The Influence of Phonotactic Probability on Repetition Accuracy of Nonwords by Children with Cochlear Implants

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INTRODUCTION

• Children with cochlear implants (CIs) may have poorer phonological representations of words than children with normal hearing (NH).

• Repetition tasks with nonwords that vary in phonotactic probability provide a way to evaluate the robustness of phonological representations.

  • Phonotactic probability: the frequency of occurrence of sounds and sound sequences in words in a language.

  • Children with NH produce sound sequences with high phonotactic probability more accurately than sound sequences with low phonotactic probability suggesting that their phonological representations of words influence their ability to produce nonwords.

• If children with CIs have poorer phonological representations of words, children with CIs may show a weaker relationship between phonotactic probability and nonword repetition accuracy than children with NH.

PARTICIPANTS

• 4- to 5-year-olds with CIs (N = 20)
  • bilateral implants
  • age at implantation of 1st CI:
    • max: 2;11 (years;months)
    • mean: 1;5
  • duration with at least one implant:
    • min: 1;5
    • mean: 3;7

• 3- to 5-year-olds with NH (N = 31)
  • passed a hearing screening.

• All children:
  • monolingual English speakers
  • participants in larger studies

• Children with cochlear implants (**CI**) were compared to two groups of children with normal hearing.
  • children matched on age (**NH-age**)
  • children matched on receptive vocabulary age (**NH-voc**)
  • Some children with NH were in both comparison groups.

| Group	N	Male	Mean age	Mean vocabulary age equivalence
CI	20	11	5;1 (0;7)	4;10 (1;9)
NH-age	20	11	5;0 (0;7)	6;0 (1;3)
NH-voc	20	11	4;5 (0;9)	4;11 (1;2)

STIMULI

• 2 and 3 syllable nonwords e.g., /dɪsɛm/, /kjonədrok/

• Pairs of nonword-initial CV/CCVs differed in phonotactic probability.

Low probability		High probability	
/du/	(-6.18)	/di/	(-3.94)
/ku/	(-6.82)	/kɑ/	(-3.75)
/twɑ/	(-9.18)	/twi/	(-7.23)
/kjo/	NA	/kju/	(-6.69)

• Each CV/CCV occurred in 3 nonwords.

• Calculation of phonotactic probability:
  • Natural log of the proportion of words in the Hoosier Mental Lexicon (19,321 words) which began with that CV/CCV
  • e.g., /di/ as in /dibɪkruz/, ln(376/19321) = -3.94

• Each child repeated nonwords from 1 of 3 lists
  • Across lists, nonword endings (sounds which followed the initial CV/CCV) were appended to different CV/CCVs.
  • Across lists, the order of nonwords differed.

• Audio recordings were made of an adult female native English speaker saying the nonwords in a child-directed speech register.

PROCEDURE

• The nonwords were presented to the children over speakers.
• A color photograph of a novel object, animal, or plant was presented on a computer screen as the child heard the auditory presentation of the nonword.
• Children's productions of the nonwords were recorded.

