CARL VON OSSIETZKY universität OLDENBURG

Vowel recognition in noise

A comparison of children with cochlear implants and their peers with typical hearing

Marcel Schlechtweg, Mark Gibson, Judit Ayala, Xianhui Wang & Li Xu

Research question

How do **children with bilateral cochlear implants (CIs)**, in comparison to their peers with typical hearing (TH), perceive the five Spanish **vowels** [a], [e], [i], [o], and [u] in different types of **adverse listening conditions**?

Participants

- 7 children with bilateral CIs and 7 children with TH
- Matched for hearing age and biological sex
- Monolingual native speakers of Spanish

Table 1. Further characteristics of the children

Age (in years; months). Abbreviations: HA = Hearing age; AoFI = Age of first implantation

	Children with CIs	**Children with TH**
Age range	5;10 – 13;2	6;0 – 10;1
mean (SD)	8;11 (2;11)	7;6 (1;10)
HA range	4;11 – 11;10	6;0 – 10;1
mean (SD)	7;6 (2;10)	7;6 (1;10)
AoFI range	0;8 – 2;5	-
mean (SD)	1;5 (0;9)	-

Materials

- Five syllables [da], [de], [di], [do], [du]
- Spoken by one female and one male Spanish-speaking adult
- Embedded in two types of noise
  - Multi-speaker background babble (six speakers) (informational masker)
  - Speech-shaped noise (energetic masker)
- Three SNRs (0, 6, 12)

Procedure

- Matlab-based test
- Five syllables presented on a computer screen
- Selection of syllable children heard
- 240 trials (5 vowels x 2 noise types x 3 SNRs x 2 speakers x 4 presentations each)
- Random distribution

Analysis I

- Descriptive analysis plus binomial logistic regression in R (R Core Team 2021), using the packages lme4 and lmer Test (Bates et al. 2015; Kuznetsova et al. 2017)

- Tukey tests (Lenth 2020)

- Response variable = Accuracy (in %)

Analysis I

- Fixed effects
  - Group (children with CIs, children with TH)
  - Vowel ([a], [e], [i], [o], [u])
  - NoiseType (babble, speech-shaped)
  - SNR (0, 6, 12)
- Random effect = Intercept by Participant
- First model = Only main effects
- Second model = With all possible two-way interactions

Analysis II

- Error type analysis (types of vowel confusions)

