The Effect of Word Length on Nonword-Repetition Accuracy For Children with Cochlear Implants vs. Children with Typical Hearing across Time

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Introduction

Children with cochlear implants (CIs) perform more poorly than children with typical hearing (TH) on nonword repetition (NWR) tasks – for many possible reasons. Accurate repetition of heard nonwords requires good perceptual acuity, good manipulation of phonological representations of speech sounds which, in turn, requires good: perceptual and phonological encoding, short-term working memory (STWM), and speech production. Here, the effect of short-term working memory on NWR performance is examined for children with CIs and TH; NWR accuracy is examined *longitudinally*, and by number of syllables in the nonword: long (4 & 5 syllable) vs. short (2 & 3 syllable) nonwords.

1) Prediction re: *longitudinal* effects – the NWR accuracy of all children, with CIs and with TH, will improve as children develop.
2) Hypothesis re: short-term working memory (STWM) – due to the degraded speech signals in their phonological processing, children with CIs will have poor WM; and increasing syllable length will decrease CI children's NWR accuracy even more than seen in children with typical hearing (TH).

Participants & Methods

Participants:
- 38 typical hearing (TH) children
  - Session 1: mean age 6.7 years, SD 1.3 years
  - Session 2: mean age 8.7 years, SD 1.3 years
- 101 children with two CIs or bimodal devices (CI+ HA)
  - Session 1: mean age 7.0 years, SD 1.3 years
  - Session 2: mean age 9.0 years, SD 1.3 years
  - using oral communication
  - prelingually deaf
- All with normal cognitive function

Methods (at both Sessions 1 and 2):
NWR: Child heard 20 prerecorded nonwords.
- Nonwords presented via audio speaker, at 65 dBA in the sound field
- Five nonwords each with 2, 3, 4 and 5 syllables
- Child's verbal responses (imitations) were recorded and transcribed for accuracy, defined as 'percent correct phonemes' in the nonword

STWM: The CELF forward digit-span subtest was administered.
- Child heard a string of single-digit numbers presented via live-voice.
- If the child repeated the string correctly, subsequent strings of numbers were longer until the child failed to repeat the string correctly. The final digit-string length was converted to a scaled score, by age.

A three-way ANOVA was performed with NWR accuracy as the dependent variable. Factor 1 was hearing status (CI, TH), factor 2 was test session (Session 1, Session 2), and factor 3 was syllable-length (short, long).

STWM Results: Forward Digit-Span (CELF) Scaled Scores

	Cochlear Implants		Typical Hearing	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Session 1	9.50	3.35	10.39	2.62
Session 2	9.41	3.23	10.16	3.05

There are no statistically significant differences in Forward Digit-Span (CELF) scaled scores across test sessions (Session 1 vs Session 2) (F=0.41, p = 0.524), or between participant groups (TH vs CI) (F=2.27, p=0.134).

NWR Accuracy Results: Main Effects of Hearing Status & Word Length

First, **hearing status** is a statistically significant main effect; children with TH have higher NWR phoneme percent-correct scores than do children with CIs (F=54.7, p<.001).

Syllable length is also a statistically significant main effect. As seen in Figure 1 for both groups of children, NWR accuracy was better for short than for long nonwords. Syllable length impacted both groups similarly: **children with CIs were not disproportionately affected by nonword length compared to children with TH** (F=0.88, p=.351).
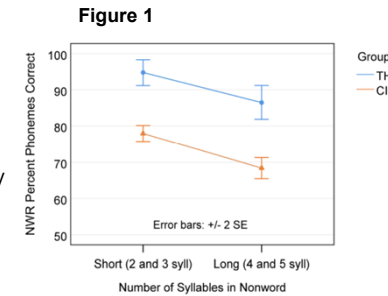
Figure 1

NWR Accuracy Results: Interaction of Session x Hearing Status

Figure 2
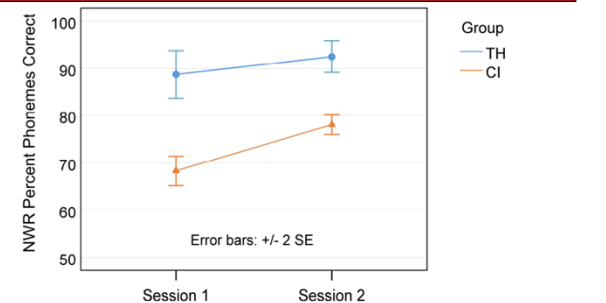
Again, children with CIs have poorer NWR accuracy than children with TH. At Session 1, mean accuracy for children with CIs was 67% (short words: 73%, long words: 64%) while it was 88% for children with TH (short words: 93%, long words: 85%). At Session 2, CI children's mean accuracy increased to 77% (short words: 83%, long words: 73%), and TH children's mean accuracy increased to 92% (short words: 97%, long words: 88%). And, there is a statistically significant interaction between session and hearing status (F=11.4, p<.001), as seen in Figure 2.

SUMMARY:
1) Longitudinal Prediction: As predicted, both groups' NWR accuracy improves from Session 1 to 2. The amount of improvement, however, depends on hearing status.
2) STWM Hypothesis: Contrary to our prediction, there is no significant interaction between hearing status and syllable length. That is, all children's NWR accuracy is poorer for long than for short nonwords, and declines similarly.

Although children with CIs score lower overall, a similar decline in NWR accuracy was observed for both groups of children as word length increased. While children with CIs show an overall deficit, these data show that increasing syllable length affects both groups similarly. This would suggest that CI children's primary deficit is related to poor perceptual acuity, due to the degraded signals from CIs (Dillon et al. 2004).

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