/twɑzɪkrætʃ/
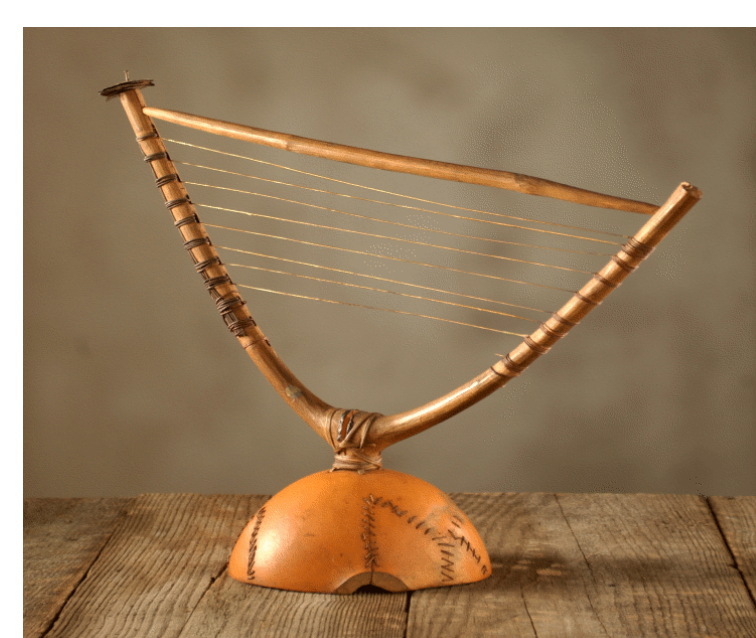
• Standardized tests:
  • *Peabody Picture Vocabulary Test, 4th edition* (children with CIs)
  • *Receptive One Word Picture Vocabulary Test, 2nd edition* (children with NH)

ANALYSIS

• Accuracy of initial consonants (Cs) and consonant clusters (CCs) was scored by a trained adult native English speaker.

• Interrater reliability for the children with CIs and the children with NH was 84% and 87%, respectively.