Results

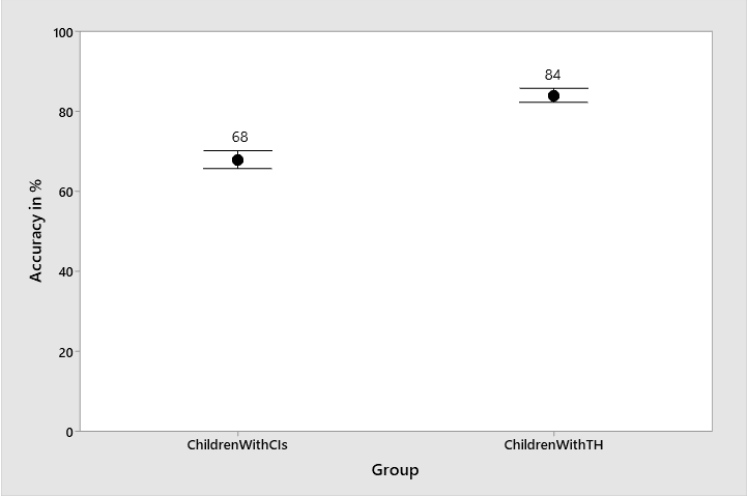

Figure 1. Main effect of Group

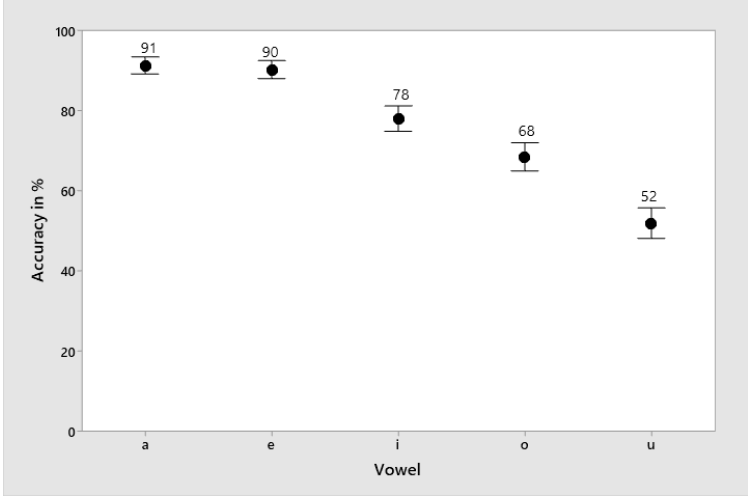

Figure 2. Main effect of Vowel

All comparisons significant except for [a] vs. [e]

