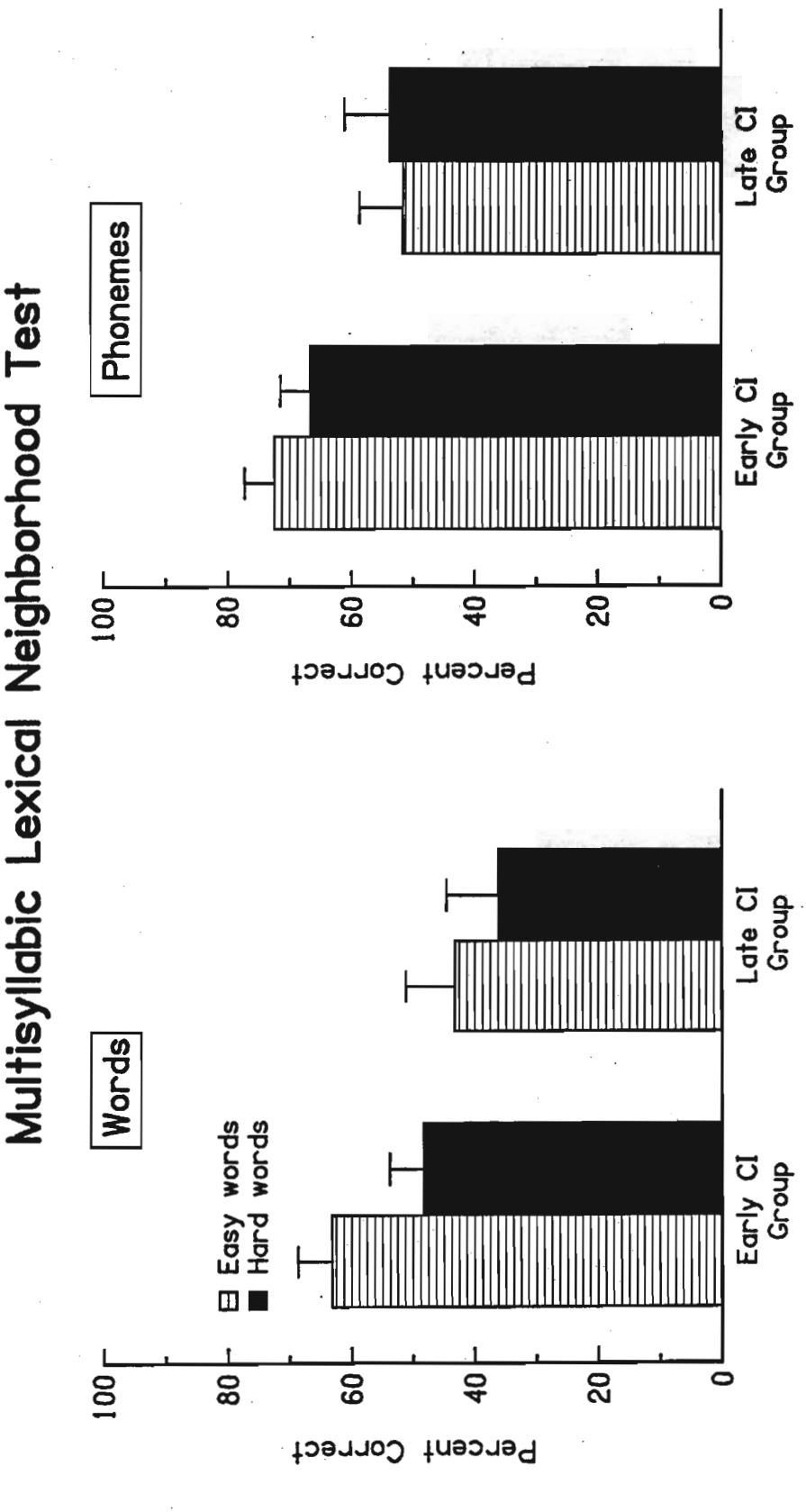

Figure 2. The percent of multisyllabic words and phonemes correctly identified as a function of age at time of implantation and lexical difficulty.

Correlations with Language Measures. To examine the relationship between word and language abilities, performance on the LNT and MLNT was correlated with the language quotients derived from the PPVT and the receptive and expressive portions of the Reynell Language Development Scales, as shown in Table 3. Only 15 children from the Early CI group were included in this analysis as the remaining had not been tested with the Reynell. The results demonstrated:

• Early CI Group - Performance on the Reynell Developmental Language Scales was moderately correlated with performance on the LNT Easy words ($r = +.43$ for both expressive and receptive quotients, not significant) and MLNT Hard words (receptive: $r = +.58$, $p < .02$; Expressive: $r = +.50$; $p < .06$). There was no relationship between performance on the PPVT and word recognition for this group of subjects.

• Late CI Group - The PPVT language quotient was moderately correlated with performance on the LNT Hard words ($r = +.55$) and the MLNT Hard words ($r = +.49$), but only the former was marginally significant ($p < .07$).

Table 3

Correlations of word recognition and language measures by age at time of implantation.

	Early CI Group (N=15)			Late CI Group (N=12)
	PPVT	Reynell - Expressive	Reynell - Receptive	PPVT
LNT - Easy	.07	.43	.43	.24
LNT - Hard	.14	.39	.35	.55# #(p<.07)
MLNT - Easy	-.02	.35	.34	.27
MLNT - Hard	.08	.50* *(p < .06)	.58+ +(p < .02)	.49

Discussion

These preliminary findings suggest that early implantation (i.e., by age 5 years) produces better word recognition performance in young prelingually-deafened children. Children in the early CI group had higher average word recognition scores, and were better at identifying lexically difficult words, than children who received their CI after 5 years of age.

Lexical factors influenced word recognition performance, but not phoneme recognition. Easy words were identified with significantly greater accuracy than Hard words, but this was significant only for monosyllabic words, possibly because of the small numbers of subjects tested in the Late CI group. The finding that Easy words were identified with greater accuracy than Hard words on the LNT is in agreement with the earlier results of Kirk et al. (1995).

Word recognition was moderately correlated with some measures of receptive or expressive language abilities for subjects in the Early and Late CI groups. The strongest correlations were found for the Hard words on the LNT and MLNT tests. Thus, the present findings suggest that that children who are better at making fine discriminations among phonetically-similar words stored in their lexicons are also those with better language skills. Word recognition is an important component of spoken language processing, as it represents the interface between sensory input and linguistic knowledge. In other words, it represents the interface between speech perception and spoken language comprehension.

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