• Likelihood ratio tests were used to assess the statistical significance of fixed effects in predicting accuracy within mixed-effects logistic regression models with random intercepts for participants and item pairs. Tests statistics were compared to a chi-squared distribution with df = 1.

RESULTS

Do children with CIs differ from children with NH in how phonotactic probability relates to nonword repetition accuracy?
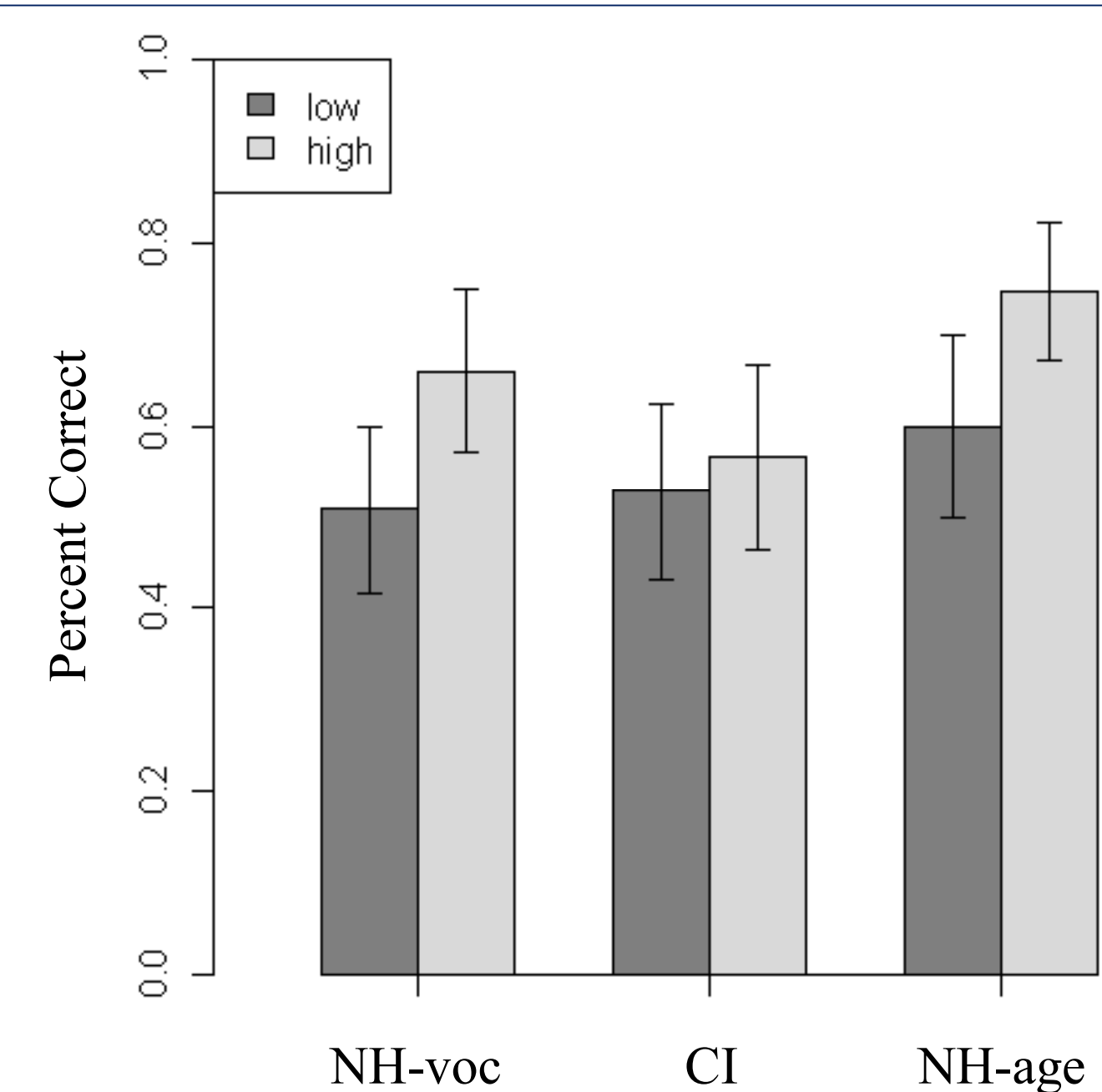