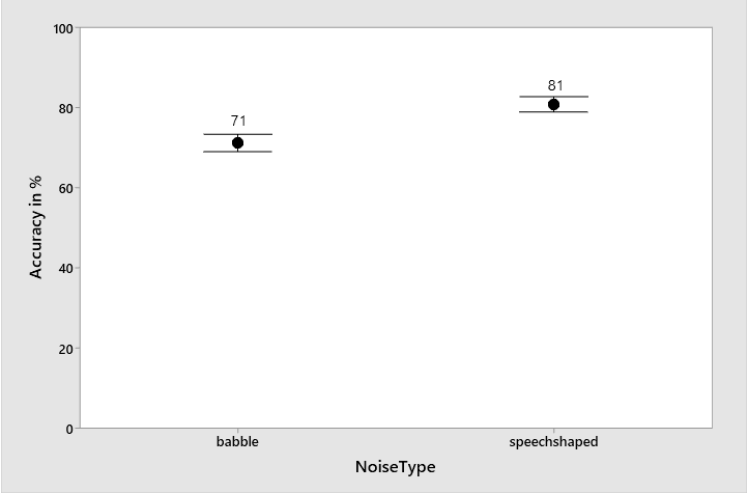

Figure 3. Main effect of NoiseType

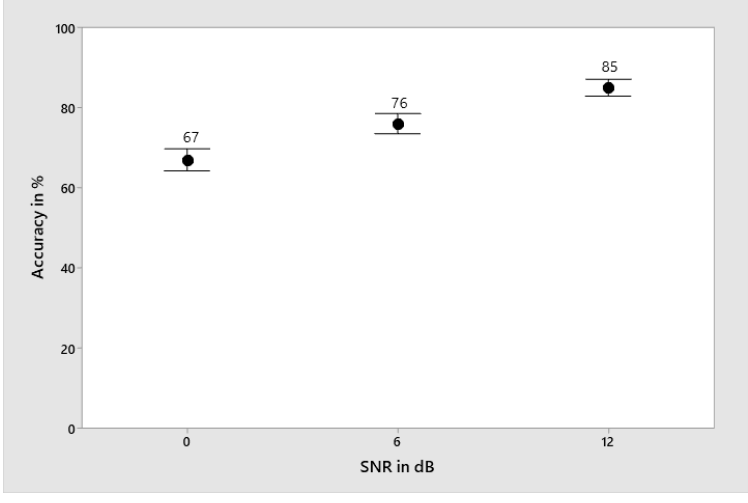

Figure 4. Main effect of SNR

All comparisons significant

Results

Significant interaction

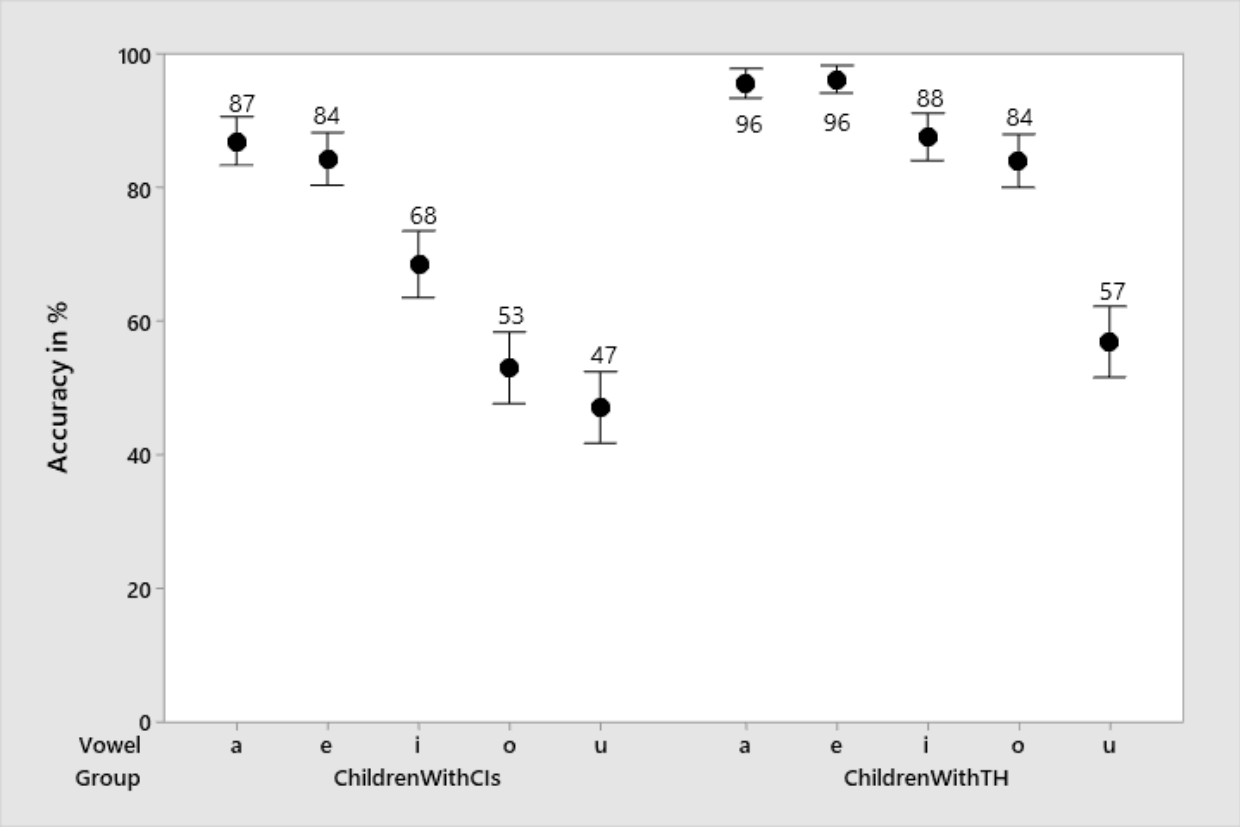

Figure 5. Interaction of Group and Vowel

- With the exception of [a] and [u], children with CIs responded significantly less accurately than children with TH
- Children with CIs only: Significantly higher accuracy for [i] than for [o]
- Children with TH only: Significantly higher accuracy for [o] than for [u]