Vocabulary matches:
Group, N.S.
Phonotactic probability, N.S.
Interaction, *p* = .058

Age matches:
Group, N.S.
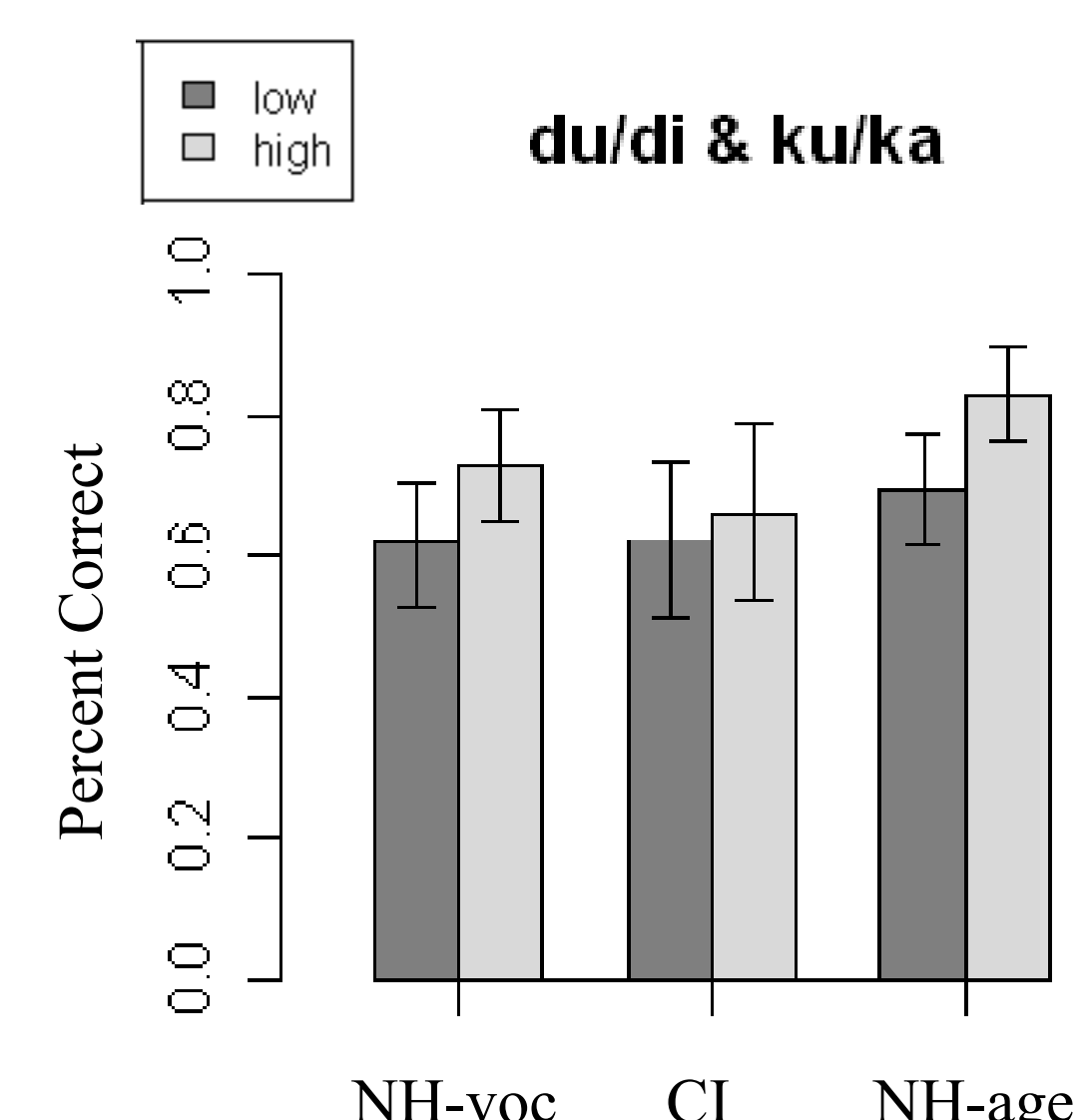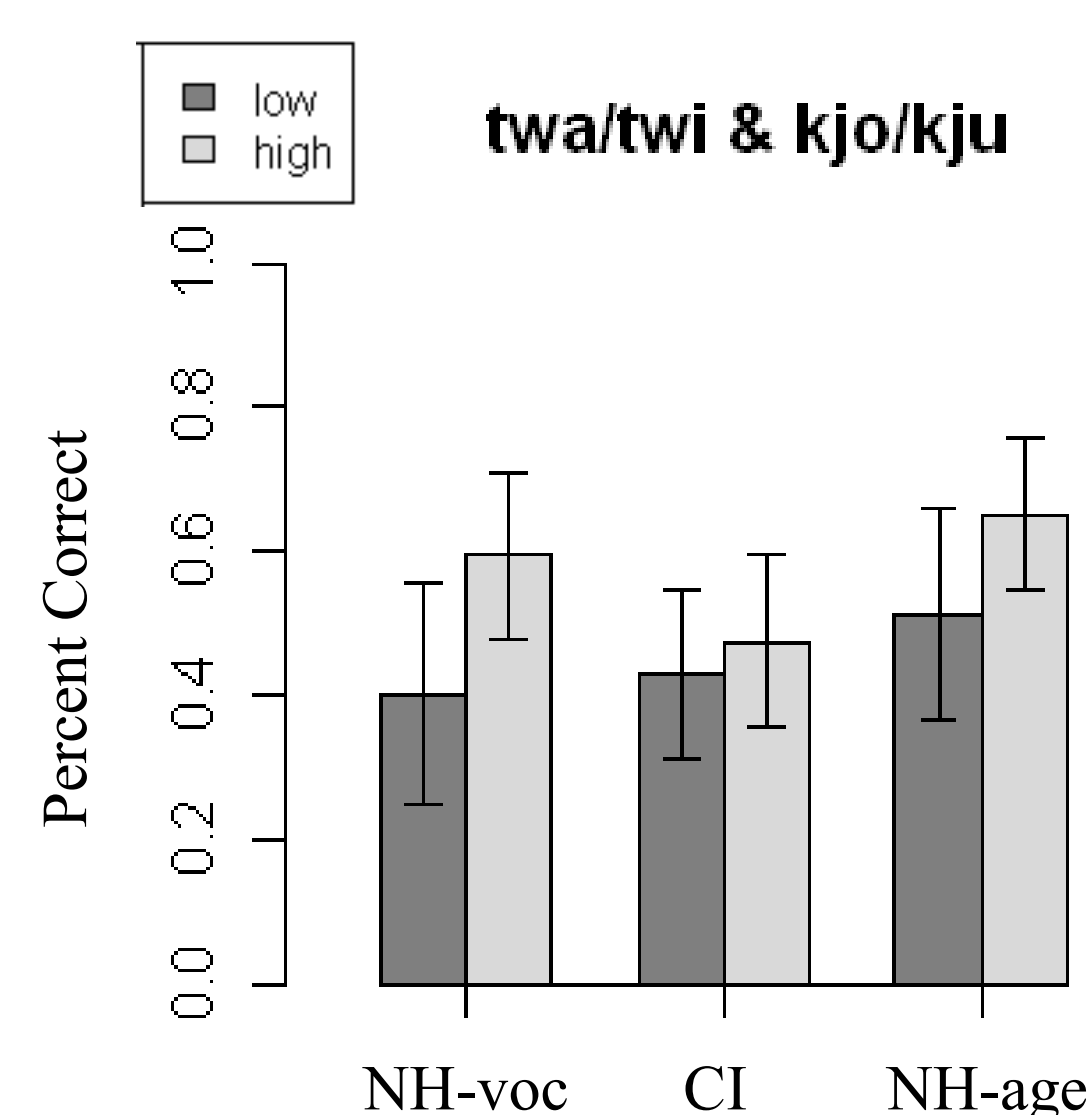Phonotactic probability, N.S.
Interaction, *p* = .053

Figure 1. Repetition accuracy of C/CCs in syllables with high and low phonotactic probability in nonwords. Error bars show standard errors.

/d/ and /k/
Interactions, N.S.

Vocab. matches:
Group, N.S.
Phon. prob., N.S.

Age matches:
Group, *p* = .051
Phon. prob., *p* = .03

Figure 2. Repetition accuracy of Cs in syllables with high and low phonotactic probability in nonwords. Error bars show standard errors.

/tw/ and /kj/
Interactions, N.S.

Vocab matches:
Group, N.S.
Phon. prob., *p* =.02

Age matches:
Group, N.S.
Phon. prob., *p* =.04

Figure 3. Repetition accuracy of CCs in syllables with high and low phonotactic probability in nonwords. Error bars show standard errors.

Do children with CIs with larger receptive vocabularies differ from those with smaller vocabularies in how phonotactic probability relates to nonword repetition accuracy?

Vocabulary group, *p* = .003
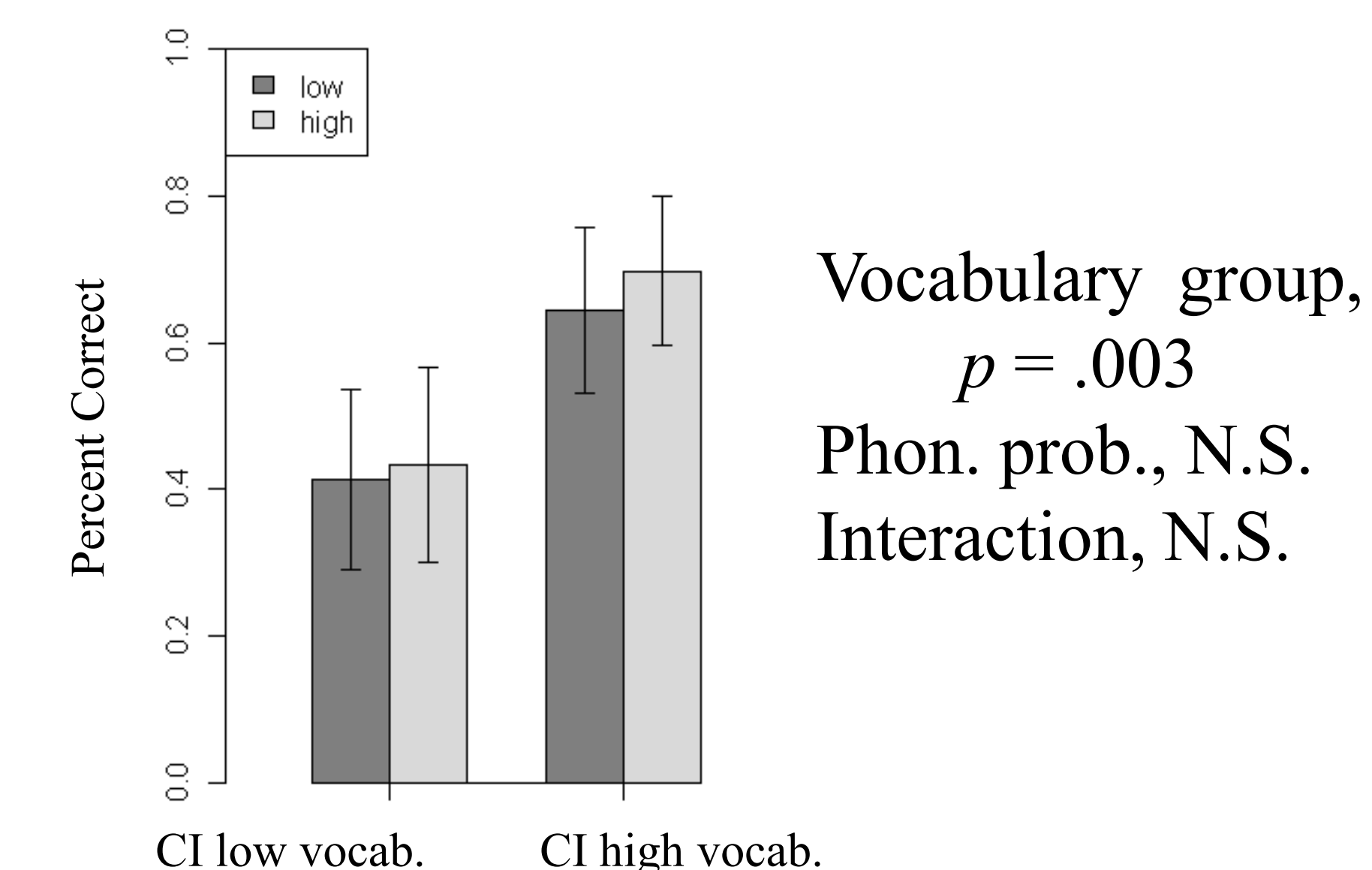Phon. prob., N.S.
Interaction, N.S.

Figure 4. Repetition accuracy of C/CCs in syllables with high and low phonotactic probability in nonwords for children with CIs with smaller receptive vocabulary ages and children with CIs with larger vocabulary ages. Error bars show standard errors.