Results

Significant interaction

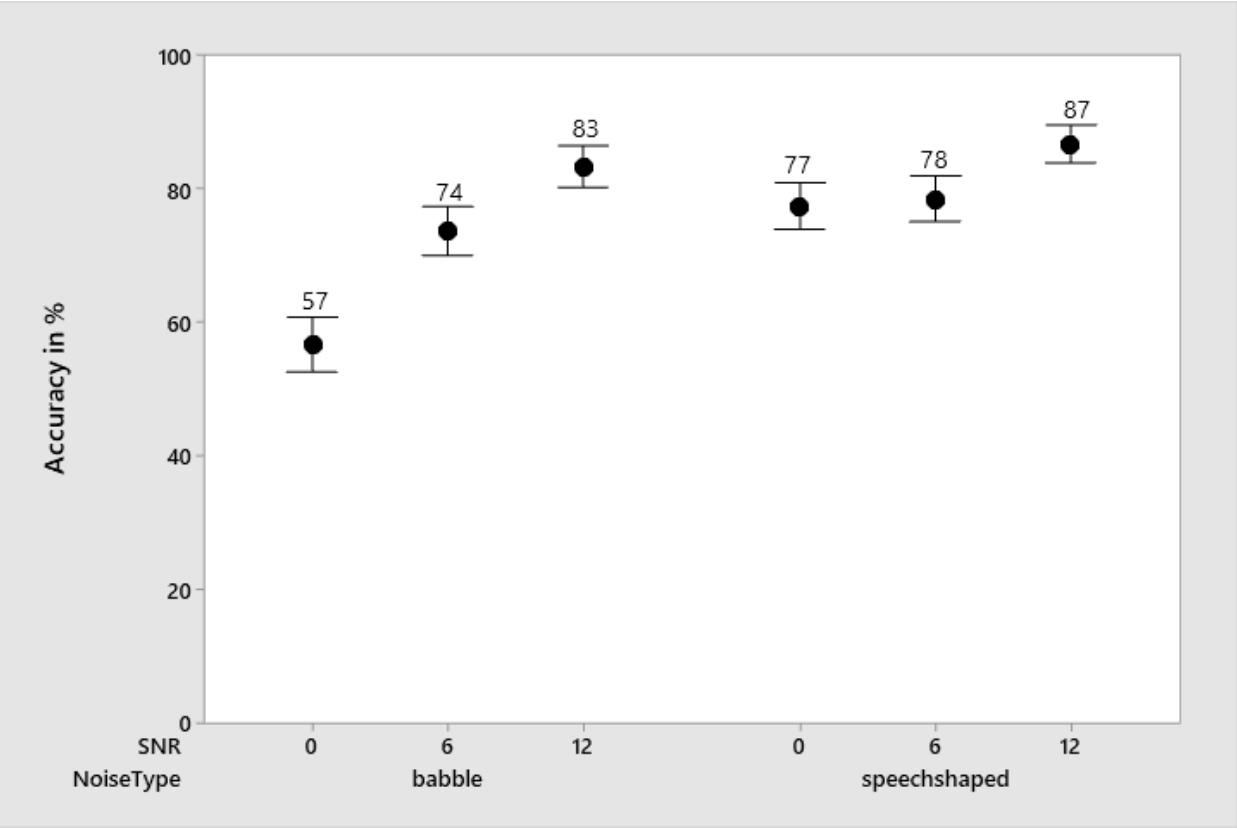

Figure 6. Interaction of NoiseType and SNR

- Significantly higher accuracy for speech-shaped than for babble noise at 0 dB only

Results

Table 2. Error types

Presented stimulus	Selected answer	Children with CIs (errors in %)	Children with TH (errors in %)
[a]	[e]	3	1
	[i]	3	1
	[o]	5	1
	[u]	2	1
[e]	[a]	3	1
	[i]	7	2
	[o]	3	0
	[u]	3	0
[i]	[a]	3	3
	[e]	17	7
	[o]	6	1
	[u]	5	1
[o]	[a]	3	3
	[e]	7	5
	[i]	8	4
	[u]	29	5
[u]	[a]	7	2
	[e]	9	4
	[i]	6	5
	[o]	31	31

Discussion

- Children with CIs seem to have difficulties in perceiving vowels on more acoustic levels (F1, F2) in noise than their peers with TH

- Lack of visual support possibly especially problematic for the perception of rounded (back) vowels (see Robert-Ribes et al. 1998)