Do children with CIs differ from children with NH in how receptive vocabulary size relates to nonword repetition accuracy?
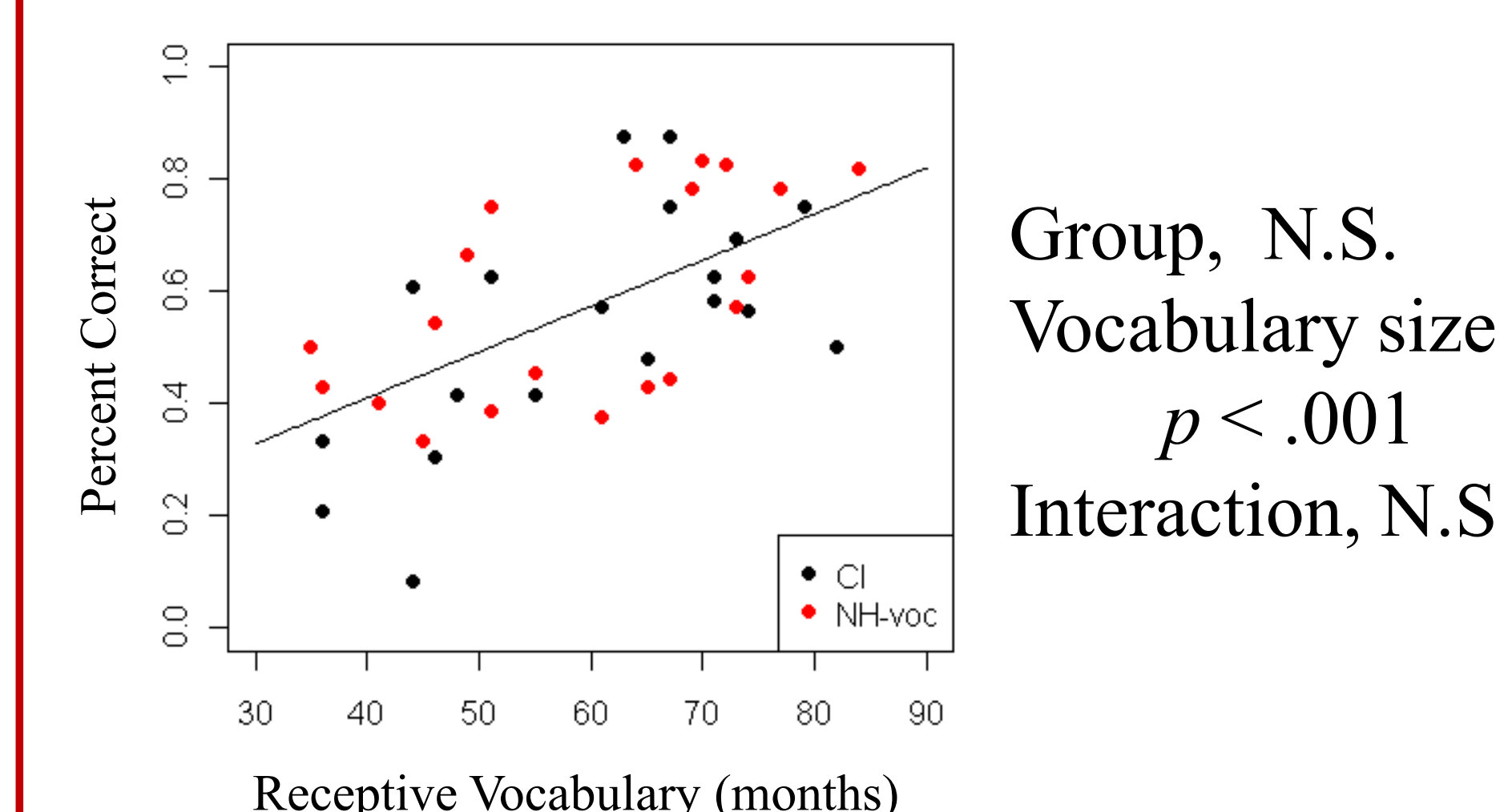

Group, N.S.
Vocabulary size, *p* < .001
Interaction, N.S.

Figure 5. Repetition accuracy for C/CCs in nonwords in relationship to receptive vocabulary age.

CONCLUSIONS

• The children with CIs relative to the children with NH, tended to benefit less from high phonotactic probability in production of nonwords.
  • Interactions between group and phonotactic probability approached significance.
• Receptive vocabulary size was not significant in predicting a difference in the effect of phonotactic probability on nonword repetition accuracy for the children with CIs.
• Similar relationships between receptive vocabulary size and overall nonword repetition accuracy were found for the children with CIs and the children with NH.